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Chapter 1 – Introduction

Background

Planner Training - Where and how this course fits.

The Corps of Engineers has adopted a "core curriculum" of eight courses/workshops. This curriculum was developed on the basis of recommendations from the Civil Works Planning Capability Task Force. Its objective is to improve and maintain the planning capability of the Corps. The other courses are:

1. Introduction to Planning
2. Planning Orientation Workshop
3. Planning Process
4. Consensus Building for Water Resources Planning
5. Environmental Considerations for Planning
6. Hydrology and Hydraulics for Planning
7. Economic Analysis in Planning

This course fits as follows a 4-day workshop addressing the entire plan formulation process as it applies to the Corps multipurpose plan formulation requirements. While the course outline covers the four project purposes of ecosystem restoration, flood damage reduction inland navigation, and deep-draft navigation each session will be modified to cover ecosystem restoration and one of the other three project purposes.

The Target Student Population

The "Core Curriculum" is intended to provide a common baseline of understanding of key planning skills and abilities and to help move new planners quickly to the journeyman level of competency, when supplemented by appropriate on the job experience and mentoring.

The journeyman level means that the planner could lead a planning team through a straightforward planning study with moderate guidance from his or her first line supervisor. This means that the journeyman has both experience on a planning team and also has let at least one small planning study, with substantial supervisory guidance.

Therefore, the target student population for the "core curriculum" is any beginning corps planner who might begin a study team, all such members will need the envisioned common baseline of understanding and are potential future leaders of the study team.

The Target student population for the "core curriculum" is any potential member of the technical planning team. All such members will need the envisioned company baseline of understanding.

Introduction to the workbook

Primary purpose

The primary purpose of this workbook is to support a one week instructor-led workshop. It will provide a permanent summary of the workshop content. It includes all of the slides, questions and instructional material used in the workshop.

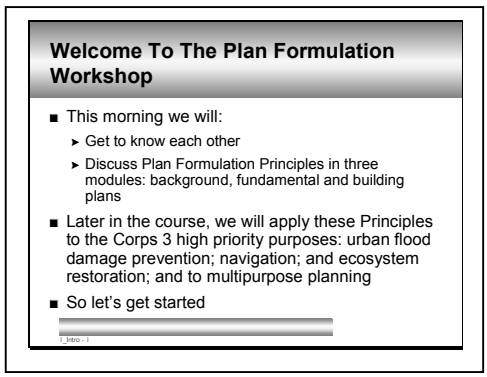
The student will use some of the material from the workbook directly in the class and will be provided this material at the beginning of the course. Other material is intended for use by the instructors during the course and by students after the course. This material is designated at 'Instructor Notes' in the text (in blue text in the electronic version of the text) or in the appendix.

Secondary purpose

This workbook further supports the course by providing a concise, stand-alone reference document for the student. The student may use it to refresh his or her memory of the course and to address everyday formulation concerns. This workbook is intended to have secondary utility even for beginning planners who have not yet been able to attend the course. Hence it includes all instructors' material. It is recommended that the Planner's Manual be used as a companion document to this workbook.

Introduction to the Workshop

Goals of the Workshop



This course is directly designed to improve the Corps plan formulation capability. Plan formulation is the third step in the Corps planning process. This is the basic plan formulation course. It is designed for beginning Corps planners with 1-3 years of experience. This course assumes that the student has taken the Corps Introduction to Planning/Civil Works Orientation Course or Planning, Principles and Procedures.

This course will be successful if it helps emerging planning team leaders learn:

1. How to systematically develop plans in a generic sense and in a variety of water resource settings

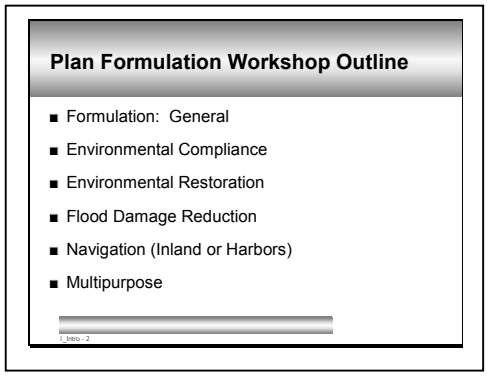
2. How to avoid common mistakes in plan formulation

3. How to address areas where the approach to formulation is uncertain: eg emerging concepts such as environmental sustainability and ecosystem restoration.

Student Learning Objectives

Student learning objectives are specified for each module in the workshop and summarized in the presentation materials. Students should use these to determine progress in the course.

Course Structure



The course is designed to start with general plan formulation principles and concepts. Among these are how plan formulation, the third step in our six step planning process, relates to other steps and how it differs from them. These general principles and concepts will then be applied to several project-specific purposes to illustrate single purpose (not single objective) planning. Then, they will be applied to multipurpose planning, including cost-allocation and cost sharing. Finally, we will undertake a planning exercise based on Murrieta Creek, a multiple purpose project for flood control, ecosystem restoration and recreation.

In addition, plan selection criteria and cost-sharing issues related to the locally preferred plan cost allocation and apportionment and the impact of cost-sharing on plan formulation outcomes are discussed in the G and M-4 modules, because these topics are not covered elsewhere in the core curriculum.

Selected Notes to the Instructor

Instructor Notes and Exercises:

As an introduction advise the students that this workshop is oriented to the apprentice planner with the goal of improving plan formulation capability. Let them know that it is a workshop and that the workshop is structured to keep them actively involved. Before starting the course introduce yourself and the other instructors (or have each instructor introduce themselves), then have each student introduce themselves. As part of this process collect some general statistics on the class composition. You can either select a couple of students to tabulate the information for you at the board or at their desks. As part of the introductions, have the students indicate their educational background (engineering, economics, environmental sciences, other); experience (less than 1 year; 1 to 3 years; 3 to 5 years, more than 5 years); what part of the country they are from (north, south, east, west). At the end you can summarize the information for the class.

Provide a brief overview of the course. Briefly describe the purpose of each major section.

1. General. Provides a general introduction to plan formulation concepts and strategies.

2. Environmental Compliance. Provides a brief overview of environmental legislation and its impact on plan formulation and explores the concept of mitigation.

3. Ecosystem Restoration. Reviews the Corps environmental restoration authorities and discusses plan formulation concepts and strategies for environmental restoration projects. Ends with a case study.

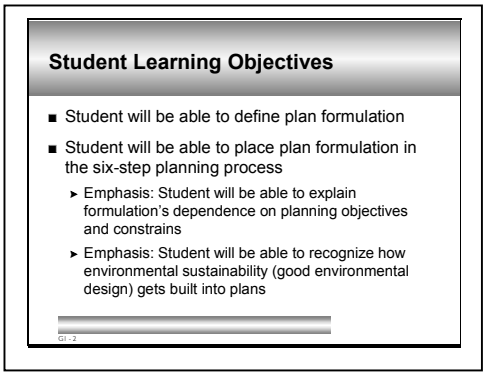
4. Flood Damage Reduction. Reviews the Corps flood damage reduction authorities and discusses plan formulation concepts and strategies for flood damage reduction projects.

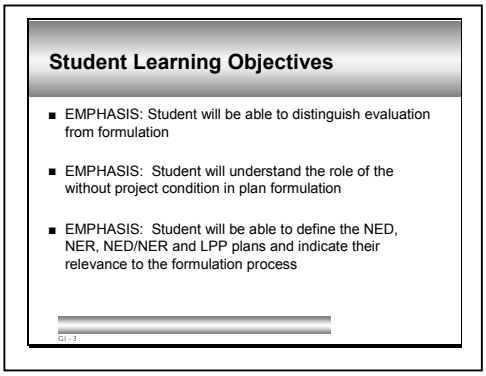
5. Navigation (either Inland or Harbors). Reviews the Corps navigation authorities and discusses plan formulation concepts and strategies for navigation projects.

6. Multipurpose Projects. Reviews the Corps role in providing projects for other purposes and discusses plan formulation concepts and strategies for multipurpose projects. Ends with a case study.

Chapter 2 – General Plan Formulation

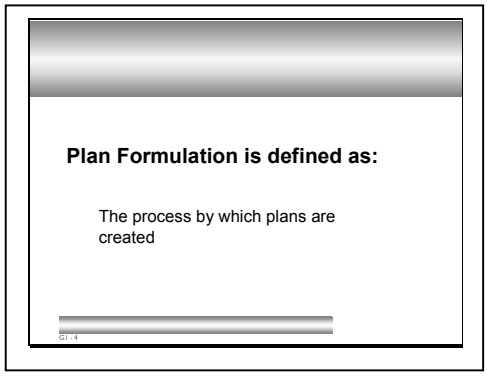
Module G-1: What is Plan Formulation?



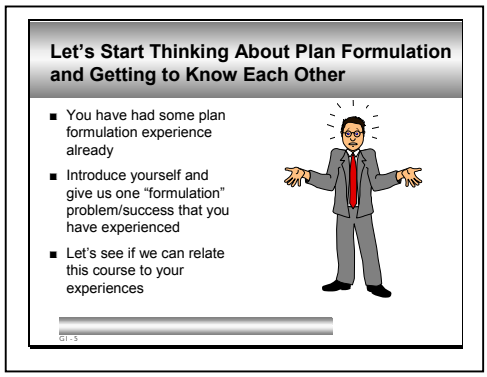


Developing a Working Definition

There are three definitions of plan formulated. First is a simple definition; i.e., plan formulation is the process by which District planners create plans.



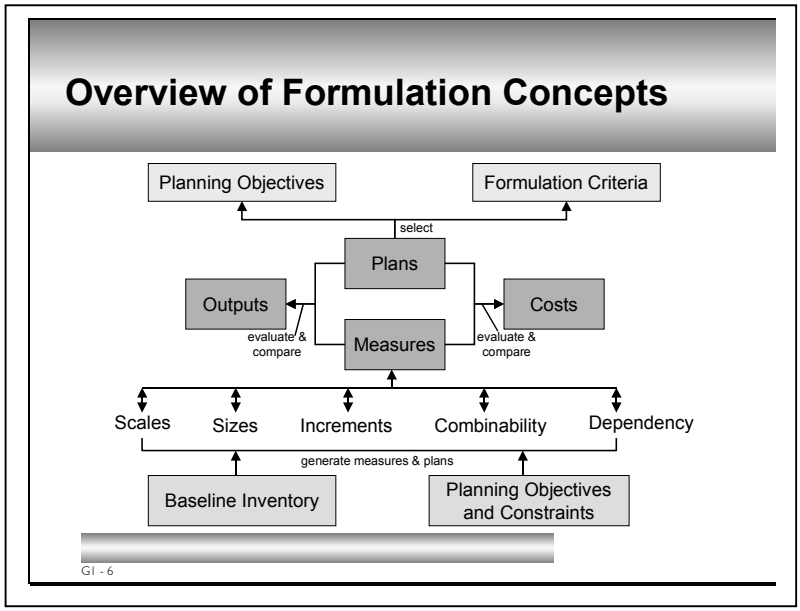
In Class Exercise:



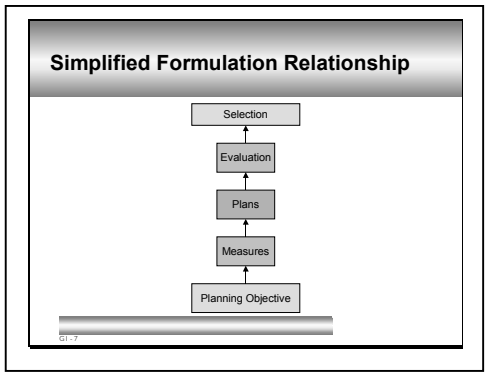
You have had formulation experience. Can you think of when you last formulated a project? An economist might answer: when I showed that the incremental benefits did not exceed the incremental costs. A hydrologist might answer: when I determined where the floodwaters would exit the creek. A designer might say: when I found a cheaper material for a lock, or a less costly design sequence. A planner might say: when I found my solid planning objectives. You are on the right track; all of these activities help in the iterations of the formulation process. However, none of them directly tells you how to come up with a reasonable set of plans.

A diagram

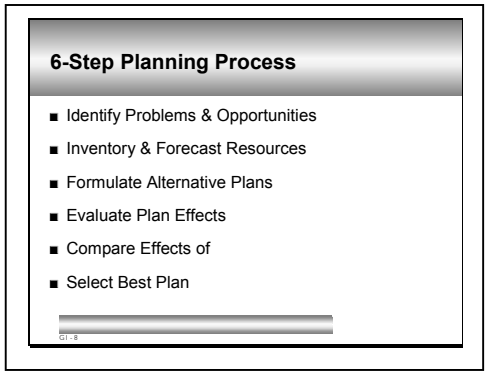
Slide G1-6 shows that planning objectives, evaluation, selection and other steps in planning are interrelated.



Slide G1-7 simplified the relationship. Plan objectives are said to generate measures. Each objective is used to generate measures. These are combined into plans, evaluated and ultimately selected.



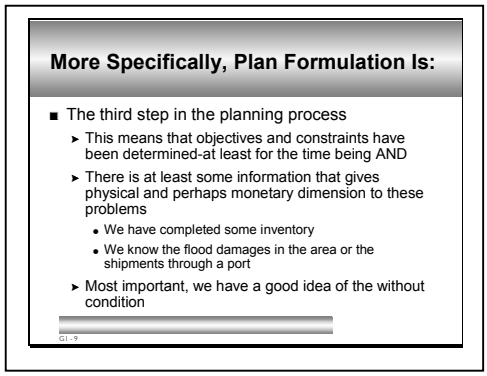
Second Definition of Plan Formulation Based on Planning Manual



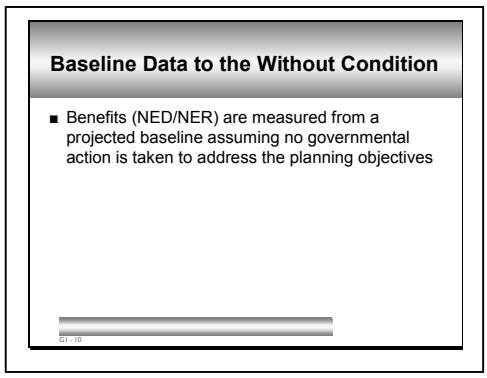
The planning manual defines Plan Formulations as "The process of building of plans that meet the planning objective and avoid planning ands traits. Specifically, it is the third step in the Corps six step planning process (Slide G1-8). However, there are elements of plan formulation in all six planning steps. For example, during the inventory step, identification of endangered species habitat can lead to the formulation of plans that avoid impacting that habitat. Placing formulation in this context helps us to see what formulation is and how it relates to other steps. First, let's concede that almost any planning process will be reiterative--and a little messy. To help our understanding, let's simplify things and assume we are just going to go though the planning process once.

What would we have to work with, if we were only given one iteration? We would have our planning objectives and our planning constraints.

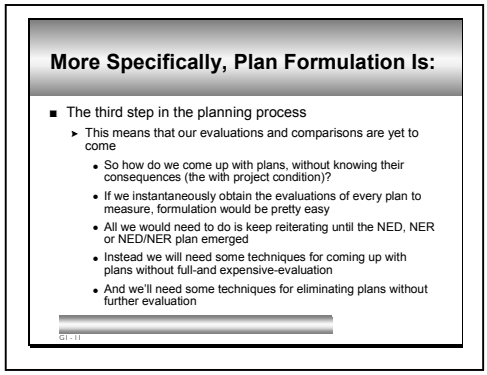
After the first two steps of the planning process, we have a good idea of what the publics want in terms of planning objectives. We have a good idea of what they do not want as well (planning constraints or "negative" or "avoidance" objectives) and a very good idea of what will happen assuming no governmental action is taken to address the planning objectives. This is called the without project condition.



The without condition is the basis from which plan benefits and costs, monetary and nonmonetary, will be judged. We know where we are starting.



What we do not know in any detail is the with-project condition(s). We cannot know this in our once through model for two reasons. First, we have not decided what the plan(s) are that we want to consider. Second, once we do have the plans, we have to evaluate them. Evaluation is the fourth step of the planning process.



Third Expanded Definition of Plan Formulation

We are now ready to define formulation in its purest, most abstract form. Formulation is the creation of plans before we know the with-plan conditions. It is the planning space between the without and the with conditions. It starts with no plan and ends with several unevaluated plans.

Why an Expanded Definition?

This way of looking at formulation is not realistic in the sense that it is not what happens in the real world. We must and do reiterate or reformulate plans and as we do so, we gain a better and better idea of what the with condition is likely to be. Still the expanded definition teaches us some important features of plan formulation:

The Expanded Definition Teaches Us:

1. The planning objectives are our first and best guide. The plans we formulate must achieve or contribute to our planning objectives.

2. We must be able to formulate and choose among plans and their components even when we do not have all the information and evaluations at the level of detail we might like. Rational comprehensive planning, where we know everything about every possible plan, is understood in the planning literature to be unrealistic. Further, several experts claim that it is also undesirable because if "wastes scarce cognitive resources" (Simon).

3. We must begin formulation with incomplete knowledge. Our early decisions will determine how many with project conditions we will generate, for what areas, and in what level of detail.

Relationship to Other Steps in the Planning Process

a. Planning objectives and constraints. Developing planning objectives is critical to formulating measures, the first major criteria of the planning process. Our measures depend on our objectives. In order to illustrate this point, consider a generic problem: Homeland security.

Sometimes the Corps is called upon to conduct pure planning studies. Watershed Management Plans are an example. The Corps has been asked to study metropolitan water supply and solid waste disposal in the New York area. In cases like this the Corps may be providing a software planning service without thought of a Corps project at the end of the planning stage. Our experiences in these studies show that the basic Corps structure for planning will work, even when Corps implementation funding is not a factor. This is because the underlying Corps methodology is driven by the planning objectives and constraints and not by the policies that surround any single "type" of plan or project.

Good Formulation is Based on a Good Set of Planning Objectives/Constraints

- In order to formulate well, you need to know specifically where the problems are
  - Remember that the physical problem and its source may be geographically separate
- And where they are likely to be in the future

G1 - 12

The exact nature of the constraints and objectives that are built into a specific study may be broad or narrow. For pure planning studies, we would expect, all other things equal that there would be fewer constraints and more alternatives formulated. Even within the Corps programs, we find that environmental restoration and flood management lend themselves to a wider array of alternatives than inland navigation. This is because most work on the inland system involves improvements to existing waterways, rather than expansions of the existing system and because the system is in fact a system which constrains alternative lock sizes and sill depth.

Good Formulation is Based on a Good Set of Planning Objectives/Constraints

- This is especially important for environmental matters of all kind, since Federal law directs us to pay particular attention to environmental factors for any type of project
- Poor environmental constraints and objective will lead to an inability to formulate a good plan

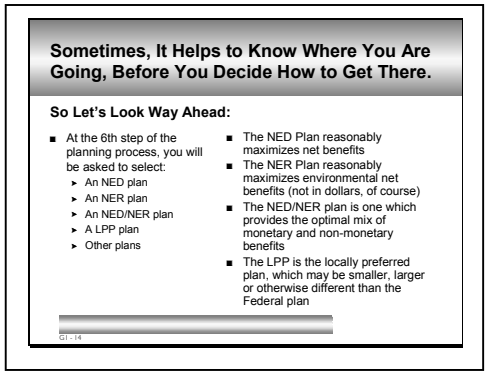
G1 - 13

Whatever the type of study and whatever the policy or practical constraints on the range of plans to be considered, a precise specification of the planning objectives is the key to good formulation. Basic as this point seems to be and as often as it is repeated, there is a tendency to forget it under the pressures of time constraints and demands from local sponsors. Real as these pressures are, the most common failure of formulation according to the planning manual is a failure to specify the planning objectives as to location and quantity.

b. Baseline inventory and without condition. The without conditions defines what will happen in the absence of governmental action. Hence, it forms the baseline from which all measures (and, later, plans) will be evaluated. Evaluation leads to reiteration. Hence, proper definition of the without project conditions forms the base for measuring the performances of alternatives.

c. Evaluation (and comparison). Using planning objectives to generate measures will only get you so far. Unavoidably you will have to evaluate measures or plans to continue the plan formulation process. If the costs and outputs of each viable measure are known, formulation becomes much easier.

Let us look forward in the planning process.



Designation of "Named" Plans

We know that at step six we may have to designate three critical plans: the National Economic Development (NED) plan; the National Ecosystem Restoration (NER) plan; and the NED/NER plan.

NED/NER to NED/NER plans

Definitions

- The NED plan is the plan that reasonably maximizes net benefits consistent with protecting the Nation's environment for a plan meeting a planning objective which is in the Federal interest, such as flood control.
- The NER plan is the plan that reasonably maximizes ecosystem restoration benefits compared to costs for a plan meeting a planning objective that is in the Federal interest, such as wetland restoration. The benefits are not in dollars, of course.
- The NED/NER plan provides the optimal mix of monetary and non-monetary benefits by attempting to maximize the sum of NED and NER benefits, and to offer the best balance between the two Federal objectives.

Importance to Cost Sharing

- They define the limits beyond which the Corps cannot participate financially.
- The Corps will not normally budget for any plan where the financial participation exceeds the Federal interest established by one or both of the "national" plans.

LPP's

- The LPP is the locally preferred plan, which may be smaller, larger, or otherwise different from the "national" plans. The locally preferred plan will be cost shared in the same degree as the national plan if its costs are less than the national plan, assuming it is not different in kind or location. Hence, a restoration plan favored by the non-Federal sponsor for 50 acres, rather than the nationally optimal 100 acres, will be cost share 65-35, assuming the 50 acres is located within the footprint of the 100 acres.

Example of Importance of NED Plan

- On the other hand, Federal participation in a larger LPP, assuming it is of the same kind and location, will be limited to the amount the Corps would have contributed to the national plan. In our example, if the local sponsor wanted 150 acres, the Corps financial participation would be limited to the amount it would have contributed to the 100-acre plan.

You can easily see the importance of plan formulation in the real world. Let us return to our once through model to see why. Let us say that we posit three plans:

Sometimes, It Helps to Know Where You Are Going, Before You Decide How to Get There.

So Let's Look Way Ahead:

- At the 6th step of the planning process, you will be asked to select:
  - An NED plan
  - An NER plan
  - An NED/NER plan
  - A LPP plan
  - Other plans
- The NED Plan reasonably maximizes net benefits
- The NER Plan reasonably maximizes environmental net benefits (not in dollars, of course)
- The NED/NER plan is one which provides the optimal mix of monetary and non-monetary benefits
- The LPP is the locally preferred plan, which may be smaller, larger or otherwise different than the Federal plan

G1 - 14

1. Plan A efficiently destroys all remaining wetland in the area (later, after evaluation we find that its net NED benefits are $100). Its costs are $1000.

2. Plan B is expected to significantly reduce flooding, without environmental harm (later, after evaluation, we find that its net NED benefits are $10). Its costs are $2000.

3. Plan C permits street flooding for large flood events (its net NED benefits turn out to be $50). Its costs are $1500.

It should be clear, after evaluation that Plan C is the NED plan and therefore that the Federal financial participation for Plan B is limited to $975 (65%x1500). However, what if we had a planning objective to eliminate street flooding. Therefore, at the request of the local sponsor, we refused to consider any plan, which did not eliminate street flooding. We would not have found the NED plan.

Even worse, suppose Plan B's net benefits were not +10 but -10. Since we had not developed Plan C, and since Federal participation in Plan B would be zero, we would have done our local sponsor and the Federal interest a disservice.

How about Plan A. Should it limit Federal financial participation to $650,000 ($1000x65%)?

After all, it might be confused with the NED plan, since its nets NED benefits are $100 while is greater than the Net NED benefit ($50) for the actual NED Plan.

This plan should have been constrained out at the beginning. Presumably, it was not mitigable It is presumably not mitigated because it is physically impossible or because mitigation is not justified under current, written Corps guidance. A plan must be mitigated to the extent justified; there is no blanket requirement for full mitigation, however. In any event, Federal law makes clear that we should avoid such plans whenever possible. Hence, we wasted our time by evaluating it. Even if the numbers tell us it is, in some abstract sense, the NED plan, it is NOT a "reasonable NED" plan because it does not adequately protect the environment.

This reasoning is not limited to the environment. All plans must be reasonable. Any severe adverse impact should be avoided by appropriate placement in the planning objectives and constraint. For example, the following situations lead to planning "avoidance" objective in real projects: upstream and/or downstream induced flooding; a by-pass channel that splits a community apart; and bridge relocations that negatively impact on a town center.

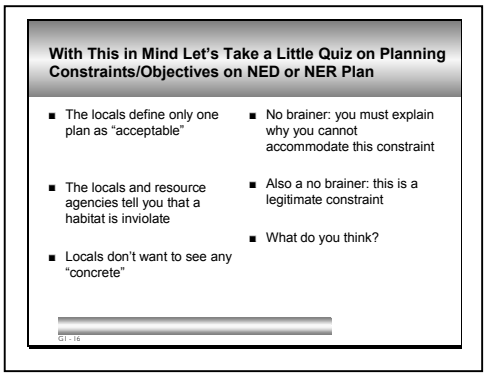
One further practical point should be considered. Destroying all the remaining wetlands in an area would almost surely bring (justified) environmental opposition.

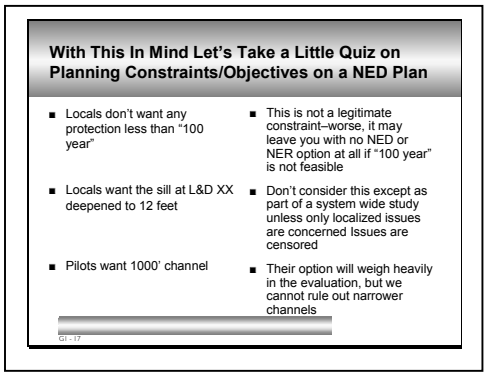
As a rule of thumb, if you should try enhance the environment or at the bare minimum not make matters worse, this not only leads to environmental sustainability but to project acceptability.

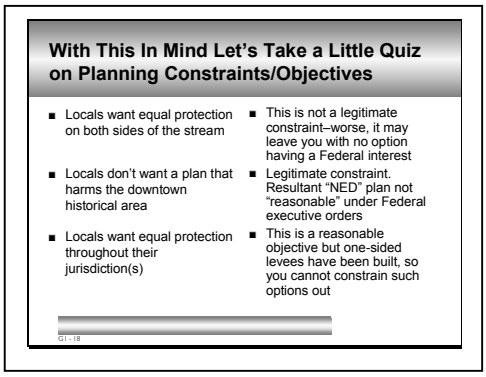
Examples of Importance of Planning Constrains in Determining Names Plans

The NED plan (or NER or NER/NED) is too important to be artificial. Whether it is the selected plan or not, it must be real and reasonable. One of the best ways to make it realistic is to constrain out measures that are unacceptable or incomplete. "Constrain out" may be too harsh; perhaps "eliminate or minimal evaluation" or "eliminate early in the formulation process" it more accurate.

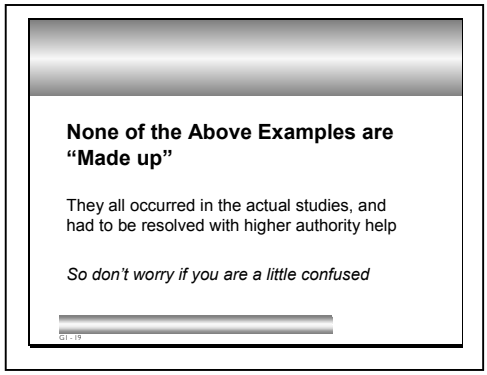
A plan F1 is presumably not mitigated because unit is physically impossible or because mitigation is not justified under current, written Corps guidance, a plan must be mitigated to the extent justified; there is no blanket requirement for full mitigation, however.





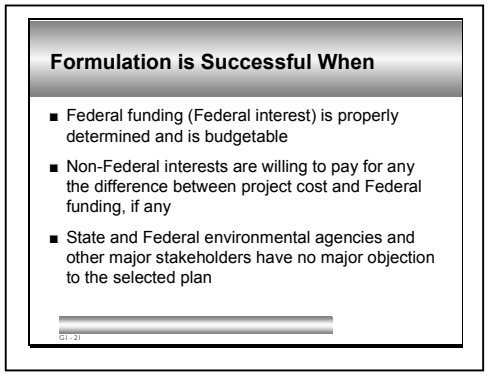


The point is that formulation is an art. This follows from the judgments that must be used in the 6 major steps of planning. These judgments include: significance of planning constrains; level of detail; choice of evaluation techniques; and the need to compare inputs which are not measurable in comparable units. Despite, the number of judgments involved, the process itself is quite rational and fact beised. However, it is fact based and rational. It is conducted in the context of a set of rules and institutions, which allow more or less flexibility in the range of alternatives that it makes sense to study in detail. The formulation process and even results of formulation therefore depend on:



1. The formulator
2. The size of project
3. The type of project
4. The institutional setting
5. Available planning funding, time and available information

As we go through the course, try to distinguish general principles from project specific applications. Do not be frustrated by apparent differences in applications. Since this course is primarily about Corps funded projects, let us focus on when formulation is successful in that context:



1. Federal funding is properly determined and budgetable
2. Local sponsor(s) are willing to pay for any difference between project cost and Federal funding (if any)
3. State and Federal environmental agencies and major stakeholders have no major objection to the selected plan

Review Questions

1. What is plan formulation?

2. Where does plan formulation occur in the planning process?

3. Which of the following will likely be available at the first iteration of formulation? Pick one or more and explain why.
   a. Planning objectives
   b. Without condition
   c. With condition
   d. NER plan

4. What makes a NED plan "reasonable"?

5. Define:
    a. NED Plan
    b. NER Plan
    c. NED/NER Plan
    d. LPP Plan

6. What is the role of constraints in determining the measures/plans, which can be considered?

7. What are the two dangers of "constraining out" plans or types of plans?

8. What practical consequences follow from the determination of the NED/NER plan?

9. In what two senses is Formulation an Art?

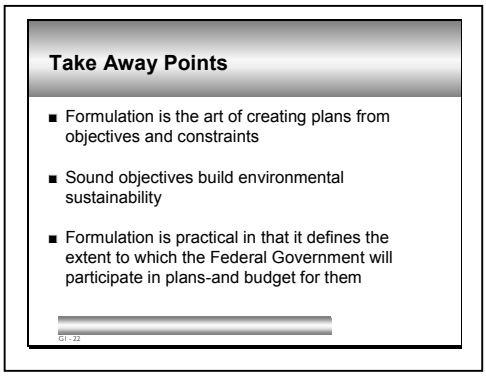
10. When is formulation "successful"?

Section Summary and a Look Forward

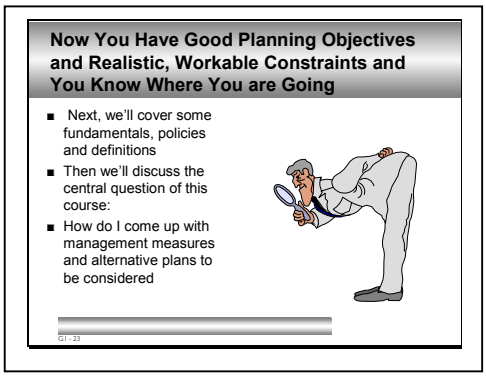
Formulation is the art of creating plans from objectives and constraints.

Sound objectives build environmental sustainability.

Formulation is practical in that it defines the extent to which the Federal Government will participate in plans-and budget for them.

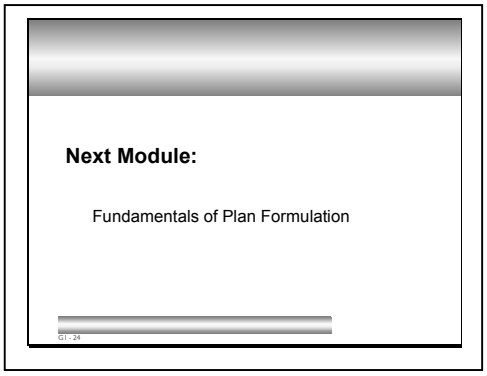


Look Forward



Fundamentals: policies and definitions (G-2).

Coming up with management measures and alternative plans (G-3).



References and Suggestions for Further Reading

Planning Guidance Notebook Chapter 2, April 2000,ER 1105-2-100, CECW-P.

Lindblom, C. and R. Brayburn, *The Science of Muddling Through* (questions the comprehensive decision making model).

Lowi, T., *The Death of Liberalism* (argues in favor of a return to the rationalistic approach of the Founding Fathers).

Simon, Herbert, (Professor Simon won the Nobel Prize for Economics).

Yoe, Charles and Kenneth Orth. Planning Manual Chapter 8. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. 1983. U.S. Water Resources Council.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will be able to define plan formulation
2. Student will be able to place plan formulation in the six-step planning process
3. Student will be able to relate plan formulation to each of the other 6 steps in the planning process
4. Emphasis: student will be able to explain formulation's dependence on planning objective and constraints
5. Student will be able to recognize how environmental sustainability (good environmental design) is built into plans
6. Student should be able to distinguish evaluation from formulation
7. Student will understand the role of the without project condition on plan formulation
8. Student will be able to define the NED/NER, NED, NER and LPP plans and indicate their relevance to the formulation process

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Instructor Notes and Exercises:

This module should take about 45 minutes. It covers material that the student already has had in the Planners course, so we want to be brief. Therefore, you may want to limit the amount of time you spend on slide G1-4. You could limit discussion to a few topics, or "save" the topics for later. The important point is to get the class thinking about what plan formulation is in relationship to the other tasks. I assume that several of the formulation issues that will be raised will be evaluation, selection problem identification issues and without-project issues, so this gives you a chance to put formulation in context.

Most of the slides are straightforward and should not surprise the students, so I suspect you can go through them fairly quickly. You will want to emphasize slide G1-9. Many students may not realize that, even for the first iteration of plan formulation, there is a significant amount of information available on the without condition. This is because the study team has already completed the first iteration of data collection.

Per slide G1-11, you do not have any information on the with-project condition yet for two reasons. First, you have not formulated plans yet. Second, you have not begun evaluation. If you posit a number of plans on the first iteration, you will have many plans to evaluate. When this is time consuming and costly, the formulator must limit the number of alternative and/or the level of detail necessary to eliminate some plans.

The purpose of slides G1-12 and 13 are two-fold. First, there is no course on plan selection, so we will try to cover it in this course. Second, the "art" of formulation and the apparent "academic" approach of

the P&G often blind young planners and local sponsors to the serious practical consequences of the formulation process.

Slides G1-12 & 13
Exercise G1-1
Tell students we are going to do an exercise in problem identification that is purposely not in the area of flooding. Divide them into small groups to work on this. Gov. Ridge has been put in charge of office of homeland security newly created by executive order of the President in light of the events of 9-11-2001.

Give the class 5-10 minutes to state what Ridge's objectives ought to be and what problems (constraints) he ought to be aware of. Intelligence gathering will lead to one set of measures. Interdicting biological warfare to another set of measures; airport security to another set; and so forth. Thus getting the problem identified properly is critically important. The way we define the objective determines the type of solutions we seek.

The questions raised in slides G1-14 to 16 at first seem academic-even pedantic. There are not enough facts given to answer any of them definitively, so challenge the class to think more deeply about whether the "answer" is correct in all cases. Slide G1-17 serves to reinforce the real world nature of the concerns raised.

Slides G1-16 to 18
Exercise G1-2
The purpose of the planning constraints/objectives quiz is to raise the issues, not to resolve them. Depending on time availability let the students draw on their own experiences. Expect some comments like "We don't do it that way" or "Tell it to my supervisor".

Equal protection within a jurisdiction or adjacent jurisdiction may be a valid planning objective, but we may not be able to get there from here, because of NED/EQ or other considerations. In one specific case (Lock Haven) two sided levees were not feasible. Of course a one sided levee increased flood flows on the opposite bank. The District was able-not without difficulty- to formulate a non-structural plan for the unprotected side, which proved to be acceptable. In another specific case, Petersburg, West Virginia, the District accepted "equal protection" as a planning constraint, but upon review was required to formulate unequal protection; the District was able to show that equal protection was the superior plan unless very low levels of protection were considered; higher authority agreed that very low levels of protection were not effective nor in compliance with urban flood protection policy, given the severity of large storms in the mountainous terrain. Use examples like these, or your own examples, to give the class a sense of the very real and serious nature of the issues being discussed.

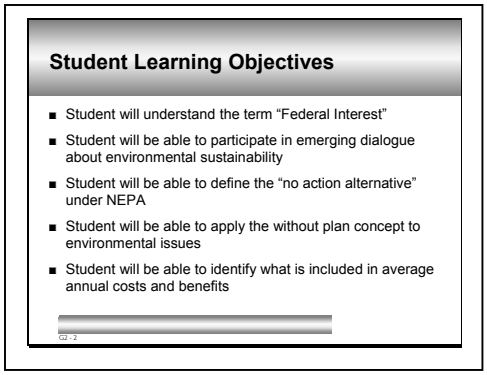
Another point to emphasize is that the Corps' preference is to consider measures and plans that don't cause serious and obvious negative consequences, especially to the environment, and that analytically contribute to the positive planning objectives. Measures and plans may be eliminated early on the basis of preliminary evaluation.

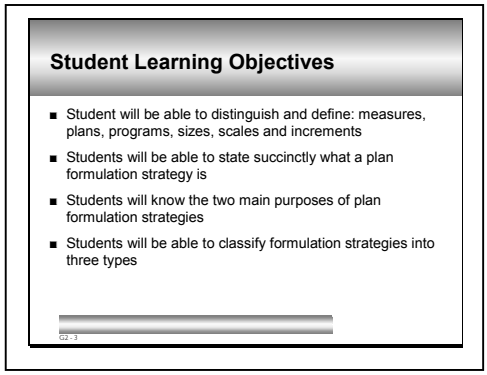
It is possible that the class may not respond to this quiz. Perhaps they don't have enough experience to realize the importance of the issues being raised. In that case, don't force discussion. Just plant the seed and get back to basics (Slides G1-18 to 22). On the other hand, if the class likes this quiz and it generates discussion, consider skipping the subsequent, more basic slides (G1-18 to 22).

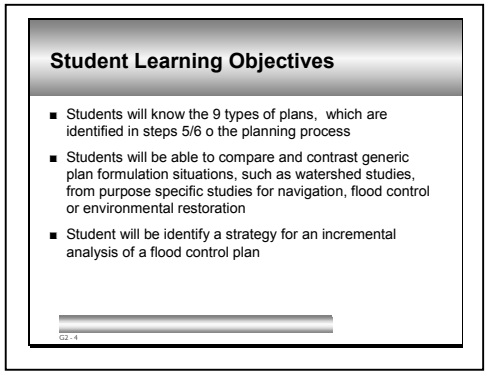
Slide G1-19
The studies were: Virginia Beach, VA; Passaic River Basin, NJ; Sims Bayou, Texas; Petersburg, W. Va.; Lock and Dam 26 (Melvin Price L&D), MO and IL.; Norfolk Harbor, VA; Lock Haven, PA.; Scottsdale, VA,; Green Brook, NJ.

Slides G1-18 to 20 are basic. Slide G1-21 may raise some eyebrows since it implies that the formulator is at fault if plans do not work out. Be prepared to discuss the slide as an ideal. There may be circumstances beyond the formulator's control that lead to no project (change in economic fortunes of the local sponsor; change in budget priorities by OMB; etc).

Module G2: Fundamentals of Plan Formulation-Key Definitions and Terms







Before we can communicate effectively about how to formulate, we need a common language about basic terms. Several of these terms can be clarified by the use of examples.

Incorporating Federal Interest: General Concept

The Congress, acting within the tax and spend, general welfare and interstate commerce clauses of the US constitution have entrusted directly to the Corps responsibility for certain Civil Works projects, either generically or on a project specific basis. Well-known examples include flood control, commercial navigation and ecosystem restoration. The details of these programs are frequently changed.

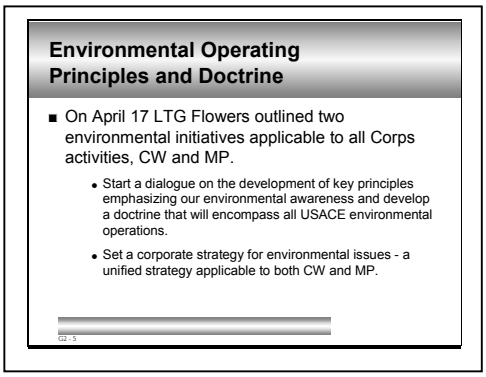
Federal Interest in Cost Sharing

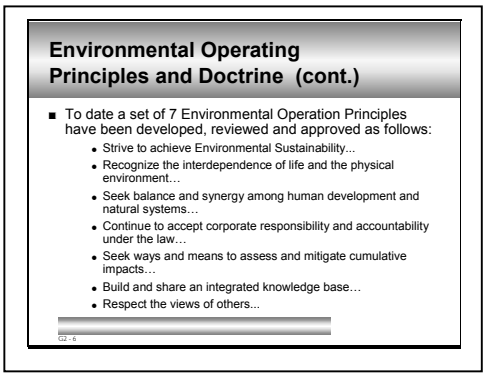
One obvious area of Federal Interest is federal financial participation in studies or projects. This participation comes through the Corps' programs; this means appropriated funds are allocated to the Corps.

Federal Interest in Other Objectives

Congress or the President frequently tells the Corps how to exercise its role as trustee of certain programs. Often this guidance is not specifically directed to the Corps but rather is "cross-cutting." It applies to all or many federal agencies. Environmental and legislation and executive orders are likely to be "cross-cutting" NEPA, ESA, and F&WCA are but a few examples.

Both types of "Federal Interest" need to be incorporated into Corps studies.





Incorporating Federal Interest: Environmental Sustainability

Status

Use handout or current status, as of December 2001. The status was that Congress had provided no direct funds or authorities on a program basis, as it has for ecosystem restoration. The Chief has incorporated environmental sustainability into all aspects of the Corps Civil Works to Military Programs efforts. The Chief has asked for a dialogue on this subject, to include the EAB (Environmental Advisory Board) and Corps leaders for all program areas.

Concepts

This portion of the workbook is meant to encourage dialogue. Senior planners have no particular expertise, so students will hopefully feel free to "jump in." One key concept is environmental sustainability.

Basics

The heart of environmental sustainability is meeting the needs of the present without compromising the quality of life for future generations. This implies, at a minimum that long-term resource impact should be

considered as part of acceptability and completeness criteria, and should be incorporated into planning objectives and constraints.

As a Purpose

The NER program is an example of attempts to restore environmental sustainable ecosystems, which have already been degraded. Several types of studies and several specific efforts are clearly geared toward environmental sustainability. These include: Everglades Restoration, Upper Mississippi River Environmental program, Missouri River Master Plan, Snake River studies, DMMP's watershed studies and the like.

As an Add-On

This concept implies that a recognized purpose is the objective of the study (e.g., flood control). Once a viable plan is established, the Corps could add funds on a cost-shared basis to take advantages of opportunities for environmental sustainability created by the project. Set back levees to retain meanders is one example. It is emphasized that Congress has not authorized such efforts. In theory the Corps could recommend such projects to OMB and Congress, but this decision obviously rests in Washington.

As Environmental Design

In formulating projects for other purposes, there is no doubt that the Corps has the authority to incorporate environmental design, even though the resulting "NED" plan may be more expensive. Avoiding sensitive, federally recognized environmental resources is one example. In fact, this practice is written into NEPA.

Retrofitting

Existing reservoirs or locks and dams or a system of such structures may be prime candidates for re-study from an environmental sustainability perspective.

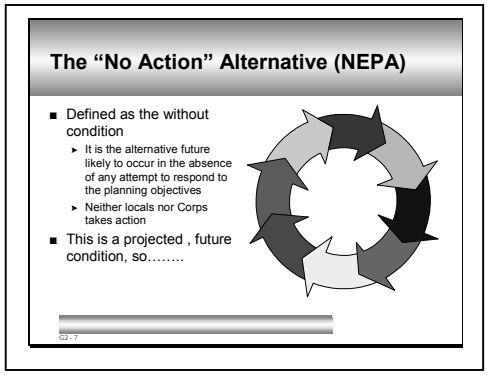
Traditional studies may identify environmental sustainability opportunities (the resources of a basin are strained or overtaxed or may become so). This can lead to specific, spin-off studies if Executive and Congressional decision-makers concur in the need for such a Corps-led effort.

Whatever the source of study, environmental sustainability is a process that requires an analysis of long-term additive demands on natural resources. The most likely relevant resource for the Corps is water (to related land) resources. This implies a basin-wide approach or an estuary (or coastal zone) approach.

Some Suggestions

- Agency and intergovernmental coordination and public participation will be crucial to successful environmental sustainability.
- The Corps may or may not be the logical "lead" (e.g., Coastal Zone Management, Flyways Chesapeake Bay Program, and other resources/programs logically lie elsewhere).

However, the Corps ecosystem restoration authorities, infrastructure and water resource planning and evaluation capability make it a logical "lead" for basin efforts.



The "No Action" Alternative (NEPA) and the "Without Project Condition"

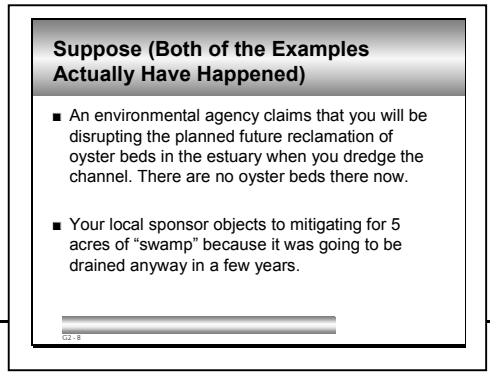
Concepts and Definitions

The National Environmental Policy Act of 1970 requires that Federal agencies identify the "no action" alternative. The Corps has interpreted this requirement to mean that the Corps should consider doing nothing, taking no action. This means that the Corps, as well as local governmental entities will make a conscious decision to let the without condition occur.

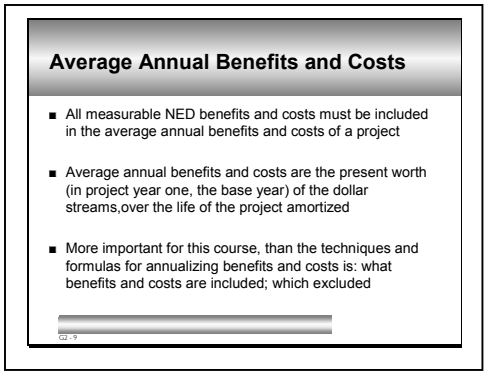
The Without Condition

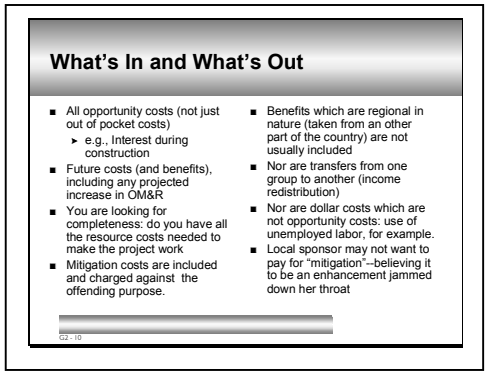
- Begins on the day of the study
- Is projected to the base year, meaning the year in which the project becomes operational. It is noted that the with condition will not exist until this point with the following exceptions; project under construction may accrue benefits, a project under construction may cause environmental impacts, beneficial or adverse, and a project under construction will accrue a cost: interest during a construction.
- Is projected many years into the future. Of course, the future is always uncertain so risk and uncertainty are involved. Your goal is to determine what is most likely to happen in the future if no action is taken to respond to the planning objectives.

Although treatment of the without condition may seem axiomatic to you as Corps planners, it nevertheless may confuse the public. Confusion will occur at two levels. First, the public may not recognize that the without condition means no governmental action by the Corps or anyone else. Second, the public may not fully appreciate the projected nature of the without condition. Therefore, they might confuse the without condition with the existing condition.



Average Annual Benefits and Costs. What's In and What's Out.





Building Blocks of Planning, Measures and Submeasures

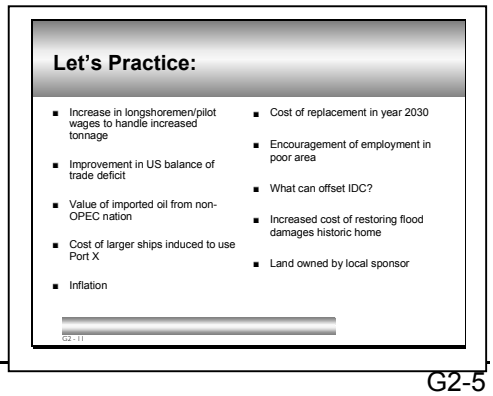
The projects that follow are Rahway Basin, NJ and the Delaware River Comprehensive Navigation Study.

While the concept of the without condition is a crucial one, it has some counter-intuitive implications. For example, if a structural project would destroy 100 acres of wetlands during construction, proponents cannot claim that mitigation or avoidance is not necessary because the wetland would have been destroyed by urbanization anyway

On the other hand, when a government agency has a positive plan to restore a natural resource, then you have a positive duty to try to insure that your project does not undermine that agency's plan. The without project concept would help you explain this concept to the public. Look for possible synergies instead. In the example cited on the slide, analysis showed no negative impact of the channel on potential new oyster beds.

Slide G2-11 answers are, in sequence

- ❖ Not a benefit to the project; counted in the benefit analysis as a cost.
- ❖ The Corps takes an international view. Trade deficits sum to zero (by definition) on a worldwide



basis. Neither increasing nor decreasing trade deficits count.

- Encouraging oil import from non-OPEC nations is a transfer. No benefit.
- Not an associated cost. Already countered in the benefit computation; it is unlikely one project will change the world fleet.
- Annual benefits and costs are at a common price level. BCR numbers, unlike budget cost estimates, are not projected to account for inflation.
- Included. Even far distant replacements are counted as a cost. Of course, so are future O&M costs throughout the project life.
- Not counted. There is a theoretical basis for the benefit, but policy prohibits using it
- Benefits during construction
- Included as a benefit (assuming historical restoration will likely happen).
- Include the value of the land in its permitted use. Ownership is not the issue

The without condition becomes the baseline from which all benefits and costs are measured. This applies to monetary and nonmonetary benefits and costs. Let us focus on NED benefits first. They include all increases in incomes directly attributed to the project and which do not involve a transfer. NED benefits measure the economic value of the outputs of a project. NED costs measure the opportunity costs of the resources used to implement a project. These may be direct or indirect. Indirect includes induced flooding and value of lost fisherman days.

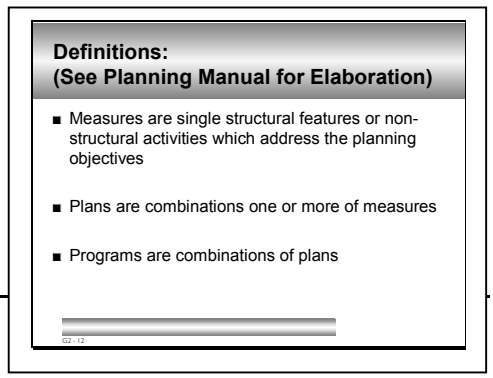
Costs may be project costs or associated costs. Associated costs are those additional costs necessary to make the project work, over and above project costs. Associated costs are not cost shared as project features. Examples of associated costs include landside facilities in harbor projects. The project is not "complete" without these costs.

This workbook is not intended to explain benefit cost analysis. The PGN and other training courses cover this topic.

Annual benefits and costs refer to the usual way of presenting benefits, costs and benefit-to-cost ratios (BCRs) in Corps reports. Specifically all benefits and cost are brought to present worth in the base year and amortized over the project life.

More important than the technique and formulas for annualizing benefits and costs is: what benefits and costs are included and which are excluded.

These slides reiterate briefly the definitions in the Planning Manual, Chapter 8. Can you see the beginnings of a way to approach formulation from these definitions? Start with objectives. Then: (1) look for measures; (2) combine into



plans and/or programs; and (3) refine by scaling and/or incremental analysis.

When you combine measures into plans, there is an important distinction. Some measures are mutually exclusive and cannot be combined. Others can be combined. Still others almost "beg" to be combined, because they function much better together. If measures are not mutually exclusive, they are "combinable."

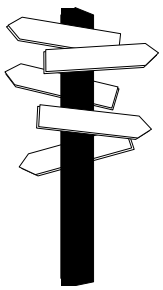
Definitions:
(See Planning Manual for Elaboration)

- Scales are different sizes, compositions, physical properties, locations and timing and duration of the same measure
- Increments are increases or decreases in the impact of a plan cause by a vertical or horizontal change in such plan

G2 - 13

If measures beg to be combined, they are "dependent." Measures that have dependency are most closely associated with ecosystem restoration. This is because ecosystems themselves are based upon mutually reinforcing natural processes, so when we attempt to restore ecosystems we often find that mutually reinforcing measures are effective. The relationships may be:

- One measure may be absolutely necessary for another. Plantings without irrigation will usually fail in a dessert environment.
- One measure may reduce the risk of failure (irrigation for plantings in the east for example).
- One measure may enhance project performance. Fertilizer or flushing may enhance and protect plantings, as may eradication control over undesirable plant species.



Look at Slides G2-15 and G2-16. Are the listed items programs, plans, measures, sizes or other scales? Which ones are increments?

Let's Practice.
Categorize the Following:

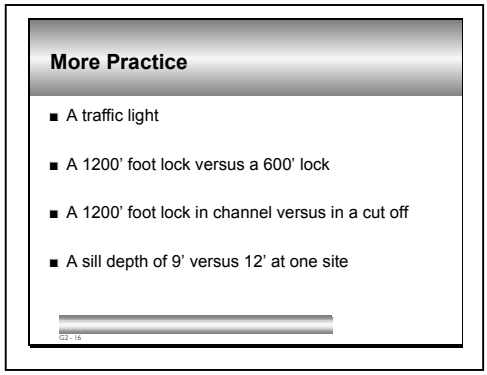
- Upper Miss. Comprehensive Management Plan
- 100 year levee versus 50 year levee at same site
- 100 year levee set-back versus riverside
- 100 year protection (bypass) versus 50 year protection (floodwall)

G2 - 15

Answers are:
Slide G2-15: (1) program; (2) scale (size) of 1 measure; (3) measures; and (4) measures.

Slide G2-16: (1) measure; (2) scale (size); (3) scale (location); and (4) program and no action alternative.

Several of the above may engender discussion. For example, can 13-3 and 14-3 be distinguished. Here is the rationale. A set back levee is a far less intrusive structure for the same output. The lock will be the same in its intrusiveness.

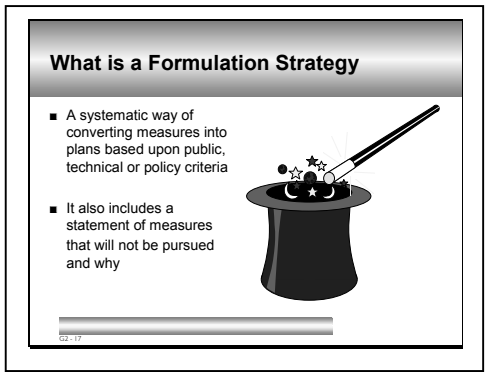


How about slide G2-16 14-4? At first blush, sill depth of 9' (by which I mean sufficient to accommodate a draft of 9 feet) versus 12' would appear to be a scale (size) change. However, existing sills are a 9' so 9' is the "no action alternative" or without condition. On the other hand, a 12' depth would make no sense at one site (the rest would still be 9') so 12' actually involves a program of system changes, unless the need for 12' was based on a vagary of the local situation or justified on benefits within one lock pool.

An increment is a vertical or horizontal increment of a plan, so any of the examples could be increments except for the third one on slide 13 and the third one on slide 14. You would not add a 100-year set back levee to a 100-year riverside levee; you would not add a 1200' lock in a cut off to a 1200' lock in a channel. In both cases the output levels are the same.

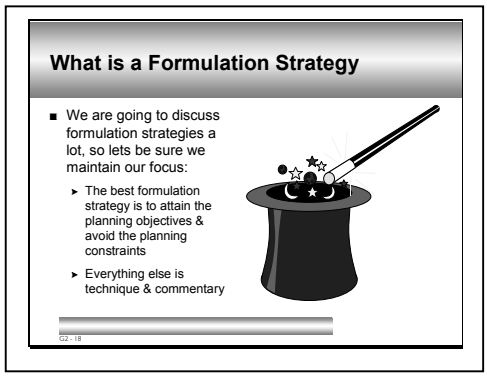
Formulation Strategies

We have now stressed some fundamentals and some definitions. We continue by introducing the definition and concept of a formulation strategy.



Definition

Formulation strategies. A formulation strategy is a reason to combine measures into plans. It assumes we have determined a number of potential alternative measures for each planning objectives. Now we will have to both refine the measure (scales, increments, sizes, locations) and combine the refined measures into plans since the possible combinations are virtually infinite, we need to have guides for developing plans. These guides are called strategies.



- One opposite of a strategy is to look at every possible measure, get all possible data and then compare.

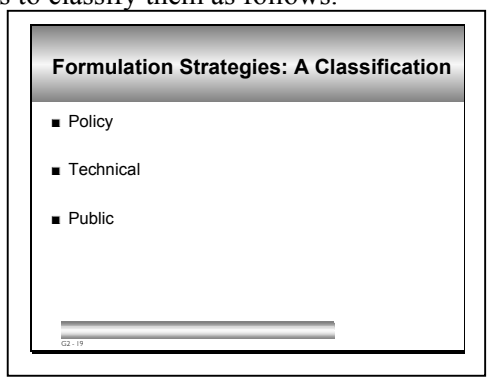
- At the opposite extreme, we might look at just one measure or plan and see if it is justified.

Neither of these "opposites" is proper planning. Unfortunately a consistent context or classification system for strategies has yet to be developed.

Best strategy

The best approach to plan formulation is to develop measures for each planning objective and assemble into compatible groups. Then assemble into packages that address all the objectives. Then evaluate.

A classification. Another way to address formulation strategies is to classify them as follows.



- Policy: certain named plans must be formulated. Specific studies may be controlled by enabling legislation (study authority or guidance in appropriation bills are examples). Policy refigures formulation of plans which will be judged by their contributions to NED, NER or both. As a practical matter, one of the most important policies is the professional standard. These standards, within the Corps, are engineering standards that pertain to reliability of the structure and its efficiency.

- Technical: There are several technical approaches to formulation. These are approaches that the formulation community with the planning community have relied upon

  1. Start small at the source of the "problem" and add measures or sizes/increments.

  2. Start with the most cost effective and add measures or increments.

  3. Try to be as comprehensive as possible in developing plans; then use screening criteria to get to a reasonable number of alternatives for more detailed analysis.

  4. Expand each measure to generate a lot of alternatives for each planning objective.

- Public: Public strategies formulating plans in response to input received from relevant publics. The techniques include asking people, especially community leaders; holding focus groups; holding initial public meetings to solicit views; working with Federal, state, and local resource agencies, etc. As information is collected and views become known, it is important to reflect this information in the plans that are formulated.

  1. Where there is serious conflict over the use of a natural resource, you might formulate a plan for each interest group. For example, formulate a plan for the farmers; then one for the proponents of flyways.

  2. Formulate plans to avoid or favor certain types of <u>measures</u>. For example, if the local sponsor really believes that clearing and snagging is all that is needed, formulate such a plan to confirm or contradict her belief.

3. Formulate plans to avoid certain effects, such as "no relocations" or "no loss of business during construction" or "don't block views of the river".

Discussion

Whatever classification system is used, the heart of formulation strategies is to create differentiated plans. Each "strategy" leads to a different plan. Each strategy responds to different public technical or policy objectives and constraints; and uses a specified method or methods (e.g., only non-structured measures). At least one strategy would have to have the criteria of maximizing NED (or NER) benefits and considering all potential combinations of measures and submeasures.

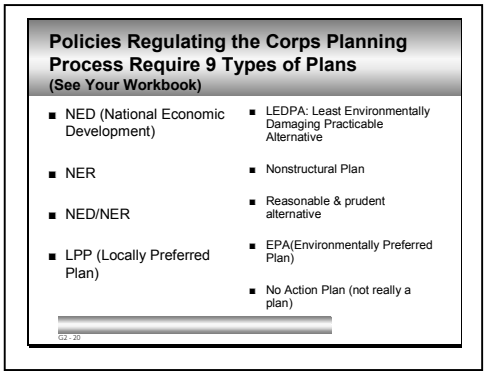
Illustration

The use of a highly differentiated multiple strategies would appear most useful in planning settings where stakeholders have strongly held views. Perhaps such stakeholders are willing to pay to any modifications outside the federal interest. Alternatively, a stakeholder may be "fighting mad" about a certain issue. For example, excluding a method ("concrete") as one strategy makes sense if a significant stakeholder objects to "concrete". Perhaps this approach will lead to the NED plan. If not, it will highlight the NED (and other) consequences of excluding concrete. The objective of planning is to inform decision makers. This should guide the number of strategies.

Named Plans

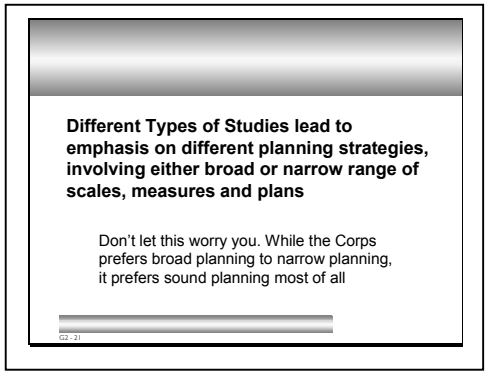
Policies Regulating the Corps Planning Process Require 9 Types of Plans

One example of policy driven formulation strategies is "named" plans. These are plans that you are required to formulate because of policy. Therefore, you must be aware of these plans, the source of the formulation requirement, and when you must formulate them.



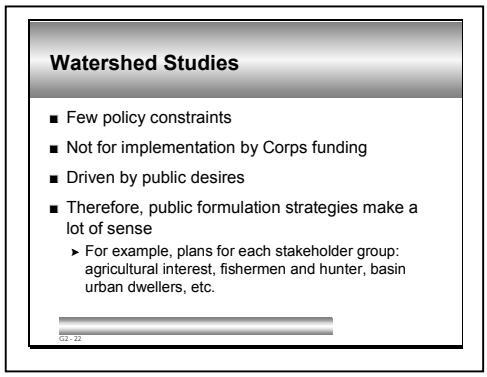
Different Breadths of Studies

Different types of studies lead to different strategies, involving different mixes of plans, measures, sizes and other scales. It is important to recognize these differences and why they exist. Hopefully, in your career, you will be lucky enough to formulate and see implemented several types of plans. Don't be frustrated by the fact that some seem more constrained than others. Breadth of planning is neither a virtue nor a curse; it is a reality that flows naturally from the planning process and the particular circumstances of individual studies.



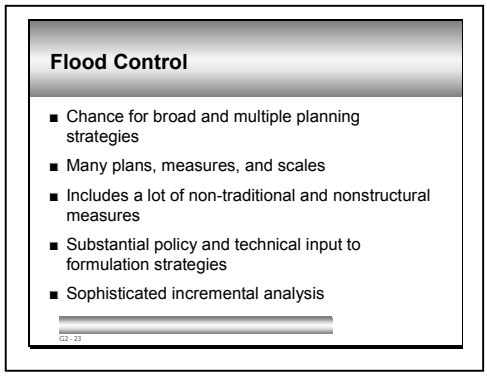
Watershed Studies

Watershed studies are close to pure planning studies. There may be no Federal interest in implementing plans coming out of watershed studies. Hence, there are fewer policy constraints. There are fewer named plans that you must consider and fewer that you cannot consider. Watershed planning studies are holistic looks at watersheds. Accordingly, measures and plans should be developed in an integrated, multi-agency, multi-jurisdictional framework to leverage the authorities and capabilities of all of the "players" in the watershed. There are fewer objectives you cannot convert into plans. Instead, you should focus on formulating what the public and partner agencies want. Expensive technical formulation strategies are also not needed; rather agency specific implementation studies can decide scale and other details.



Flood Control

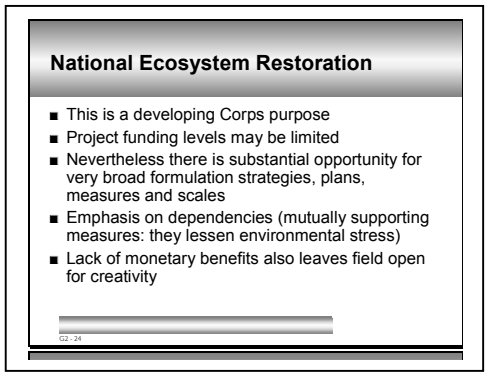
Flood control studies are also quite broad. Every flood plain is unique in terms of the physical problem and it s impact on human activities. However, the Federal government has been involved for a long time and non-Federal sponsors pay upfront) during construction) for a share of project costs. Hence, formulation strategies for these studies tend to be both broad and multiple, including all 3 types: policy, technical and public. Few alternative types of measurers are automatically screened out, even ones the Corps can't implement. Upland



zoning to minimize future hydrology changes, at least for larger basins, is usually not directly considered as a plan. However, most other measures are considered.

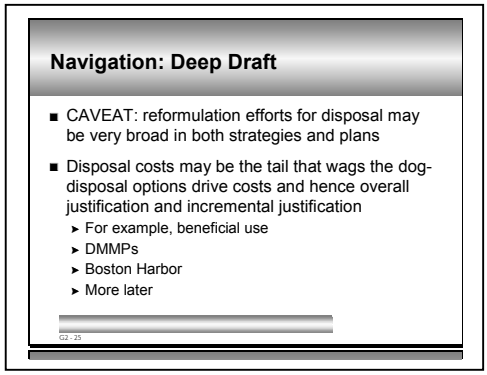
Flood control studies also consider scales and incremental planning at high levels of detail. Hence flood control studies tend to be both broad and detailed.

National Ecosystem Restoration



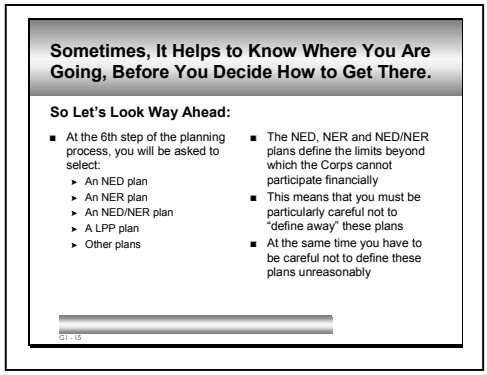
Ecosystem restoration studies are newer and involve nonmonetary outputs. Hence, the ground rules and "traditional practices" are not well established nor scrutinized as carefully on review. However, scrutiny and oversight can be expected to increase, as ecosystem restoration projects become a more significant part of the Corps' budget. Therefore, the strategies and plans are still broad as long as they accomplish a positive impact. Undoubtedly, as the Corps gains experience, the scope of some of these studies may narrow.

Navigation: Deep Draft



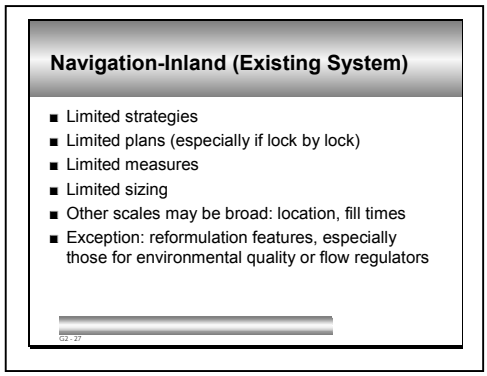
Deep draft navigation is very limited in terms of the formulation strategy and the measures we typically consider. The landside facilities, which the Corps does not contribute to financially, are much more costly than the channels that we do participate in financially. Hence, alternatives involving realignment of a harbor's landslide facilities are rarely considered. Therefore, the Corps' option is to provide a deeper channel (or a new one) or not. Everything else will be a size scale of the basic plan; either its width or depth will change, but not its location (at least not the terminus). Of course, in a large harbor study, plans will be made up of different channel deepening or widening so incremental analysis is very important.

There is one major caveat–possibly a case of the tail wagging the dog: once you have decided that a channel is a likely candidate for expansion, you may wind up doing a very broad sub-study of disposal alternative, unless a DMMP has been conducted separately. In a single study context, disposal is a reformulation effort. However, the cost impacts may be so great that it effects justification, scaling and incremental analysis. In that case, you cannot wait for reformulation to decide on a disposal area. In any event, the disposal options may themselves be very broad.



Navigation-Inland (existing system)

Finally, the inland system is not cost-shared up front by a local sponsor. The local share comes from a trust fund from fuel taxes; Congress, not industry, controls the use of that trust fund in financing waterway improvements. On the other hand, the alternatives that can be considered are limited in a single lock study. This is because the inland system is a system. This system is sized around 2 system constraints: (1) barge sizes and tow configurations and (2) environmental limits on controlling system depths. Neither of these 2 variables can be changed in a single lock study or even a study of a portion of the system.



We are not building new waterways and existing waterways are analyzed as systems. Hence the general sites are fixed by existing licks. There for lock replacements will be 360' (rare), 600' or 1200' by 105', but this really depends upon the specific circumstances of the waterway. For example, the largest single problem navigation problem on the Ohio River is the impact of closure of the main lock chamber for repairs at sites with 1200' main chambers and 600' auxiliary chambers. The auxiliary chambers are not sufficiently large to handle the traffic and delays due to congestion build up very rapidly. Controlling depth will be 9'. The formulation action is limited to location (cut-off or channel; upstream a bit or down), fill-times etc. Occasionally, formulation includes non-structural considerations to reduce delays, flow regulators to maintain channel depths and environmental features and activities.

Incremental Analysis

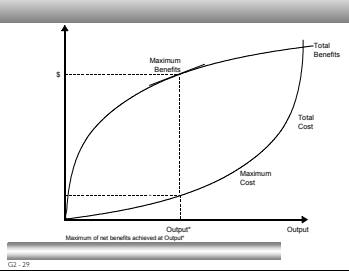
Incremental analysis is intended to maximize net benefits. Maximization of net benefits occurs when total benefits exceed total cost by the greatest amount. Maximization of net benefits also occurs where the incremental cost just equals the incremental benefits. These two different ways of approaching the optimum project are illustrated conceptually in the slides. The important point to remember is that they give exactly the same answer as to the appropriate project.

Airline Costs and Revenues

Route	Costs	Revenues	Profits
Capital City	$5M	$4M	-$1M
Metropolis	$10M	$15M	$5M
Gotham	$20M	$17M	-$3M
Center City	$2M	$2M	$0M
Amazonia	$6M	$7M	$1M

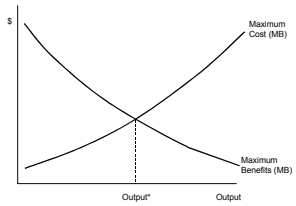
G2 - 28

Maximization of Net Benefits



G2 - 29

Maximization of Net Benefits



G2 - 30

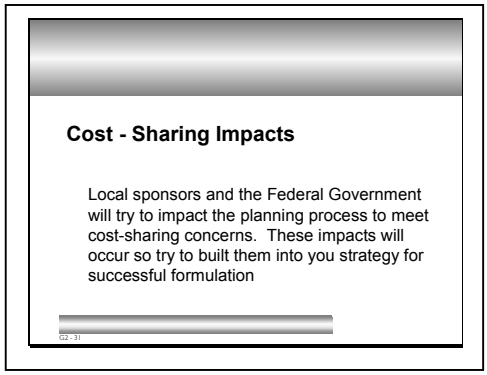
There is an additional term that we need to elaborate upon: incremental analysis, especially for flood control studies. Often this term is confused with scaling (size). Sizing itself means that a single measure in a location must be increased or decreased to provide different output levels; e.g. different levels of protection.

However, incremental analysis focuses on the best way to provide different protection levels. The distinction between sizing and incremental analysis becomes critical where there are large breaks in the cost-curve. This will occur, for example, when we find a major cost item like a bridge replacement. What we want is the best size measure up the to level of the bridge replacement (e.g., floodwall). Beyond that level, we need to consider alternative measures and plans; e.g., floodwall and detention basins; bypasses; siphons; or one-sided protection. This problem is very common.

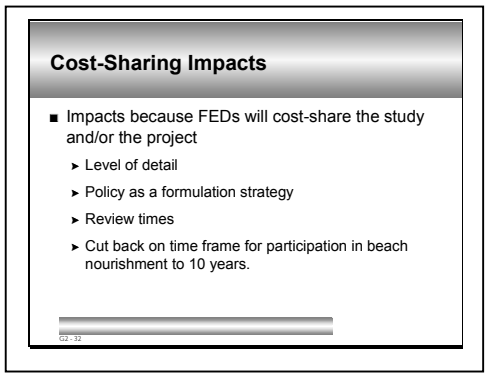
The two projects are Guadeloupe River, California and Moorefield, W. VA.

Cost Sharing Impacts

Before leaving this module, it is important to recognize explicitly what we have alluded to several times. Cost sharing does impact on formulation and formulation strategies. We often think that cost-avoidance strategies by locals are the major hindrance to sound planning. Your job is to formulate all the reasonable alternatives and not to limit the formulation to alternatives that avoid or limit non-Federal cost sharing or cater to the desires of specific interest groups.

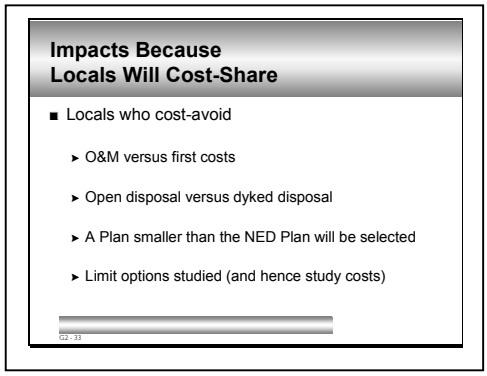


Consider the following. Prior to the 1980's the technology of choice for beach erosion was filled groins. Then beach nourishment rose in acceptance, being less intrusive to the natural sand transport system. Congress tried to encourage this "new" technology by putting nourishment costs on an equal cost-sharing footing with hardened structures. As hardened structures became a non-option, the Administration realized that nourishment projects were very popular, very expensive and involved long-term and large commitments from the Federal budget. Therefore, the administration limited recommendations for cost-shared nourishment to 10 years. Clearly cost-sharing impacted what projects the Federal Government would fund and for how long.



Other impacts flow form Federal cost-sharing: level of detail, review times, plan formulation policy, number of named plans' and evaluation criteria.

Therefore, it should not surprise us that local cost-sharing requirements also impact on our studies. Some sponsors use cost-avoidance strategies. For example, they favor capital (first-cost) intensive projects over maintenance intensive ones, where Federal cost-sharing is higher for the former (flood control) and visa versa (deep draft navigation). Another example: environmental proponents may not recognize or admit environmental enhancement, as opposed to mitigation because, the offending purpose pays for mitigation and the mitigation becomes an integral part of the project for that purpose. On the other hand, a non-Federal sponsor will have to pay for the non-Federal share of "enhancement." In fact, the term "enhancement" is rarely used because of the cost sharing implications.



Another example is to try to limit the candidate for NED plans by using "acceptability" criteria. Often, the contention is made that the local sponsor will only cost-share plan X. Hence, the plan X is the only

"acceptable" plan. Moreover, it is a waste of money to study any other plans. Since plan X is the only acceptable plan, it is also the NED plan. This approach is not technically sound. It misses the obvious fact that the Corps is not merely a planning consultant but a financial partner. The corps financial participation is limited to the national (NED, NER, NED/NER) plan. Thus the NED plan must be formulated. A plan is unacceptable and hence eliminated only if it violates "laws, regulations and public policies." However, acceptability may be a factor in plan selection and in deciding whether to carry a plan forward. As a practical matter, there is a great danger in allowing the sponsor to limit the options to one and only one plan: namely, if the BCR for that plan is not at least 1.0, then there is no viable project to serve as a basis for federal cost sharing.

As another example, the local sponsor may advocate a high cost disposal option in order to make Federal cost sharing for "beneficial uses" appear more attractive.

Not every local strategy is based on cost-avoidance between locals and the Fed. Some strategies are based upon gaining advantages over competitors. For example, Ports have agreed to, or even proposed, increased cost sharing believing that their projects would fair better in the competition for Federal funds under high cost-shares.

Impacts Because Locals Will Cost-Share

- Other local strategies
  - Upfront versus deferred payment
  - Multiple sponsor projects
  - Gain advantage over competitors (other ports or for federal dollars)

G2 - 34

These realities lead to a question that you as young planners should ask yourself. What is your role in the decision making process? Are you?

1. A broker between Washington and the locals
2. A protector of the Federal interest
3. A technical expert
4. Other
   - ❖ Provider of facts to decision-maker
   - ❖ Provider of facts to the public
   - ❖ Technical study coordinator
   - ❖ Report writer

Although You Are Relatively New to Formulation, Begin to Develop a View of Your Role. Are You…

- A facilitator (broker) between local needs and Washington rules (Federal interest).
- A protector of the Federal interest, at least for certain types of studies and projects
- A technical expert applying a set of rules and procedures to a specific locality
- Other
- All of the above?

G2 - 35

The answer may be "all of the above".

Review Questions

1. What is the "no action" alternative under NEPA?
2. How long is the without condition?
3. Name 5 items that are NOT included in project benefits and costs.
4. Name several items that are not out of pocket but are still part of project costs.
5. Distinguish measure, plan and program.
6. Distinguish scale (size) from increment.
7. Name 2 types of scale other than size.
8. What are the 2 purposes of a plan formulation strategy?
9. How many types of plans are required by Corps policy?
10. Why are some studies broader than others are?
11. What is environmental sustainability?

Section Summary and a Look Forward

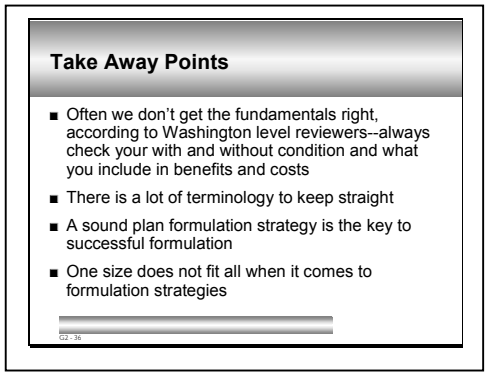
Section Summary

According to the Corps top Washington reviewer, Steve Cone, we often don't get the fundamentals right. Two common mistakes: misunderstanding the without project condition and not including the right items in annualized benefits and costs.

There is a lot of terminology to keep straight.

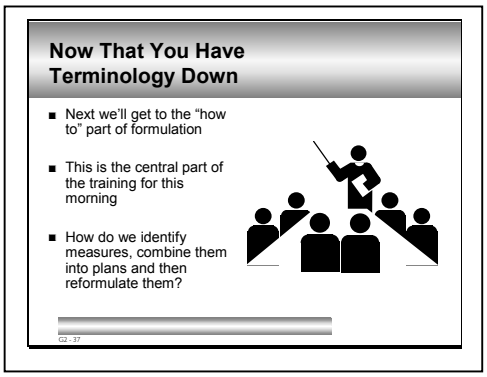
Sound formulation strategy is the key to successful formulation.

One size does not fit all when it comes to formulation strategies.



Look Forward

How do we identify measures, combine them into plans and then reformulate the plans?



References ad Suggestions for Further Reading

Maass, Arthur. 1951. Muddy Waters: The Army Engineers and the Nation's Rivers. Cambridge, MA: Harvard University Press.

Yoe, Charles and Kenneth Orth. Planning Manual Chapter 8. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. 1983. U.S. Water Resources Council.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will understand the term federal interest
2. Student will be able to participate in emerging dialogue about environmental sustainability
3. Student will be able to define the "no action alternative: under NEPA
4. Student will be able to apply the without plan concept to environmental issues
5. Student will be able to identify what is included in average annual costs and benefits
6. Student will be able to distinguish and define: measures, plans, programs, sizes, scales and increments
7. Students will be able to state succinctly what a plan formulation strategy is
8. Students will be able to classify formulation strategies into three types
9. Students will know the 9 types of plans, which are identified in steps 5/6 of the planning process

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Instructor Notes and Exercise:

This module has a lot of material. Much of it is definitional. Try to limit the amount of time spent on the presentation of definitions. Instead, use handouts to cover, for example, plans identified in steps 5/6 of the planning process. Your students already have a working definition of the NED, NER, NED/NER and LPP plans from Module G1. Most questions about these categories have to do with the consequences of categorization rather than the categories themselves.

Try to limit this module to 45 minutes. It is important to cover environmental sustainability. It is suggested that you provide a "status" handout. The material here is same preliminary terminology as of December 2001 and may need frequent revision as concepts, regulation to leaves are developed. It is important to cover the NEPA no-action alternative and its equivalence to the without project condition. Most students should grasp the concept easily. Then move quickly to average annual costs and benefits, perhaps using your own quiz to reinforce slides G2-9 and 10.

Definitions of measures, plans, programs, sizes, scales and increments should be relegated to a handout for future reference. Instead of going through a list of definitions, use the PowerPoint quiz (slides G2-14 and 15).

Definitions of measures, plans, programs, sizes, scales and increments should be relegated to a handout for future reference. Instead of going through a list of definitions, use the PowerPoint quiz (slides G2-14 and 15).

There are three concepts in this module that require emphasis and expansion. They are as follows:

1. Environmental sustainability
2. Generic plan formulation versus purpose specific studies
3. Cost-sharing perturbations

Slides G2-15 to 17 introduce the idea of a formulation strategy. We are primarily concerned with the definition and purposes of formulation strategies (slide G2-15) and in categorizations of them (slides G2-16 and 17). It is important to recognize that different formulation strategies lead to different plans. They direct our attention one way <u>and not another</u>. We will deal with formulation strategies throughout the course. You are building on the idea that the art of formulation involves what to analyze and consider further, in detail and what to ignore (slides G2-18 to 24). For example, planning normally won't address a plan, which is unacceptable to a financial partner. How do we explain coming up with plans our partners say they won't support?

Slides G2-31 to 34 give a partial answer to the above challenge: cost-sharing. We are not just planners. The Corps itself is a financial participant. Hence our policy driven formulation strategies carry great weight. When implementation financing is not involved, then we are less constrained. We need to give the student confidence that we recognize real world problems like these and are not mere theoreticians.

We end with food for thought on the roles of the formulator (Slide G2-36).

Slide G2-27
Exercise G2.1 Airline Profits
Not all of your students will be economists so spend some time with this concept. It is an important one and one that is often misunderstood. Begin by asking students to imagine they individually own an airline that services five cities as shown in the slide.

Slide G2-27
Their only goal in life is to make as much profit as possible. Ask them to use the data you provide to make their business as profitable as possible. Profits currently are $2M but could rise to $6M if they dropped those routes that do not pay their own way. Point out that each city must pay its own way or it drags the company's profitability down. This wastes resources in the process. Ask if any student would pay $700 for a $300 television. No one would. And neither would a company pay $20M for a product line that is worth $17M to them. That is a waste of resources. They should drop Capital City and Gotham from their service.

Ask if anyone disagrees with this solution, assuming we decide based solely on profit maximization. If anyone does, probe their reasons and convince them that they are wrong. Once you have agreement ask if there is going to be anyone in the world touched by their airline that disagrees with their decision. Someone should recognize that Capital City and Gotham customers would not like this decision. Once you get that point established ask what criteria they would base their position on if they were to argue to keep the routes at a public meeting.

The point here is they cannot use profit maximization. They can reject profit as a proper criterion. They can argue there are other important criteria too. But they cannot win this argument based on economic efficiency. It is a cut and dried decision based on economics. And if profit is the only criterion the owner is much better off with this decision even if some individuals in the land are not. Lead students to see that, to a great extent, whether this is a good deal or not is a matter of perspective.

Module G3: How to Identify Measures and Build Then into Plans

Student Learning Objectives

- The student will understand a general plan formulation approach
- The student will be able to identify the starting point for plan formulation
- The student will be able to identify the 3 major iterations of planning
  - identification of management measures
  - initial formulation
  - reformulation

G3 - 2

Student Learning Objectives

- The student will be able to list at least 5 practical ways to identify measures for any type of planning situation
- The student will be able to apply the 3 kinds of formulation strategies to a planning setting to generate an appropriate number of alternatives
- The student will be able to identify 3 ways by which plans or measures are narrowed from many to a few

G3 - 3

Student Learning Objectives

- The student should be able to give several example of reformulated plans
- The student will understand the advantages of formulating multiple plans even when the local sponsor has "decided" what it wants

G3 - 4

Formulation Approach

Three Major Iterations

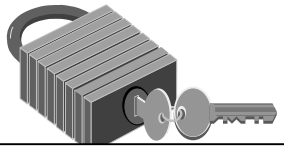
- Develop appropriate measures
- Combine measures into plans using a formulation strategy
- Reformulate plans

G3 - 5

Where Do I Start?

We know that we must start at the beginning with the planning objectives. Working collaboratively with the non-Federal sponsor and interested public to develop good planning objectives is essential for successful plan formulation.

Where Do I Start?



Determine Measures to Address Objectives

When we consider measures, we don't want to overlook a good alternative-no matter which objective we are focusing on and

How Do I Identify Management Measures

- There are several ways
- One of the most effective ones is to brainstorm with others
  - This builds team work
  - Helps to identify relevant measures
  - Brings together people with different backgrounds, skills and interests.
  - Can be done "in-District", "in-Corps" or "publicly"

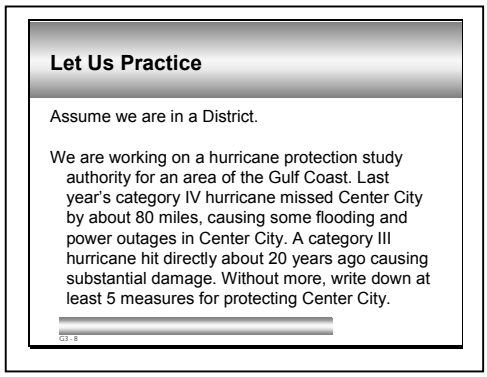
G3 - 7

in what sequence. So, how do we come up with alternative measures? There are several techniques, which are listed in the Planners Manual (see pages 132 - 143).

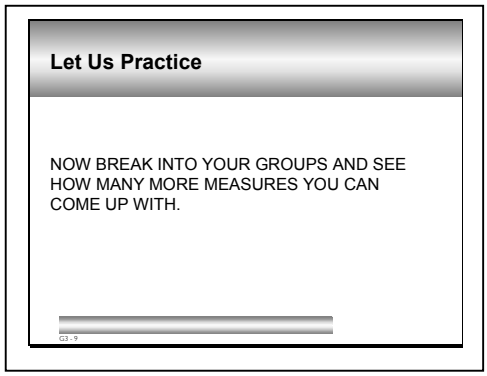
Brainstorming

Let us start with "brainstorming: this brings together members of the planning team within the District to list the possible measures to meet the planning objectives. Often this exercise is expanded to the local sponsor and/or others. Soliciting the ideas of the non-Federal sponsor, the resource agencies, and other interested parties through brainstorming is a great way to enhance the formulation process and build public confidence in the plan formulation process.

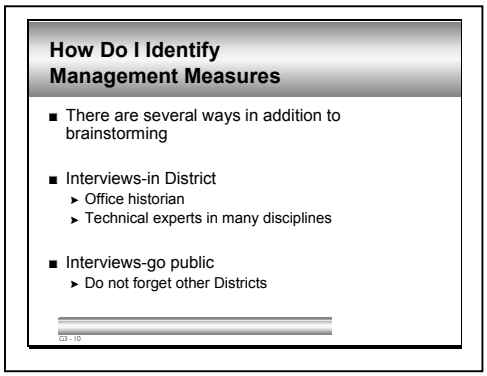
Assume we are at a district. We are working on a hurricane protection study authority for an area of the Gulf Coast. Last year's category IV hurricane missed Center City by about 80 miles, causing some flooding and power outages. A category III hit the City directly about 20 years ago causing substantial damage and two lost lives. Without more, write down at least 5 measures for protecting Center City.

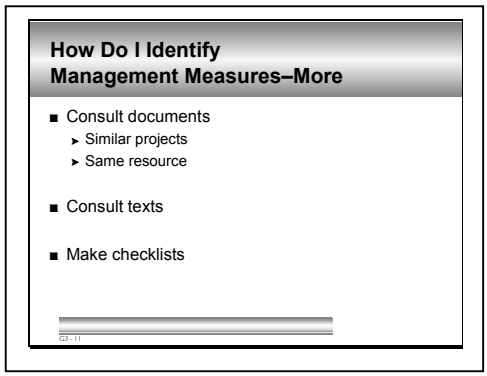


Now, try talking the problem over in a group with several people at work or in the classroom. Make sure you get an interdisciplinary take on the problems.



This may work better for non-coastal Districts than for coastal ones. The point is that people working alone will not do as well as people in a group. Here are some of the items people may come up with on their own: groin fields, seawalls. Jetties, offshore break water, beach nourishment, emergency evacuation (remember the "problem" is part nature, part human), permanent evacuation, and being dropped from flood insurance program. One's that require some discussion are: building codes, zoning codes, sand bypasses, nonstructural raising, beneficial use projects form nearby dredging, removal of jetties or other interference with littoral drift.





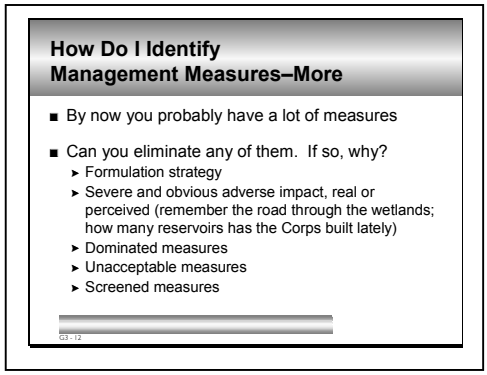
Other Techniques Include:

a. Interview people who are knowledgeable or interested. Examples include the office "historian"; various technical specialists; members of the public; people who have worked on similar projects; and people who have worked the same area (resource) from a different perspective (your permits people or your operations people, for example). And don't forget your sister districts.

b. Consult documents. Consider documents on similar problems or documents on the same area but from a different perspective (an EPA water quality report for example or a state water supply study).

c. Consult existing checklists or make your own.

One caveat: it is often assumed that Corps planners will have a hard time coming up with measures. Often, we will miss measures. However, if the techniques above are used, it is doubtful that there will be many measures we don't "think of."



Screen Out Measures that Don't Appear Promising

The critical issues usually are more troublesome. Are there any measures we need to drop? How are measures or plans narrowed from many to few? Possible combinations may run into the thousands for larger projects.

For NED/NER Candidate Plans

1. There is a preliminary question: why don't we just evaluate all impacts of all plans to a comparable, high level of detail?

2. The possible combinations of measure, scales and increments may run into the thousands for larger projects. For example, 5 measures, 7 scales and three locations yield 4410 combinations.

3. Few people can make sense out of that many combinations. Hence informed choice–the heart of planning–becomes less likely. It becomes too difficult to sort through all the information. This is the "level of detail" issue.

4. How do we reduce the number of alternatives to a comprehensible number? In a general sense we use the 4 selection criteria of the Principles and Guidelines as screening criteria. The four are acceptability, completeness, effectiveness, and efficiency. More specifically, the following are guides-not absolutes.

5. Efficiency and dominance. Cost-based screening and simplified cost estimates for construction will get you a long way. If two plans or measures do the same thing, but one does it more cheaply, the least costly is the most efficient or cost-effective. If two measures cost the same but one measure is better than another in 3 locations and the next 5 locations are similar, then the first measure is probably dominant over the other in that planning setting because it provides greater output for the same cost. Hence developing scales for the dominated measure may be counter productive.

   - Adverse impact screening. Measures which have significant negative impacts on objectives recognized as in the Federal interest, should be screened out of further consideration.

     - These impacts may be social; for example, disruption of business, dividing a neighborhood into two; destroying a local park. Such impacts are not consistent with Federal executive orders.

     - Other adverse impacts may be environmental. You may screen out plans with significant adverse environmental problems. This decision is especially

appropriate where (1) mitigation appears difficult and (2) other, non-environmentally adverse alternatives appear feasible.

  - A particularly good use of screening by adverse environmental impact is where the measure if for NER. This is because current guidance states that mitigation is normally not appropriate for NER plans (caution: this admonition may not be reflected in actual studies.)

- Environmental sustainability screening. Assuming the estuary or riverine resource is under stress, measures which exacerbate the problem are candidates for being out early. This is a special case of adverse impact screening. It is "special" because of the Corps adoption of environmental sustainability as a corporate goal.

- Percent of potential benefits screening. Marginal benefits tend to decrease with project size while marginal costs tend to increase. Stated another way, total costs tend to increase faster than total benefits as the percent of possible benefits approaches 90 to 100 percent. This is especially true for flood damage reduction and harbor transportation benefits.

- Focus on one evaluation criteria like existing damages for flood control.

- Apply a sequential formulation strategy to eliminate some projects by considering them late in the process. This is "avoidance" as used in NEPA. See *Volpe vs. Overton Park* for the courts handling of such criteria.

- Triviality (an application of the effectiveness rule, often aided by Corps technical expertise): plans that do little to meet the planning objective(s) may be trivial; ten year flood protection for example.

- Use a combination of screening criteria.

For LPP Plans

The prior section dealt with attempts to identify a NED or NER plan. How about a LPP? There are three scenarios. First a LPP may turn into a NED/NER plan; the prior paragraphs apply. Second, if it is clear that something other than the NED/NER plan is locally desired, then the screening criteria has to be developed on a case-by-case, based on the goals of the local sponsor. Screening criteria for LPP's can be very specific. Examples from actual studies (caution: none of the following are appropriate for screening a NED or NER measure or plan.)

1. As much damage reduction as we can get for $X. Screen based on $X.

2. We need a project depth of 50 feet. Screen out–for LPP purposes–any depth over 50 feet.

3. We want 100-year protection for the whole flood control district at the least possible cost. Screen on costs (but don't forget to define what "100-year" means to sponsor).

4. We want no less than 45-foot depth in the main channel. Screen–for LPP–at 50-year level for main channel, but consider other depths for the side channels.

Third, sometimes the local sponsor knows in detail what it wants. The plan and its measures should not be screened. The plan should be evaluated and carried through to the final array of alternatives. Since such an LPP is very likely to be the project built, it should be evaluated at a high level of detail–especially the costs.

Application of Screening Criteria

This application is based on highway planning–just to keep our analysis generic and outside the water resource field. We could just as easily make this problem three-diversion alignments for flood control or three-channel routes for harbors, or a bridge relocation.

Since screening is crucial to formulation, let us learn by doing. Then we will come back to theory and lecture.

Consider the Following Planning Setting

You are the state DOT. South Cross has a problem. Transportation delays from one end of town to the Freeway now exceed your criteria. The current road runs west through the town and its business district. The business men do not want the road torn up, They derive a lot of business from the flow through traffic. Commuters and citizen object to sitting in traffic. South Cross is bordered on the north by a state park valued by residents of the tri-county area for is trees and tranquility. The area to the south is swampy with weak soils. The State Natural Resources Dept. has indicated that the area has strong wetland value and supports 2 rare and endangered species.

G3 - 13

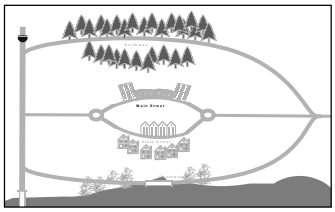
How Would You Approach This Problem?

- First you might try to refine the problem, but let's skip that.
  - Assume the objective is to reduce congestion through the town
  - Assume congestion is currently beyond state congestion standards
  - Assume you have several measures in mind for each route
- One way to screen: look at measures for the existing, north or south routes
- What additional data will you need
- Once you have a route, what do you do next

G3 - 14

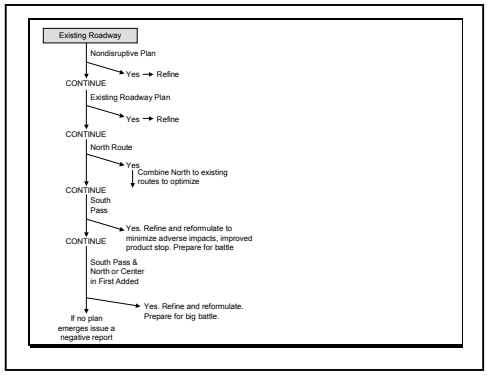
Try the exercise in Slides G3-15 and 16 on your own. It is even better if you have a Corps teammate-preferably an expert in a different discipline. How would you approach the problem? Let us assume that we are at the first iteration, so we know the without condition (no action alternative): more and "unacceptable" delays through the "town route".

Map



G3 - 15

We also know about the planning objectives, which are the start of the formulation process. We would probably want to refine these objectives in the real world-by asking more "why" questions but let us skip that for now.



There is no one right answer, of course, but there is enough to enliven class discussion. The problem is purposely vague on just how bad the traffic delay problem is and how much each measure might contribute to solving the problem. Time permitting, assign the students to interdisciplinary teams.

One screening approach is to minimize EQ harm first. Therefore, start with the existing route. Shop owners don't want traffic diverted, but they don't want their businesses disrupted either. Commuters just want to "get there". Your agency has standards for determining acceptable delays. (Note: Such standards are rarely absolutes but are guidelines) Measures can be broad: how about decreasing demand, smart roadways, one way traffic during commute hours, involving secondary streets. Bottom up planning is called for. Perhaps traffic signals, turning lanes, HOV (heavily occupied vehicle) lanes, or some form of mass transit (buses) might get the job done.

There will then be a second phase of the approach, which starts from the proposition that the "small" and relatively non-disruptive plans are either ineffective or too risky and uncertain. The second phase is to consider widening the existing roadway. You want to know whether the roadway can be widened without taking out a portion of the downtown business area. Severe impacts on downtown buildings would probably involve a constraint because of project cost considerations and adverse social impacts.

The third phase would be to consider North options with and without existing roadway options. The South route would be considered only as a last resort (See attached flow diagram).

A second screening approach would be to constrain out the South route but consider "all possible" combinations of the North and existing routes to a screening level of detail. We would then refine and reformulate in the North, to retain or enhance aesthetic and tranquility values (parkway, not a highway, for example). Screening criteria might include: cost per mile of road (or number of cars); delay times; social disruption; and environmental impacts.

A third screening approach would be to consider all three routes equally and lay out in a fair level of detail the impacts of options both invasive and non-invasive.

Before deciding on a screening approach, make sure the class discusses pros and cons of their approach. The first approach starts from the premise that the agency will try to do everything it can to accommodate all concerns. After that it moves sequentially to avoid environmental harm. The cons are: this approach may take longer and may miss some options.

The third approach has a ring of value-neutrality, which is often important for the plan formulator's credibility. Cons are: the level of detail may be high and expensive. The resultant project, especially if the South route is included, may be unacceptable.

The second approach is a compromise. Clearly the environmental values are not as clear-cut, so "pre-judging"-having a preference for the existing route may not be appropriate. Cons are: you may have unnecessarily created a conflict where there is none: after all, if the existing route can handle the increased flows non-invasively, why get into a trade-off situation?

Of course you don't have enough baseline information. However, you have enough information to develop a tentative approach. You could have decided to look first at the existing roadway and consider

with non-invasive options to minimize delays; e.g. HOV lanes, one-way traffic, improved turn lanes, "smart" roads, and so forth. Then consider other North route options. Only as a last resort, consider South options, because of environmental harm and likely high costs of building in a swamp.

This approach will drive your data collection for the with condition. Most important is the level of delay and the impact of existing route plans on delays. When you select a route, you want to refine it in two directions: minimize adverse consequences and improve efficiency along the route. Finally, if it occurred to you to reiterate at least once to make sure that any north or south route could be combined with a non-invasive existing route, you are on the right track.

You might have decided to come up with all alternatives on all routes (or just on the North and existing routes). While more expensive and more likely to raise conflicts, this approach signals a high level of agency impartiality. In this case, your data needs magnify substantially.

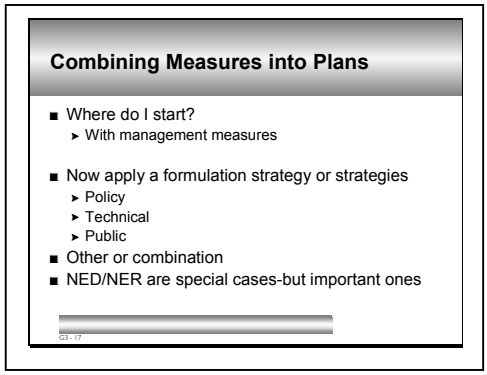
At this point, it is sufficient that you begin to understand the importance of a screening approach.

What can we learn from this exercise? First, the starting point for formulation is the planning objectives and constraints. Undoubtedly our task would have been easier if we had a better idea of the intensity and specificity of the different stakeholder beliefs. But this information is generally not known at the beginning of a study and usually evolves throughout the study as measures and plans are developed. Second, the boundary of formulation is evaluation. In other words, we could only get so far with formulation before we needed an idea of the magnitude of the difference between the without and the with condition. Within these limits, however, we really got quite far with several systematic approaches to screening. These approaches drove not only the formulation sequence but the data collection (for evaluation) sequence as well.

The first approach starting with a list of all possible measures to solve "the problem" of traffic delays but chose not to pursue some of them. Instead, for perfectly sound reasons, it began with the existing route. Notice that this approach has some value judgments embedded in it. Environmental values were important and the values of local businessmen were also important. The potential for short-term fixes is implied. In the second approach, wetland values dominate and alternatives being considered are limits to those that avoid impacting the wetlands. This approach may show a preference for environmental sustainability but not for aeshethics nor business disruption. Obviously, an approach which needs all planning objectives and constraints is preferable, ceteris paribus, to one which does not. In the third approach, the agency value and penchant for solving "the problem" dominates (the best way to eliminate traffic delays).

Approach number one seeks to accommodate all interests-but perhaps only for a short period of time. Only after failure to do that, does it envision more intrusive measures for businesses and ultimately for the wetland environment considered in the plan formulation process.

Combine the Remaining Measures into Plans



- Formulation strategies - general
- Formulation strategies - types

Formulation of alternative plans is the fourth major iteration of the plan formulation approach. It starts with the planning measures. Group the measures for a single objective; then go to other objectives; then combine the two. The objective-by-objective approach simplifies the formulation of alternative plans. It is the single best strategy for formulating.

Next apply a specific screening approach. A screening approach is a reason for combining two or more measures into an alternative plan. There are:

1. Policy
2. Technical
3. Public

Policy as a Basis for Combining Measures into Plans

Policy refers to formulation strategies that must be considered in all planning studies. For example, under Corps guidance, a LEDPA plan must be formulated in every flood control study; it does not have to be carried through to the final array, however. This means it can be eliminated based on a lesser level of detail than (say) a candidate NER Plan. A candidate NER Plan is one that shows the promise of becoming the NER plan or the base for the NER plan.

Likewise, the locally preferred plan (LPP), if there is one, must be formulated. There usually is one because the local sponsor usually has an opinion about the best alternative. The locally preferred plan does not have to be carried through to the final array. However, if the local sponsor feels strongly about the plan, it usually is carried through to the final array. One way to carry it through is to simply evaluate the given plan to an appropriate level of detail. More likely, however, the plan is incomplete or vague; and can be enhanced by reformulation. Often the locally preferred plan will have positive measures which can be combined with measures of other plans to derive plans more in conformance with Federal criteria and/or more in conformance with the planning objectives of the local sponsor.

Not all policy related plans need to be candidates for implementation. An NED or NER plan must be formulated, even if it is unlikely to be implemented. This is to set the reference point for Federal cost sharing. For example, single purpose alternative for a given NED or NER purpose must be formulated if the SCRB (separable costs/remaining benefits) is going be used for cost allocation of multiple purpose projects. No one expects this plan to be implemented and it is not in the final array; its costs must be to a sufficient level of detail to support the cost allocation.

Several plans must be formulated to satisfy environmental constraints. For example, the Endangered Species Act requires the formulation of an Environmentally Sensitive Plan (ESA) that avoids and or provides for impacts on protected species habitat. NEPA requires the formulation of a Least Environmentally Damaging Preferred Alternative (LEDPA), which requires a plan that accomplishes the agency (Corps) purpose in the least environmentally damaging manner. Neither of these plans needs to be in the final array.

There is another type of "policy" that impacts Corps formulation efforts. This involved Corps agency "biases" or "ethics." The two most important are: (1) safety and (2) efficiency. The Corps, as an engineering organization, is very mindful of public safety and strives to build safe, reliable projects. Likewise, efficiency is a strongly held engineering value; the engineer readily accepts that the client is entitled to whatever product she wants, but wants that product, no matter how luxurious, to be delivered at least cost.

Technical Formulation Strategies

Technical formulation strategies are strategies of technical experts in formulation, within the water resources framework and outside it that use technical criteria for combining measures into plans. There are three strategies

1. Start small, usually at the problem source or at the problem location and add measures or increments (scales) of measures.

2. Start with the most cost effective plan using a proxy for benefits. For example, least cost method of producing NER outputs. Or use existing traffic flows divided by project costs to find a likely base plan to build upon. Once you have a non-trivial cost effective plan, add measures or increments of measures to get alternatives

3. Make every possible combination. IWR PLAN is an example of a tool for making comparisons of all combinations. It uses the strategies of cost effectiveness, production efficiency and user preferences to reduce the set of all possible combinations to a reasonable set. The problem with this type of approach is finding criteria to screen plans so that you don't have to carry a large number to the final array.

Public Formulation Strategies

Public formulation strategies are strategies for developing the plans based on the input from affected publics. These are determined by public involvement strategies, both formal and informal. It is particularly important to use this approach once you have used other strategies to come to a tentative final array of alternatives, but before making a final decision. Often the public screening approach will involve actual measures, but more frequently it will involve effects to be avoided or attained. For example, in virtually every flood control study, the public will be opposed to relocations. In virtually every navigation study, tow operators will want a "straight" approach to the lock. Businesses will worry about disruptions caused by construction and/or operation of a project.

Implication

Whatever approach or strategies are used, you are headed toward a final array of alternative to be evaluated at a high level of detail. There are two important implications:

1. You need to recognize that you have eliminated many possible plans based upon assumptions or data with a low level of detail based on screening criteria or preliminary evaluation. This is appropriate, however, a problem will occur if you or someone else later compares the low level of detail to the high level. Here is an example: You eliminate channels versus levees based upon a rough estimate of construction cost. You then go to a higher level of detail, included refined construction costs, interest during construction and land costs. When challenged about why there are not channels in the final array, you respond: "They cost too much?" Challenged to prove that, you pull out the old data, which shows a low cost for levees, which get compared to today's more complete, detailed and higher costs for channels. Be prepared to do two things. First, explain the concept of screening. Second, if the implication is that the original cost comparison was skewed, you may in fact have to estimate channel costs again.

2. Analyzing the final array of plans is expensive, especially if the plans are truly different. Therefore, you want the array of alternatives to be as well defined and focused as possible. On the other hand you do not want to leave any viable plans off the table. This is why your focus should be more on plans right now then on scale. Scale may be changed during reformulation, usually-but not always-without a great increase in cost.

Implications for Incremental Analysis for NED

While general planning strategies are valuable, many of the Corps studies efforts wind up recommending and later constructing the NED plan. Hence, the policy approach to incremental analysis must be emphasizing. The planner must diligently search for the reasonable NED plan in all studies except NER studies. Further, he must insure that he has no unjustified increments. This means that the item must be justified in first, intermediate or last added position; stated another way, net benefits must be maximized with the measure in.

What is the best (NED) plan? It is A, B, and C together. Benefits are maximized at 53.

Let's go to another level of NED analysis. Suppose the first increment-measures B-can be "scaled" such that:

Net Benefits: A Concept

	Net Benefits		
	1st Added Position	2nd Added Position	3rd Added Position
Measure A	20	10	5
Measure B	40	-20	-5
Measure C	15	+8	-10

G3 - 18

Assuming measure B, size 2 can be functionally, combined with measures A and C as before. What is the NED plan and the net benefits: It is A and B (size 2) and C; net benefit are 63. This might occur where measure A has a "cost break." For example, a flood channel measures requires a bridge removal at size 3, but two upstream detention channels can be built inexpensively.

Similarly, what if measures A and C can also be scaled or modified to produce a better NED size. Assuming combinability, they should be.

Net Benefits: For Different Scales of Measure B (prior slide)

	Scale	Net Benefits	
	Size 1	35	
	Size 2	50	
	Size 3	40	

G3 - 19

Now, assume that the size of measure B, affects the NED performance of A and C in second and last position.

Notice that in this case B-2 preempts effectiveness of A and C. This can occur when B is not large enough to create opportunities for A and C to capture benefits which only lack in when a high level of output is reached. Example from real world: Flood control falls short of level needed to reduce flood insurance premiums/flood proofing costs. Another, main channel is not deep enough to make scale channels viable.

What are not benefits? Answer is 50. So what is NED plan: B-3 plus A and C. Why? Because net benefits of 53 exceed net benefits of 50.

Net Benefits: Changing Scale Can Change Incremental Analysis

	Net Benefits		
	1st Added Position	2nd Added Position	3rd Added Position
Measure A	20	-2	-5
Measure B-2	50	-20	-5
Measure C	15	-2	-20

G3 - 20

So incremental analysis, while helpful in the pursuit of the NED plan must be supplemented by scale and location variations, ceteris paribus (all other things equal).

Evaluate

Now we have identified measures and combined them into plans. It is crucial that you evaluate at this point. Unavoidably, planning is an iterative, interactive process. Do any of these plans make sense or did we run into a wall?

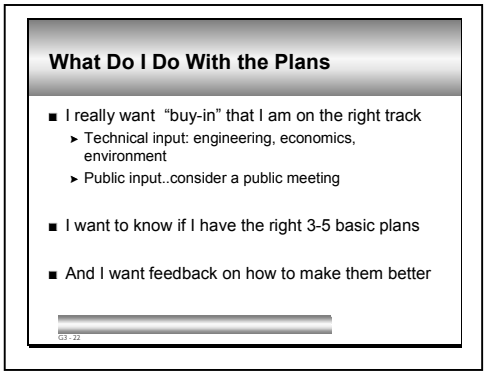
Part of the answer is technical evaluation. Engineers, economists and environmentalists on staff or outside will evaluate the plans to determine this. We are now talking about a fair level of detail, because we are headed toward the final array of plans from which the local sponsor and Federal Government will choose.

What Do I Do With the Plans

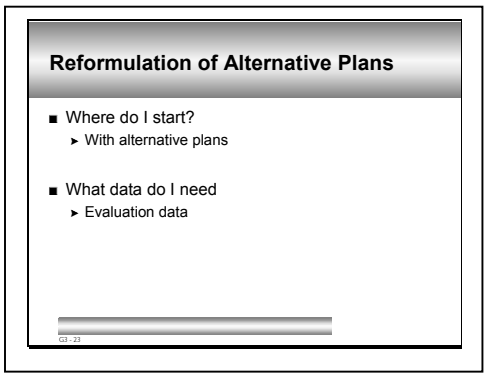
- Evaluate them first
  - Begin with screening criteria
    - For first round, the 4 reformulation criteria will help
- Then, "go public"
  - Of course, you have been coordinating all along
  - But now, make sure you have touched base with everyone who has an interest or stake
    - Did I miss something important impact or concern
    - Is there a plan out there I missed
  - I am not asking publics to pick a plan-yet
  - I want to know if I can make the plans I have better

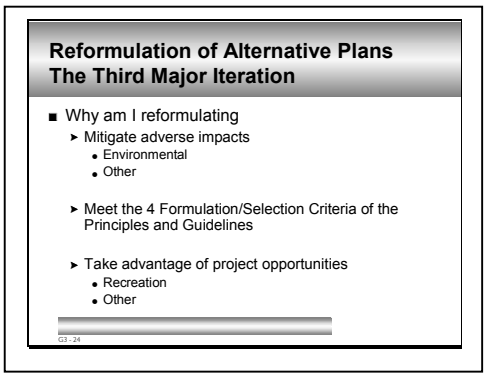
G3 - 21

Part of the answer is public. This is why now is a good time to broaden your public coordination and involvement efforts.



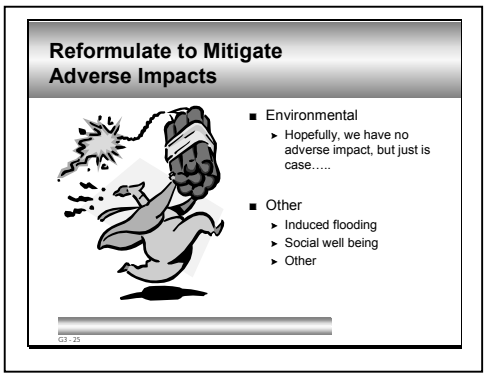
Reformulate





Once we are pretty sure we have a good set of plans, we want to reformulate them to make them better.

More specifically we want to:



1. Avoid any adverse impacts of the project.
    a. This may involve rerouting or relocation
    b. This may involve an "addition" to the project
        i. Caution: Some Corps planners refer to this as mitigation.
        ii. This type of mitigation should not be confused with environmental mitigation.

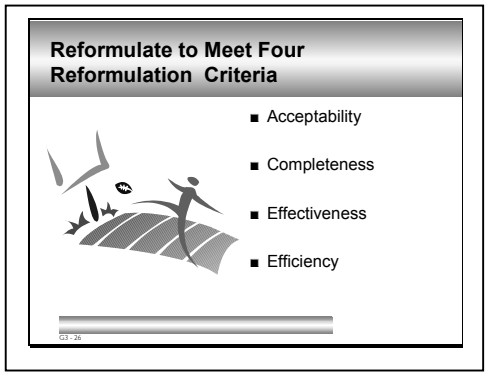
1. It is good practice to build avoidance criteria into planning objective.

2. Hopefully, environmental mitigation will therefore be minimal but, if large, this will be a very conscious decision at the screening approach step.

iii. Examples of mitigation found in actual projects are measures for addressing induce upstream and downstream flood impacts; measures to pay above market prices in relocation situation; impact payments to local jurisdictions

1. The common thread is to take some of the benefits gained and use it to assure that one group does not pay a disproportionate amount.

2. Reformulation criteria. The idea is to improve plan performance against one of the four reformulation criteria. This is a good time to present these criteria and what they mean.



a. Acceptability. Where Federal interest is involved, the mere fact that a local sponsor refuses to fund a project (or says she won't) does NOT make it unacceptable (see G1). In other words, such a plan may be the NED or NER plan.

i. On the other hand, if the locals have objections to the plan or measures that make sense in terms of Corp criteria, like adverse impacts on a central business district, then further formulation to minimize such impact

1. Can and should occur; and

2. Can and should be incorporated into the "reasonable" NED plan.

ii. It is also possible that the local sponsor has a value-based difference. For example, the local sponsor has a state law prohibiting high dams and has repeatedly turned down proposals for them. They have gotten a study resolution telling the Corps to study alternative to reservoirs. Can we eliminate reservoirs from consideration as an NED plan? Yes, obviously.

iii. How about easing the local political burden of the project by providing a common level of protection? Generally, this does not eliminate multiple levels of protection. AS usual, there are caveats: where uneven levels of protection cause induced flooding, the plan may not be reasonable; in non-structural flood control, a zone approach to evacuation may make sense if it decreases city costs and open space is among the perceived benefits.

b. Completeness. This usually means including all actions necessary to implement the chosen plan. As we get into NER planning, we will have problems with this criterion, because of the uncertainty of some of the measures and their impact on the restored, natural environment.

c. Efficiency means

i. There is no less expensive way to provide the same outputs

ii. This is a major consideration when the plan outputs are expressed in nonmonetary terms

iii. It also helps us "screen" on costs, without detailed benefit calculations

iv. CAVEAT: efficiency does not mean a plan is justified. It merely says that, among 2 or more plans, all producing the same output (acres of wetland, for example or habitat evaluation units) that one is cheaper than the other

v. The efficiency criteria should be expanded to encompass the following: overall efficiency is obtained where output per dollar for each measure is equal. If one measure produces more output per dollar than another, efficiency can be improved by adding dollars to the first and taking away from the second until the last dollar spent on each produces the same benefit.

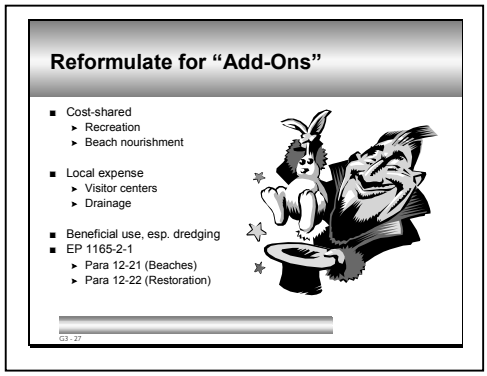
d. Effectiveness means two things

i. That the contribution to the planning objective is substantial and not trivial, especially where safety issue are involved (flood and hurricane measures)

ii. Net benefits are maximized. It should be noted that in theory this project is efficient and optimally sized. In other words, if (1) all outputs could be monetized and (2) all monetizations were comparable and (3) there were no external effects, then this would be a very dominant criterion. Because all three of these conditions will not likely occur at the same time, this criteria has to be tempered by the other reformulation criteria and the other, more useful meaning of effectiveness.

3. "Add-ons." Reformulation is a good time for project add-ons.

a. Is there a beneficial use? If so, deal now with the difficulties of "timing" and bidding packages. Often the beneficial use cannot accept the product when the project is ready to deliver it; storage may be a problem, e.g., sand from dredging. Similarly, there will be problems of how to bid the job. Consider the use of sand from a dredging project to be used as beach nourishment; the local sponsor for the beach must pay for half of the incremental cost of the beneficial use over and above the "normal" dredging cost of the channel. Should the bid package be bid in the alternative or as options or should the sponsor pay a preset percentage of the overall job including deposition on (or near) the beach? The latter is preferred, for simplicity, but it has been done all three ways.



b. Some add-ons may be Corps cost-shared.

   i. Recreation added on to flood control for example

   ii. Beach nourishment for sand from a navigation channel

c. Some add-ons may create an opportunity for locals to meet their water related planning objectives at a low cost. Amphitheaters, parks and visitor centers have been added to flood control and navigation projects, for example. Of course, locals must pay for any added cost.

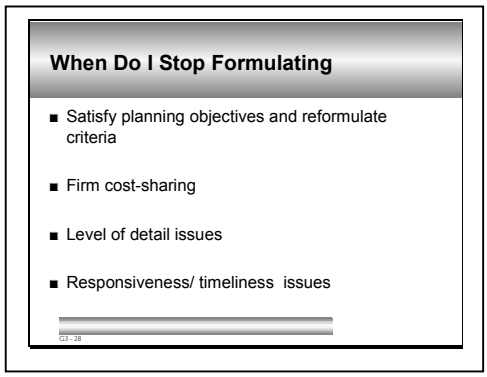
Some of our most effective planning occurs in reformulation. Often level-of-detail issues are less important, especially for add-ons.

What we are driving toward is that the local's "pick a plan," based upon proper cost sharing, that meets Federal criteria for budgeting.

Lock Haven, PA (amphitheater); Dismal Swamp, VA (tourist center); Passaic Stream bank Erosion, NJ (park). The bid package problem arose on Norfolk Deepening (Virginia); New York Anchorages; and New York Harbor main ship channel. One example of induced flooding is Wyoming Valley. Raising existing levees led to downstream effects. However the effects were not quantifiable enough to justify high levels of protection. In fact, high levels of protection in the mitigation areas would have resulted in a negative overall project. The District instead formulated lesser level projects in the mitigation area designed to roughly mitigate for induced flooding. These resulted in high costs and low benefit to cost ratios. The Secretary of the Army's Office approved the concept of mitigation, but proposed a more direct and far less expensive approach. Each impacted community (above a certain threshold) would be allocated funds to use for flood fighting measures of their choosing. This required a change in the law.

The Major Iterations of Planning

When is formulation over? The iterative nature of planning sometimes leads the public and even our Corps teammates to ask why planning takes "too long". This course in formulation provides some guidelines on when you should end formulation. There are several views:



1. Whenever we cannot improve significantly on our four-reformulation criteria in meeting planning objectives and constraints.

2. Whenever the local sponsor agrees to pay for everything above the Corps' determined Federal interest contribution.

3. Whenever we have enough level of detail to satisfy ourselves what we have done a good, professional job.

4. Whenever we have enough level of detail to satisfy our sponsor, other agencies and Corps policy reviewers.

None of these involves a specific time limit. However, timeliness issues are real. They stem from:

1. Policy (e.g., Recon studies)
2. Budget rules
3. Commitments to local sponsor, Congress or others

One solace is that planning can be done in any time frame per the Planning Manual. As a rule of thumb, you should be able, given a good set of planning objectives and the without condition, to generate a draft report and EIS in 9 months, of course the overall study effort, per budget guidances in 3-4 years, but a good bit of that is in obtaining planning objectives, collecting baseline data and reviews prior to the division commander's notice.

Review Questions

1. What is the starting point for plan formulation?

2. Name the 3 kinds of formulation strategies and give an example of each.

3. Name at least 5 practical ways to identify measures for any type of planning situation.

4. Name 3 ways to eliminate measures or plans without detailed evaluation.

5. What must come after initial formulation of plans and before reformulation?

6. Give at least 3 purposes for reformulating plans; give an example of each.

7. Why might the project sponsor object to reformulating for "add-ons"?

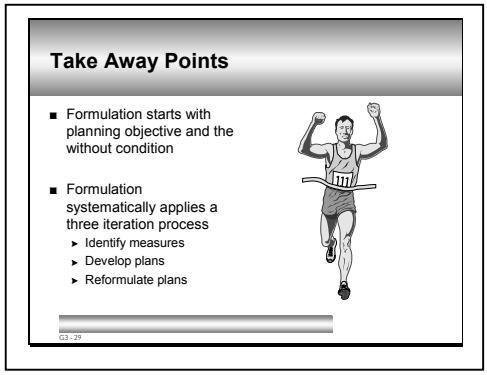
8. Measure A for wetland restoration creates 5 acres of habitat for $100,000. Measure B creates 10 acres for $150,000. Habitat values per acre are the same. We have about $250,000 to spend. What should we do?

9. When should I stop changing the project in question 8?

10. When should formulation end in theory and in practice?

Section Summary and a Look Forward

Section Summary

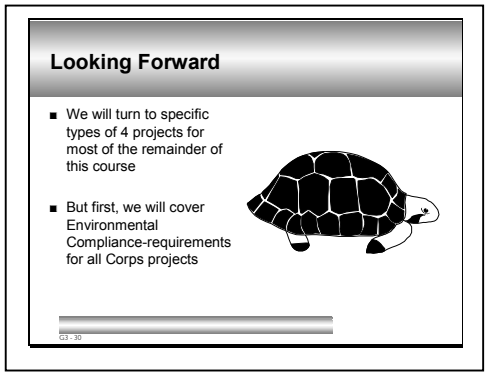


Formulation starts with planning objective, the without condition and a strategy.

Formulation systematically applies three major iterations

- Identify measures
- Develop plans
- Reformulate plans

Look Forward



We will turn to specific types of projects for most of the remainder of this course.

We will apply the general principles we have learned so far to specific types of projects.

But first, we will cover Environmental Compliance requirements for all Corps projects.

References and Suggestions for Further Reading

Yoe, Charles and Kenneth Orth. Planning Manual Chapter 8. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Principles and Guidelines.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will understand a general plan formulation approach
2. Student will be able to identify the starting point for plan formulation
3. Student will be able to identify the three major iterations of planning
    a. Identification of management measures
    b. Initial formulation
    c. Reformulation
4. Student will be able to list at least 5 practical ways to identify measures for any type of planning situation
5. Student will be able to apply the three kinds of formulation strategies to a planning setting to generate an appropriate number of alternatives
6. Student will be able to identify three ways by which plans are narrowed from many to a few
7. Student will be able to give several examples of reformulated plans
8. Student will understand the advantages of formulating multiple plans even when the local sponsor has "decided" what it wants

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Instructor Notes and Exercises:

There are three key focuses in this module:

1. Formulation approach. These seven steps guide the entire Plan Formulation process. Emphasis is on plan formulation, but consideration is given to planning objectives and evaluation without which plan formulation cannot be completed. The formulation approach starts with planning objectives and ends with an appropriate array of plans for decision makers. Emphasis is on coming up with plans, including how to combine measures into plans and how to eliminate them (screening criteria).

2. Three major iterations of planning
    a. Measures
    b. Plans
    c. Reformulated (refined) plans

3. Formulation strategies. This term is used often in the Corps, but rarely written into reports or guidance. However it is critical in enabling us to group measures into plans.

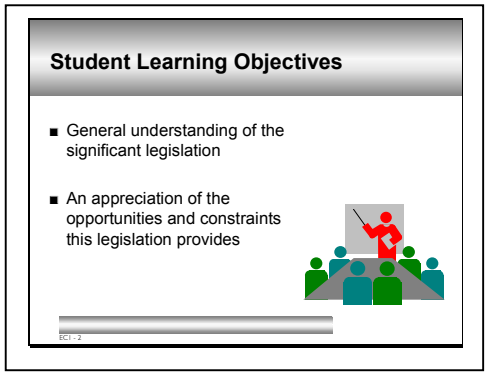
Finally, the Planning Manual covers the development of management measures fairly well. So don't waste too much class time on this part of the module. Have the class break into teams with student or instructor facilitators to foster some camaraderie.

Chapter 3 – Environmental Compliance

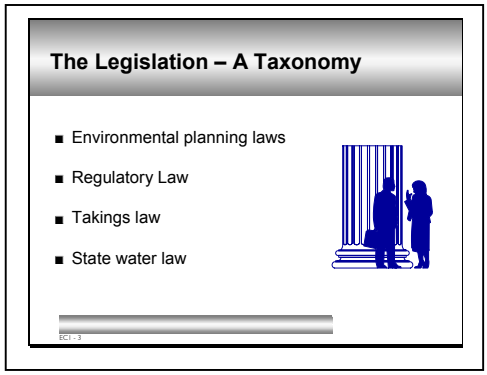
The two modules that comprise this section of the course will provide the student with a general overview of environmental legislation and mitigation planning.

Module EC1: Opportunities and Constraints of Laws and Regulations

Many laws, executive orders, and treaties govern Federal water resources activities. It has been declared in various acts, such as: the Fish and Wildlife Coordination Act of 1958; Federal Water Project Recreation Act of 1965; the National Environmental Policy Act of 1969 (NEPA); and the Water Resources Development Acts of 1986 and 1990 that full consideration is to be given to the opportunities which projects afford to restore ecological resources. These laws establish National policy for the Federal interest in the protection, restoration, conservation, and management of environmental resources. These provisions include compliance requirements and emphasize protecting environmental quality. They also endorse Federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is to be given to the opportunities that projects afford to ecological resources. As a group these laws provide opportunities for the Corps to consider, protect, preserve, and restore degraded habitat and ecosystems. Some of the more significant laws and executive orders are discussed below. For additional information on these laws and executive orders and the many other laws and executive orders that are relevant to formulating a water resources project see The Civil Works Environmental Desk Reference.

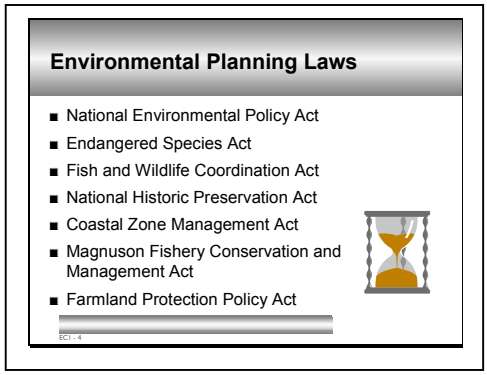


Categorizing the Relevant Environmental Legislation



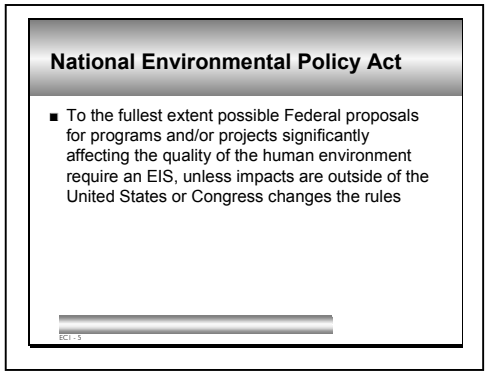
There are many ways to categorize environmental laws; one way is to group them into planning laws and regulatory laws. **Planning Laws** require government to plan or consider the effect of its actions in light of environmental concerns. The foremost example is the National Environmental Policy Act. **Regulatory Laws** essentially tell people what to do; examples are the Clean Air and Water Acts and the Resource Conservation And Recovery Act. Many laws have both elements. **Takings Law** requires just compensation when private property is taken for public use. This is not strictly environmental legislation, but it does have implications for plan formulation and is addressed very briefly in this module. **State Water Law** is another source of environmental law that can constrain the planning process, or in some instances provide opportunities for Corps involvement in assisting with some very difficult issues. States have primary responsibility for the allocation of water. They have also copied EIS requirements into State Environmental Policy Acts (SEPAs). Some have taken the extra step of requiring agencies to adopt the environmentally correct action (the Environmentally Preferable Alternative).

Environmental Planning Laws



Some of the more significant planning laws that you will deal with are listed on this slide and the slides that follow. There are two that are particularly important in their influence on the plan formulation process. The National Environmental Policy Act (NEPA), in addition to requiring that agencies follow certain procedures, espouses a policy that encourages productive and enjoyable harmony between man and the environment; promotes efforts which will prevent or eliminate damage to the environment; and encourages enrichment of the understanding of the ecological systems and natural resources important to the Nation. In addition to complying with the procedural aspects of the Act as you develop measures and formulate plans, there may be opportunities to contribute to this overall policy of environmental enhancement established by NEPA. The Endangered Species Act also provides a basis for environmental restoration. There may be opportunities for the Corps to restore or protect habitat for threatened and endangered species, or to contribute to endangered species recovery plans, as part of ecosystem restoration, natural resources management, dredged material management and water control management projects and initiatives.

The National Environmental Policy Act (NEPA), passed in 1969, is sometimes called the Magna Carta of modern environmental law and includes the requirement for an EIS. The purpose of the EIS is to assure environmentally informed decision-making. It is enforced by suits under the Administrative Procedure Act by persons who might be affected by the Agency action alleging that the government action did not follow the procedures required by law.



a. The complaint is that the agency did not make the detailed statement required by the provision

b. The relief is to enjoin the agency from taking the proposed action until it has made the required EIS

The Supreme Court has held that NEPA does not require agencies to take the environmentally proper action; it only requires them to consider the effects of their actions on the environment. NEPA requires the agency to use certain procedures; it does not require them to take certain actions. As part of the NEPA process, the responsible agency must coordinate its findings with the public. This coordination process can result in the identification of new measures that minimize impacts on the environment or communities impacted by the project. For example, The Lower Monongahela Lock replacement project replaces 3 locks with 2 and requires new dredging. As part of the NEPA process a disposal plan to place the material in a deep hole in the Allegany near Victory Hollow and fill a low area at a former industrial site were identified. This disposal plan turned out to be the least costly disposal plan and became the selected plan. The selected disposal plan grew out of the NEPA public coordination process and reflects the concerns of local residents in Victory Hollow. This example highlights the impact that coordination under the National Environmental Policy Act can have on plan formulation by surfacing new measures and plans.

If the agency determines that its action will have a significant effect on the environment an EIS is required. An EIS is required for every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. Of course, Congress can exempt particular actions from NEPA, either explicitly as was done under the Base Closure and Realignment Act (Congress exempted the decision to close or realign the base but not the decision on how to carry out the closures or realignments) or implicitly by, for example by requiring an agency action without sufficient time to complete an EIS. Furthermore, the courts have found that statutes, which deny the agency any discretion to act upon environmental concerns implicitly exempt actions under these statutes from NEPA.

As a general matter, there is no implicit exemption for agency actions that benefit the environment rather than harm it. If the beneficial effect on the environment is significant, the need to do an EIS is triggered. Because the need to do an EIS will necessarily delay undertaking the action that will have a positive beneficial effect on the environment, however, agencies have claimed that under various laws their actions are exempt from the EIS requirement. The courts have upheld some of these claims, and some remain untested. For matters of exemptions you should talk with your NEPA expert in your Office of Counsel.

Normally an EIS is prepared on a project. However, Programmatic EISs and Tiering are used when a program is being proposed. A broad, general EIS for the program is supplemented by project specific NEPA documentation.

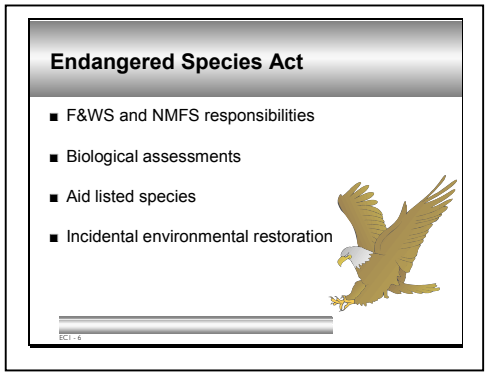
The EIS is prepared by the responsible Federal official. When there are a number of agencies involved a Lead Agency is designated. If agencies can't agree, CEQ appoints. Joint lead agencies, including state agencies is a possibility. Can be prepared by a contractor, but the Federal official is responsible for guidance, oversight, and overall adequacy.

The initial undertaking to determine the scope of the issues to be addressed by the EIS is called scoping. Scoping must be announced in the Federal register.

The draft EIS is made available to the public for comment and sent to EPA and other relevant Federal agencies for comment. Typically the agency holds oral hearings. The responsible official shall conduct a public hearing on a draft EIS. The responsible official shall ensure that the draft EIS is made available to the public at least 30 days in advance of the hearing.

The final EIS includes the preferred alternative and is circulated to agencies and made publicly available. Agencies are required to respond to comments. EPA and other agencies have the power to refer the matter to CEQ if their concerns have not been met and they believe that the proposed action is "unsatisfactory" from the standpoint of public health or welfare or environmental quality. The EIS must be supplemented if the agency makes substantial changes or if there are significant new circumstances or information bearing on the issues that arise from the EIS. 45-day review period.

The Record of Decision (ROD) reflects the final decision of the agency. It must identify the environmentally preferable alternative, identify and discuss all the factors used to reach its decision, state whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and, if not, why not, and it shall include a mitigation monitoring and enforcement program, where the decision includes mitigation requirements.

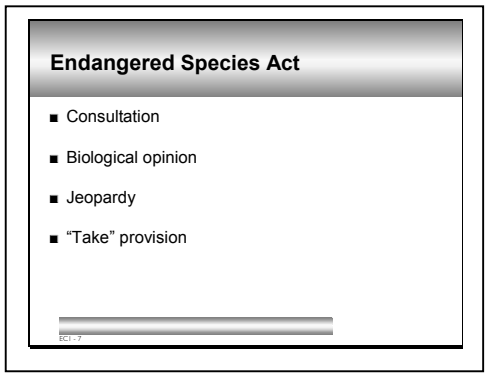


The Endangered Species Act can present very significant constraints to the plan formulation process when endangered or threatened species are identified. For example, as part of the consultation process environmental dredging windows are routinely recommended by resource agencies with the intent of protecting sensitive biological resources or their habitats from potential detrimental effects of dredging operations. Compliance with requests for windows can result in reduced options for contracting dredge plant and equipment, severely constrain mobilization/demobilization schedules, limit contingencies for repairs and severe weather shutdowns, create hazardous working conditions, and ultimately increase dredging project costs. Identifying the likely constraints early provides time to work with the resource agencies to minimize the impact of this type of constraint. Early identification will also provide time to work with the Dredging Operations and Environmental Research Program administered through the Waterways Experiment Station in Vicksburg, Mississippi. This program has a specific mission to assist you in this area. Another tool available to assist Corps staff involves networking with other Districts and benefiting from their experiences. There is an ad hoc ESA Working Group consisting of POCs in each MSC that could be used as a resource.

The Endangered Species Act provides for the Fish and Wildlife Service or the National Marine Fisheries Service to list species, subspecies, or distinct population segments as endangered or threatened species and designate critical habitat if those species are in danger of extinction or are likely to become so in the foreseeable future. The Act requires all Federal agencies to engage in biological assessments whenever

their actions may affect listed species or their habitat and to consult with the FWS or NMFS whenever their actions may adversely affect listed species or their habitat. If listed and proposed species or designated or proposed critical habitat are identified in the study area, these data shall be used to identify areas that should be avoided or critically considered and to determine what opportunities exist for conserving these resources during the formulation of alternatives.

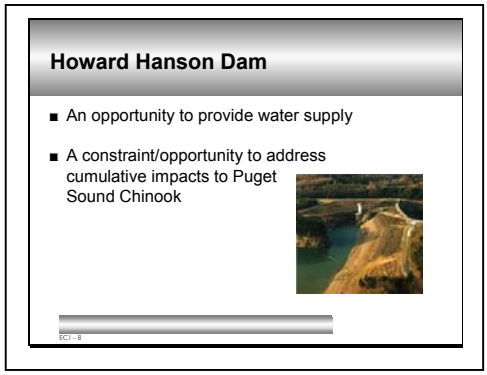
The Endangered Species Act also provides some of the most valuable and powerful tools to conserve listed species and to recover and protect critical habitat. It mandates that all federal agencies determine how to use their existing authorities to aid in the recovery of listed species and to address existing and potential conservation issues. The Endangered Species Act can be used as a basis to include incidental (not allocated to restoration as a project purpose) project features for endangered species.



The FWS or NMFS renders a biological opinion at the end of formal consultation that contains an opinion as to whether the action will either likely jeopardize the survival and recovery of the species or adversely affect its habitat. Jeopardy can be with or without "reasonable and prudent" alternatives. "Reasonable and prudent" alternatives are alternatives that the agency can implement to avoid jeopardy. The Biological Opinion (BO) is advisory to the agency. The agency may accept or reject the advise of the consulting agency. The ESA makes it a crime to "take" any member of a listed species. The Biological Opinion will also include an incidental take provision that allows the District Commander to "take" a specified number of the protected species, or impact a specified acreage of habitat in the project area, without penalty. If the action will jeopardize the species or adversely affect the habitat, the action cannot go forward unless it is authorized by the cabinet-level Endangered Species Committee (God Squad) after a special preceding that determines that the benefits of the action clearly outweigh the costs of jeopardizing the species. Issues involving adverse impacts to endangered species are usually resolved without involvement of the Endangered Species Committee. Referral to the Endangered Species Committee is very rare.

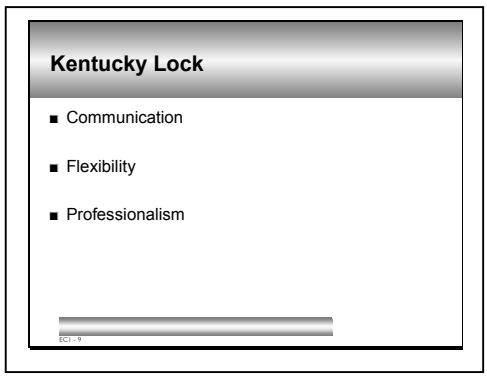
If an endangered species is identified, the Endangered Species Act consultation process will most certainly lead to new formulation ideas and measures that will have to be considered. This process may have major impacts on the plans that have already been formulated, can lead to requirements to reformulate these plans, and may require the formulation of additional measures to avoid or minimize the impacts to endangered species or their habitat. The best approach is to surface these measures early in the study process so that costly delays and reformulation can be avoided. Two strategies for accomplish this are: (1) early coordination with Fish and Wildlife Service or the National Marine Fisheries Service, as appropriate; and (2) including environmental restoration as a planning objective from the beginning. An example of the successful implementation of each of these strategies is provided below.

The existing Howard Hanson Dam Project is a flood control and summer conservation project on the Green River in the state of Washington in the Pacific Northwest. The 1999 Water Resources Development Act authorized modification to the project to add additional water supply and environmental restoration measures to the project. A key environmental restoration component of the Howard Hanson Dam Additional Water Storage Project is improved fish passage. The long-term goal is the reintroduction and survival of self-sustaining runs of various anadromous fish into the upper Green River watershed area that were blocked when the Dam was originally built. This means there must be fish passage around or through the dam. This will be accomplished in two ways. For fish returning to the watershed from the sea, a trap and haul technique will be used transport the fish around the dam. For down stream passage, a state of the art fish passage facility is being designed. Fish passage features include a new intake tower with new fish collection and transport facilities, a wet-well, a floating fish collector, a fish lock, discharge conduit, fish transport pipeline, and monitoring equipment. The design of the facilities incorporated the latest technology and biological data and was jointly developed by the study team, the sponsor, and the resource agencies. The Howard Hanson Dam Additional Water Storage Project also includes 40 sites for habitat mitigation and restoration. These sites are targeted to sustain and improve usable habitat for both fish and wildlife. Improvements to the fish habitat include gravel nourishment to the river, reintroduction of large wood, bar apex jams, and side channel reconnections.



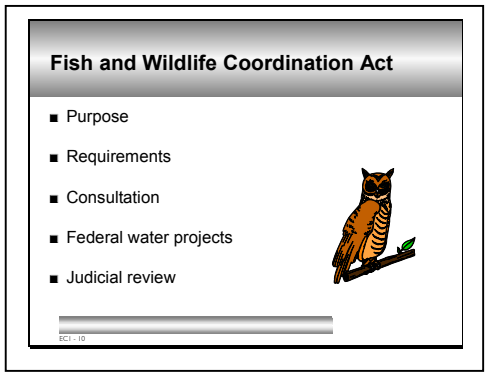
The Howard Hanson project demonstrates how including environmental restoration as a project purpose can lead to an implementable project. It is extremely unlikely that a single purpose water supply project to modify Howard Hanson Dam could have been implemented. Providing features to restore access to critical habitat for Puget Sound Chinook above Howard Hanson Dan was the key to success. Working with the sponsor and the resource agencies and including environmental restoration as a project purpose was critical to obtaining the support needed to implement the project and to avoiding a jeopardy finding by the National Marine Fisheries Service.

The Kentucky Lock project involves adding a 1200'x110' lock chamber at the Tennessee Valley Authority's Kentucky Dam on the Tennessee River. There are long-standing environmental issues with the operation of the existing dam and the tailwater is a designated mussel sanctuary. The fishery in the tailwater is the most heavily utilized in Kentucky, and the tailwater supports a highly diverse mussel community including several federally listed threatened and endangered species. Getting to an implementable project was not easy. There were three keys to achieving an implementable project. **Communication.** All interests were invited in at the beginning. As the study team went through the process of identifying concerns, performing the studies, periodically reviewing the results, refining data needs, formulating and assessing alternatives, and decision-making the other agencies came to appreciate that they were being heard and that their involvement made a difference. **Flexibility.** The Corps' study team willingly modified plans to accommodate concerns and demonstrated sincerity in considering other agencies' ideas. **Professionalism.** The interaction among agencies was conducted in a profession, respectful manner. It

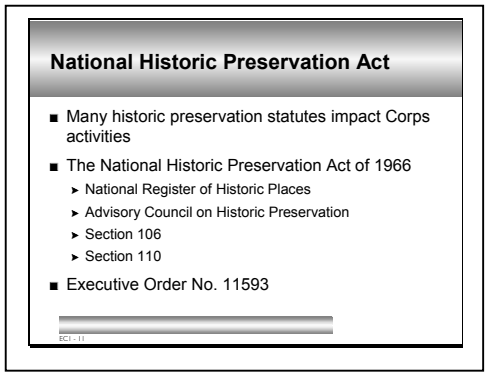


should be recognized that there was a willingness of both parties to work together. Often a lack of early participation is rationalized based on other priorities or limited resources.

In summary, issues and concerns were dealt with and resolved before the EIS was written. Accordingly, the drafting and coordination of the Environmental Impact Statement went quickly and smoothly.



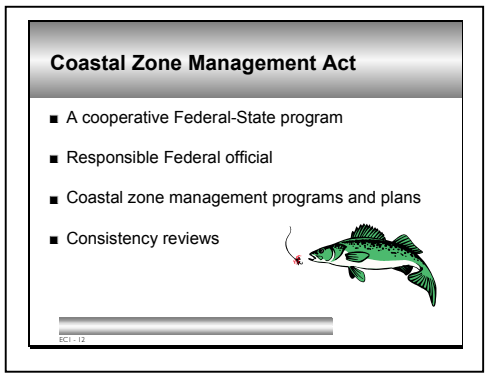
The purpose of the Fish and Wildlife Coordination Act is to assure consideration of wildlife impacts of Federal water projects. Compliance with the Fish and Wildlife Coordination Act requires Federal water agencies to consult with the Fish and Wildlife Service and with state wildlife agencies prior to the issuance of any license or permit or prior to construction for water development activities that will affect wildlife. As part of this coordination the U.S. Fish and Wildlife Service will provide a Planning Aid Report to be used as a planning tool to aid in the development of alternatives and in determining the mitigation requirements. Furthermore, the Act provides that the report and recommendations of the FWS be included in reports going to Congress. The Act also requires the adequate provision for wildlife resources in the construction of water projects and authorizes the modification of projects for wildlife conservation measures and includes a provision for judicial review. Judicial review is procedural, courts have held that good faith compliance with NEPA will take into consideration the requirements of the Fish and Wildlife Coordination Act.



Compliance with The National Historic Preservation Act requires initial coordination with the State Historic Preservation Officer at the beginning of the study to determine know historic properties and to determine the need for more detailed investigations. If further study indicates that properties will be impacted a plan to avoid, minimize, or mitigate the impact must be developed.

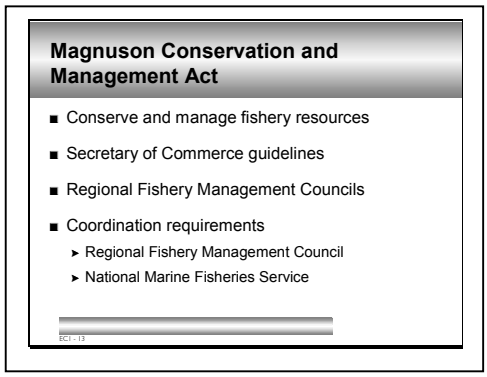
The National Historic Preservation Act authorizes the Secretary of the Interior to maintain a National Register of Historic Places. Listing is based on procedures established by the Secretary. The National Historic Preservation Act created the Advisory Council on Historic Preservation as an independent Federal agency. The Council is comprised of 20 members and is responsible for advising the President, Congress, and other Federal agencies on historic preservation. Section 106 of the NHPA requires Federal agencies to take account of the effects of Federally licensed or approved activities on properties listed in or eligible for listing in the National Register. In compliance with Section 106, Federal agencies are required to consult with State Historic Preservation Officers and with the Advisory Council. Section 106 imposes only procedural duties on Federal agencies. It requires no particular substantive outcome. Section 110 of the National Historic Preservation Act requires Federal agencies to locate and inventory historic properties under their jurisdiction, which are eligible for listing in the National Register. Section 110 requires Federal agencies to minimize harm to historic landmarks adversely affected by Federal projects. Executive Order No. 11593 requires Federal agencies to preserve, restore, and maintain Federally owned sites and objects of historical, architectural, or archeological significance.

Compliance with the Coastal Zone Management Act requires that plans for projects in the coastal zone be in compliance with state coastal zone management plans. Requirements in individual state plans can place constraints on acceptable alternatives. For example, the North Carolina Coastal Zone Management Plan prohibits the construction of hardened structures in the coastal zone. This provides a significant constraint on the range of acceptable solutions for solving storm damage prevention and hurricane protection projects and other coastal projects that can be solved by placing structures in the coastal zone.

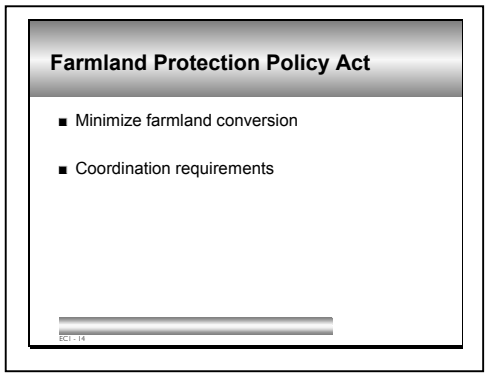


The Secretary of Commerce, with the National Oceanic and Atmospheric Administration (NOAA) as the responsible agency, administers the Coastal Zone Management Act. The Act declares a National policy to protect the coastal zone. The Coastal Zone Management Act is designed to be a cooperative management effort between states and the Federal government with the states playing the lead role. The Secretary of Commerce acting through the National Oceanic and Atmospheric Administration is the responsible Federal authority for implementing the Coastal Zone Management Act. The coastal zone extends seaward to the limit of state ownership of submerged lands and inland to the extent necessary to control shorelands in coastal states (including The Great Lakes). Pursuant to the Act, states may adopt state coastal zone management programs, which are comprehensive plans for the use of both public and private coastal zone lands. Such plans must meet standards set by the Secretary of Commerce. All states with approved management programs are required to develop a plan for the prevention of nonpoint source pollution in coastal zones. The principal incentive for state adoption of coastal zone management programs, in conformance with the requirements of the Act, is the authority of the state to conduct consistency reviews of Federal projects and actions in coastal zones. Federal agencies are required to conduct their activities in the coastal zone in a manner consistent with the state coastal zone management program.

The purpose of the Magnuson Fishery Conservation and Management Act is to conserve and manage the fishery resources found off the coast of the United States, the anadromous species, and the Continental Shelf fishery resources of the United States. The Act promotes domestic commercial and recreational fishing under sound conservation management principles, and establishes standards for fishery conservation and management, and directs the Secretary of Commerce to establish advisory guidelines, based on the national standards, to assist the development of fishery management plans. The Act establishes eight Regional Fishery Management Councils, to prepare, monitor and revise fishery management plans, which will achieve and maintain the optimum yield from each fishery. Each District commander shall coordinate and consult with the Council in accordance with formal coordination procedures established between District Commanders and appropriate Councils in his or her area. Such procedures shall be modified as appropriate to insure inclusion of review and comment procedures for feasibility reports involving coastal area development and respond within 30 days to comments and recommendations made by a Council. Coordination and consultation with the National Marine Fisheries Service shall be initiated specifically,

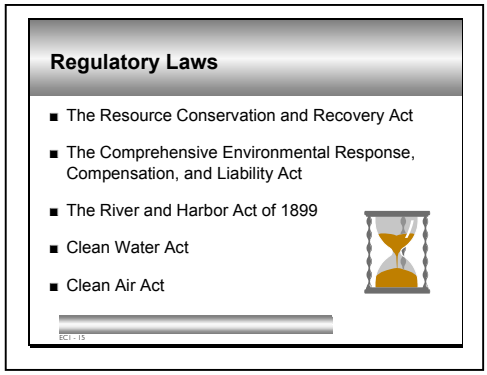


as needed, or concurrent with activities under the Fish and Wildlife Coordination Act and/or the Endangered Species Act.

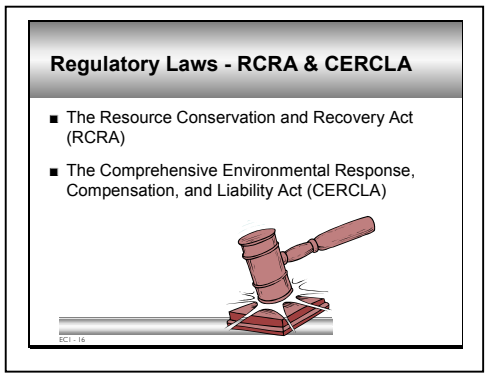


The purpose of this Act is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that Federal programs are administered in a manner that will be compatible with State, local government and private programs and policies protecting farmland. The Act instructs the Department of Agriculture, in cooperation with other departments, agencies, independent commissions and other units of the Federal government, to develop criteria for identifying the effects of Federal programs on the conversion of farmland to nonagricultural uses. It does not provide a basis for any action, either legal or equitable, by any person. The implementing guidance for the legislation requires that Corps FOAs contact the Natural Resource Conservation Service (NRCS) for identification of prime or unique farmland, which might be impacted by proposed Corps actions. Prior to taking any action that would result in conversion of designated prime or unique farmland to nonagricultural uses, the Corps must examine the potential impacts of the proposed action and if there are adverse effects on farmland preservation, consider alternatives to lessen the adverse effects. It is the Corps discretion to proceed with a project once the required examination is completed. The analysis is an integral part of the environmental assessment process under NEPA and the analysis and results will be included as part of the final NEPA document.

Regulatory Law



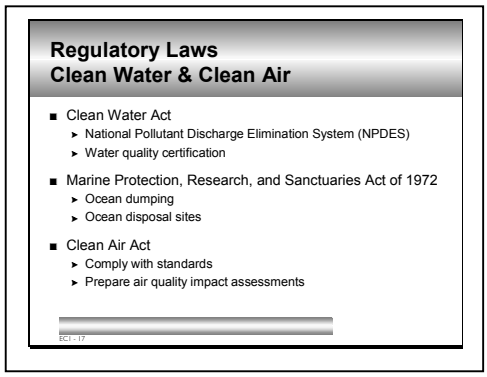
Regulatory laws tell people what they can do. In this section we will briefly discuss the laws that regulate hazardous waste and the cleanup of hazardous waste, discharges of pollutants into the air or water, and the laws that govern the Corps regulatory program.



The Resource Conservation and Recovery Act (RCRA) regulates hazardous waste, solid waste, and underground storage tanks. Anyone who generates waste must determine whether that waste is "hazardous", thus subjecting it to full regulation under Subtitle C of RCRA. EPA's rules indicate that wastes are hazardous if they demonstrate a hazardous characteristic or if they are specifically listed as hazardous. RCRA requires that hazardous wastes be treated prior to being disposed of even in regulated land disposal units. These requirements, known as the "land ban" impose significant costs on the regulated community.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is a cleanup program that may apply when a hazardous substance has been released into the environment. CERCLA establishes few regulatory requirements. Instead, it imposes liability for cleanup costs as a result of past activities. Anyone may use CERCLA to impose the obligation to pay for cleanup onto anyone else who is liable under CERCLA. This includes the government, the states, Indian Tribes, and even private entities. EPA may also order those liable to clean up the sites themselves. CERCLA operates under principles of strict joint and several liabilities. It imposes liability on the current owner or operator of the site, anyone who owned or operated the site at the site of disposal, anyone whose hazardous substances were disposed at the site, and those who transported those substances to the site if they participated in the site selection process.

The Clean Water Act includes several provisions that can constrain the plan formulation process or limit the range of alternative measures that can be implemented. The National Pollutant Discharge Elimination System program (NPDES) regulates point source discharges to navigable waters. The NDPES control strategy has two prongs. First, it imposes technology-based requirements designed to ensure a uniform degree of control within each industry. Second, it requires the impositions of such further controls as are necessary to ensure that the receiving water maintains compliance with water quality standards.



The primary activity of the Corps that is impacted by the Clean Water Act is disposal of dredged material. Because the Clean Water Act regulates discharge of dredged or fill materials in waters of the U.S., inside the 3-mile limits of the coastlines. EPA is in charge of setting the standards and sometimes changes the criteria for the standards. When this occurs, project costs for maintenance as well as new start construction projects will increase. This is because more costly methods of disposal must be undertaken. Consider the difference in cost between overboard disposal versus taking the material to an EPA designated disposal site in the ocean. Alternatively, consider not being able to use the ocean as a disposal site at all, you must use land disposal.

In addition, you may be faced with environmental windows, either for inland or deep draft disposal. An environmental window is a time period, usually several months, when you cannot dispose of material, perhaps because fish are migrating or spawning during that period. Environmental windows may come under NPDES or may come under ESA. For example, suppose you are going to use dredge material to nourish a shoreline as part of a hurricane protection project. The piping plover, an endangered species, uses the shoreline in the winter to nest; the local sponsor does not want sand pumped during the late spring, early fall recreation season. Now add in the possible impact of dredging on sea turtles and you may have very little time when everyone agrees that you can dredge and nourish (the project is Sea Bright, N.J.). Clearly you have a formulation challenge. The district resolved the issue by careful coordination with the resource agencies in the region; it turned out that a combination of surf zone disposal, fencing of habitat, and turtle guards on the dredge would shorten the window sufficiently to satisfy everyone.

Environmental windows are also associated with reservoir releases. The important points are:

- Environmental Coordination requirements under various statutes will put you in constant contact and negotiation with the resource agencies. That is what the legislation is designed to do

- The coordination will usually involve a “mini-formulation” effort

- The twist is that the “mini-formulation” effort may produce results that impacts overall project formulation by impacting costs and timing

- Late in the process, when the draft EIS is circulated is a poor time to surface issues

- Early in the process, when planning constraints and objectives are being established is the time for coordination

- Back to the first point: often Districts have a program of similar projects involving similar environmental concerns (reservoir releases in a system environment), hurricane protection along a given State’s shoreline (Florida, for example), harbor dredging, and inland navigation systems. Such Districts learn that early and constant coordination with resource agencies around such environmental concerns, including environmental summits covering a broad range of interagency issues, facilitates plan formulation. (For example, NAD sponsored a series of such “summits” in the early 1990’s. The Division office took the lead because of boundary differences between EPA regions II and IV on the District. The issues discussed included planning, maintenance dredging and permitting. These summits led to executive level understandings, which assisted communications over very difficult disposal issues, which affected Port development in Region II. It helped the “FEDS” keep their act together rather than become full proponents for their individual constituencies and supporters

Section 401 of the Clean Water Act established a state water quality certification program. Under this program a state water quality certificate must be obtained before a project can be constructed. Obtaining state water quality certification can be time consuming, often taking six months or longer. Addressing water quality mitigation in accordance with the Clean Water Act has allowed us to include incidental ecosystem restoration - one example is the Napa River Project.

The Marine Protection, Research, and Sanctuaries Act regulates the dumping of materials into ocean waters. It prevents, or restricts, dumping of materials that would degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. The Act provides for a permitting process to control the ocean dumping of dredged material. The Act also establishes the marine sanctuaries program, which designates certain areas of the ocean waters as sanctuaries in order to preserve or restore these areas for their conservation, recreational, ecological, or aesthetic values.

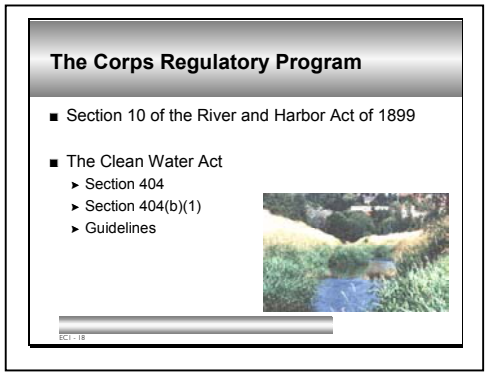
For projects involving transportation of dredged material through the territorial sea for the purpose of ocean disposal, or involving dredged material disposal within the territorial seas for the primary purpose of disposal, the discharge will be evaluated under Section 103 of the Act. The disposal must meet the criteria established by the EPA (40 C.F.R. 227 & 228). Procedures for evaluating the potential contaminant-related impacts of disposing dredged material in the ocean are contained in the "Evaluation of Dredged Material Proposed for Ocean Disposal-Testing Manual" (EPA/COE-503/8-91/001). The Corps will generally utilize ocean disposal sites designated by the EPA to the maximum extent practical. Where no EPA designated site is available, the Corps may select a suitable ocean disposal site or sites using procedures and outlined criteria in 40 C.F.R. 228.4(e), 228.5 and 228.6. Potential ocean disposal sites will be specified in feasibility reports and, to the fullest extent practicable, the Section 103

evaluation will be completed during the feasibility study. (ER 1105-2-100). Efforts are currently underway to develop joint guidance between the Corps and EPA on site management plans and monitoring pursuant to 33 U.S.C. 1271 et seq.

Activities in sanctuary areas may be authorized only if the Secretary of Commerce certifies that the activities are consistent with Title III of the Act and can be carried out within in the regulations for the sanctuary.

The Clean Air Act requires that any Federal activity that may result in the discharge of air pollutants shall comply with Federal, state, interstate, and local air quality control plans. Accordingly, the responsible agency must prepare an impact assessment on air quality to accompany its Finding of No Significant Impact or its Environmental Impact Statement.

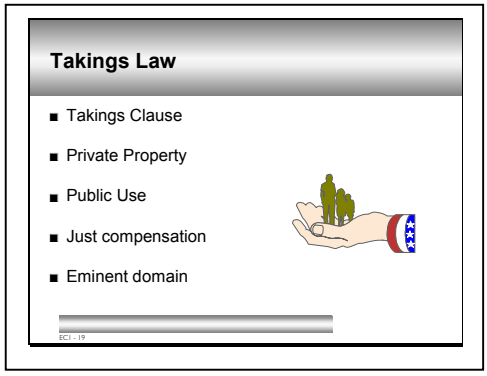
The National Ambient Air quality Standards Program (NAAQS) imposes stringent new source review requirements in non-attainment areas and preconstruction review of major projects in attainment areas to achieve or maintain compliance with national air quality standards. Complying with Clean Air Act standards can be time consuming and constrain plan formulation. In some instances requiring the use of construction equipment that does not contribute to the degradation of air quality. One example from a harbor-deepening project in California is the use of electric dredges rather than the more convention dredges that we are accustomed to seeing. Another example is New York Harbor, where the concern was that larger containerships, facilitated by harbor deepening, would cause a "spike" in poor air quality as trucks crowded into the port to be loaded. Analysis showed that the newer ships (1) used a higher grade of fuel and (2) took less time to unload; hence, the ship related exhausts offset any minor truck based spike. This information, conveyed to EPA very early in the process, forestalled the concern from being raised later in the formulation process.



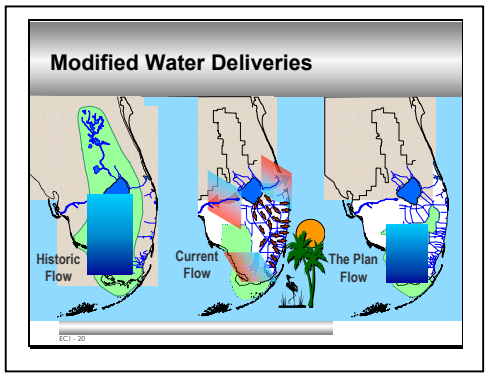
The Corps Regulatory Program is guided by two key pieces of legislation. The River and Harbor Act of 1899, sometimes referred to as the Refuse Act and the Clean Water Act. Section 10 of the Refuse Act prohibits anyone from creating an obstruction to the navigable capacity of waters of the United States or building any construction on a river or Harbor without a permit from the Secretary of War. The Refuse Act provided no basis for lawsuits and can only be enforced by the government.

Section 404 of the Clean Water Act prohibits anyone from discharging dredged or fill material into water of the United States without a permit from the Corps of Engineers. The Environmental Protection Agency writes the 404(b)1 guidelines for the 404 permit process and has veto authority over permits issued by the Corps. Corps projects are generally subject to the 404(b)(1) guidelines. An exemption, called the 404 or exemption, is available for Corps projects specifically authorized by Congress when the information on discharges, including consideration of the 404(b)(1) guidelines, is included in an environmental impact statement that is submitted to the Congress before the discharge occurs.

Takings Law

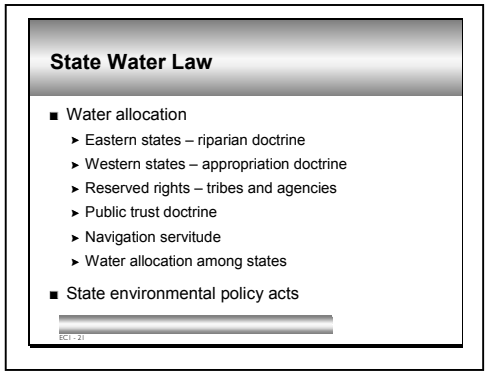


The Takings Clause of the 5th Amendment of the United States Constitution provides that private property shall not be taken for public use without just compensation. A taking under the 5th Amendment usually occurs by eminent domain in a condemnation proceeding in a court. It can also occur when a government regulation goes "too far". This is referred to as a regulatory taking. Private property is primarily real property, but it can also be personal property and intangible property as well. The concept of public use is very broad. It is essentially whatever Congress (or a State) believes is in the public interest. Just Compensation is generally interpreted to mean payment of the fair market value of the property that has been taken. Eminent Domain is the right of the government to take, or to authorize the taking of, private property for public use.



One of the projects that is already authorized and considered part of the without condition for Everglades restoration is the Modified Waters Delivery Project. This project is vitally important to the overall restoration. It is essential that it be implemented. The authorized plan of improvements consists of structural modifications and additions to the existing Central and Southern Florida (C&SF) Project to enable water deliveries for the restoration of more natural hydrologic conditions in Everglades National Park. Operating the project will increase flows in Eastern Shark River Slough, raising water levels in a residential area known as the 8-1/2 square mile area. The impact on the 8-1/2 square mile area is significant enough that a "taking" could occur. A range of options ranging from purchase and evacuation to protection of all or some of the area with a levy was developed to address this situation. Several different interest groups voiced strong opinions over the different alternatives. It appeared as if an acceptable solution was not achievable. Ultimately a consensus was achieved that balanced the views of the different interest groups. The final plan called for evacuation and purchase of the most environmentally sensitive portion of the 8-1/2 square mile area and protection of the more developed portion of the area. Additionally, persons that were displaced were given the option of relocating to land in the area to be protected.

State Water Law



States have primary responsibility for allocating water. States generally have different laws for the allocation of surface streams, rivers and lakes, groundwaters, and dispersed surface water. Eastern states have relied primarily on riparian doctrine, while western states have relied upon the appropriation doctrine. Some states, like California, use a mixture of both.

Riparian landowners have a right to the reasonable use of water in streams riparian to their land. Riparian rights are dependent upon the supply of water and the uses of other riparian landowners. The riparian right does not guarantee a fixed volume or flow of water.

Appropriation rights are acquired by putting water to beneficial use on a first come, first served basis, and entitle the rights holder to apply the water to beneficial use. Water is allocated to appropriative rights holders on the basis of their temporal priority. When the water supply is insufficient to satisfy the claims of all rights holders, the most junior must forgo use of water while the more senior gets their full allotment.

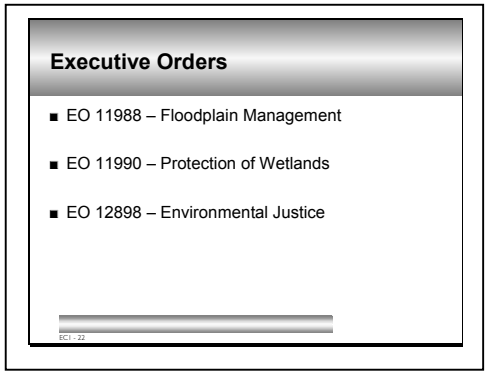
Indian tribes and the Federal agencies have reserved rights that were implicitly granted when their lands were reserved from the public domain. The nature of these rights is dependent upon the purpose of these reservations.

The public trust doctrine and federal navigation servitude recognize public rights to certain uses of certain waters. These rights are generally superior to any private claims of water rights. The public trust doctrine constrains private use that impacts public use and imposes affirmative duties on the states to enforce the public rights. Navigation servitude is the authority of the Federal government to regulate navigable waterways.

Water is allocated among states based on equitable apportionment by courts, interstate compacts, of Congressional allocation. The Federal government is required to comply with state law when Federal projects require the acquisition of water rights.

The Tres Rios project in Phoenix Arizona illustrates the impact that state water law and tribal rights can have on plan formulation. The authorized Tres Rios project will use water from a treatment plant to restore riparian habitat. The sponsor owns the water from the treatment plant as long as it does not enter the river. Once it entered the river it is adjudicated by the State. Therefore the project is designed to intercept the water for restoration use from the treatment plant rather than take the water from the river. Also on the Tres Rios project, land acquisition requirements forced the formulation of two different kinds of alternatives: 1) alternatives that included use of tribal lands; and 2) alternatives that did not include tribal lands. Two types of land acquisition measures were needed because the tribe could not commit to provide the lands and the local sponsor did not have the capability to provide lands owned by the tribes.

Executive Orders



As indicated earlier there are many executive orders that are relevant to formulating a Federal water project. For amore complete list and discussion see The Civil Works Environmental Desk Reference. Three of the more significant executive orders are described below.

Executive Order 11988, Floodplain Management, provides that each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Before taking an action, each agency shall determine whether the proposed action will occur in a floodplain. If an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a floodplain, the agency shall consider alternatives to avoid adverse effects and incompatible development in the floodplains. Each agency shall also provide opportunity for early public review of any plans or proposals for actions in floodplains. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in a floodplain, whether the proposed action is in accord with this Order.

Executive Order 11990, Protection of Wetlands, provides that each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in wetlands, whether the proposed action is in accord with this Order.

Executive Order 12898, Federal Actions To Address Environmental Justice In Minority Populations And Low-Income Populations, provides that to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

Review Questions

1. What requirements or constraints does the National Environmental Policy Act impose on Corps Planners?

2. What opportunities does the National Environmental Policy Act offer Corps Planners?

3. What is the judicial remedy if an agency has not complied with the National Environmental Policy Act?

4. What does Section 110 of the National Historic Preservation Act require a Federal agency to do?

5. Does compliance with the Coastal Zone Management Act exempt public or private parties from compliance with other environmental laws?

6. Do Federal agency activities in the coastal zone have to be consistent with the state coastal zone management program?

7. What requirements or constraints does the Endangered Species Act impose on Corps Planners?

8. What opportunities does the Endangered Species Act offer Corps Planners?

9. Section 9 of the Endangered Species Act prohibits the "taking" of any member of a listed species. Describe the possible consequences of a violation of Section 9.

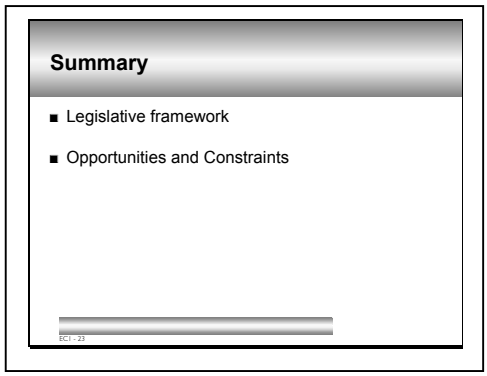
10. How does a taking under the 5th Amendment of the Constitution occur?

11. What governmental entities have the primary responsibility for the allocation of water?

12. Who writes the regulations governing the Corps implementation of the Section 404 program?

13. What are the implication of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for Corps Projects?

Section Summary and a Look Forward



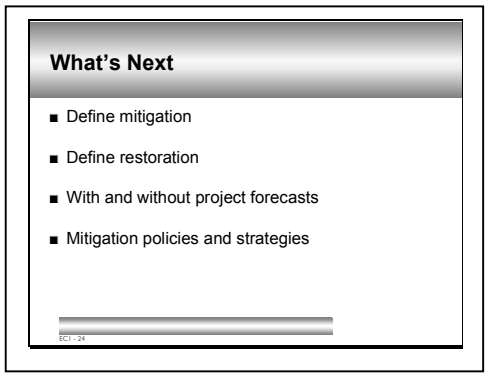
Section Summary

In summary, over the years the Congress has enacted significant environmental legislation. This legislation has in tern shaped the way the planning of water resources projects is conducted. It has constrained the set of potentially implementable options and it has fostered a planning process that requires significant input from and coordination with the responsible federal resource agencies. Developing an

implementable solution to a water resources problem is a difficult undertaking at best. One key component of a successful study is early, open, and honest attention to the purpose and requirements of the environmental legislation.

Look Forward

The next module is designed to discuss mitigation strategies and policies. It will define and contrast "mitigation" and "restoration", discuss establishment of the with- and without-project conditions, and present examples of environmentally sensitive design that demonstrate the importance of early consideration of environmental impacts in the plan formulation process.



References and Suggestions for Further Reading

Council on Environmental Quality, Appendix B: CFR Title 40.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Environmental Quality – Procedures for Implementing NEPA, March 1998, ER 200-2-2, CECW-PO.

The Civil Works Environmental Desk Reference retrieved from http://www.usace.army.mil/inet/functions/cw/cecwa2/environ.htm.

Selected Environmental Law Statutes, West Publishing Company, St Paul, Minnesota (Latest educational edition).

Selected Notes to the Instructor

Student Learning Objectives:

1. The student should gain a general understanding of the significant legislation
2. The student should gain an appreciation of the opportunities and constraints this legislation provides

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Instructor Notes and Exercises:

The learning objectives for this module are shown above and again below with slide EC-2. Questions for the students are included throughout the module to elicit discussion and student involvement. You will need to monitor discussions so that you do not exceed the time allocation for this module. This module and module EC2, Mitigation Policies and Strategies, make up the environmental compliance section of the course and are very closely related. Accordingly, you have flexibility in allocating time between the two modules provided all the material is covered and the total time for the two modules does not exceed 1 hour and 45 minutes.

Slide EC1-1
While the title slide is up you should let the student know that this module will consist of a brief overview of the legislation supplemented by examples indicating the opportunities and constraints that the legislation implies for the pan formulation process. Furthermore, the overview will draw upon real world examples to highlight some of the opportunities implied by the legislation and the constraints that are paced on the plan formulation process by the legislation and the processes that have evolved as the legislation has matured. Opportunities inherent in the legislation will be discussed generally in this module and in more detail as part of module ER1 dealing with the Corps' ecosystem restoration authorities.

Slide EC1-2
You should discuss the learning objectives with the students.

Slide EC1-4
There are many environmental planning laws that are relevant for Corps planners. This slide lists some of the more significant planning legislation that constrains or impacts plan formulation. You should let the students focus on the slide as you make some general remarks similar to the paragraph below. Advise the student that all of the planning laws are important and operate to constrain plan formulation in similar ways and that we will focus on the legislation listed to illustrate the influence of the planning laws on the plan formulation process.

Slide EC1-5
This slide shows the wording in the National Environmental Policy Act that gives rise to the requirement for an EIS. While this slide is being displayed you should provide the students with a brief overview of the requirement for an EIS and provide an example of where EIS coordination has led to a revision in the plan being recommended (see discussion below). After going through your examples you should ask the students to provide a couple of examples from their experience.

Slides EC1-6 and 7

This slide and the next slide show key points from the Endangered Species Act. While this slide is being displayed you should provide the students with a brief overview of the relevance of the Endangered Species Act to the plan formulation process. There are a couple of really key points that you should make. First, this consultation process is a big deal. It is going to take a lot of study resources. It is important to have good working relationships and strategies for dealing with the resource agencies and for recognizing and understanding the perspective of the individual resource personnel working on the consultation. The process will go much smoother if they know you and they trust you. Taking a listed species is a criminal offense; the District Commander's neck is on the line. You can also discuss the dredging window issue and the assistance that is available through the Waterways Experiment Station. The following two slides provide background information on two projects where districts have employed two different strategies to get to implementable projects given Endangered Species Act concerns. You may use these or substitute your own examples. After discussing the Howard Hanson project you can consider asking the students the following question: "What are the cost-sharing implications for environmental restoration features that are necessary to avoid ESA jeopardy?" The sponsor has argued that a significant portion of the cost of the environmental restoration features should be allocated to the existing project and cost shared accordingly. The biological opinion supports this position and the Seattle District has made a concurring recommendation. This is not a formulation issue per se, but it does highlight the significant influence of the Endangered Species Act. The Kentucky Lock example is a real good example of the benefits of starting the NEPA process early. After going through your examples you should ask the students to share examples from their experience with the class.

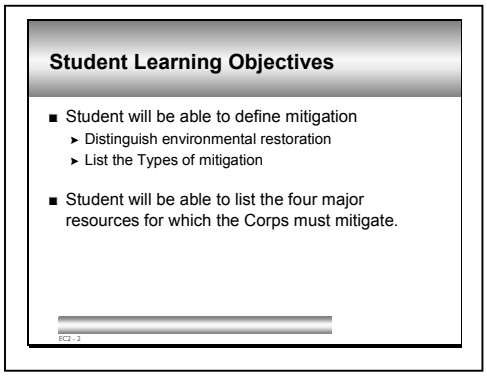
Slide EC1-16

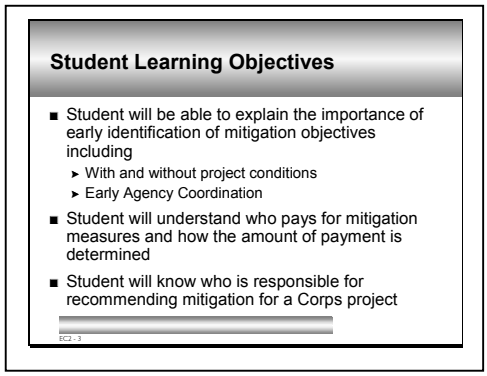
In this section you will briefly discuss regulatory law that impacts Civil Works projects as well as the regulatory law that underlies the Corps regulatory program. This section should be covered rather quickly so that more of the time for this Module can be devoted to the other areas.

Slide EC1-19

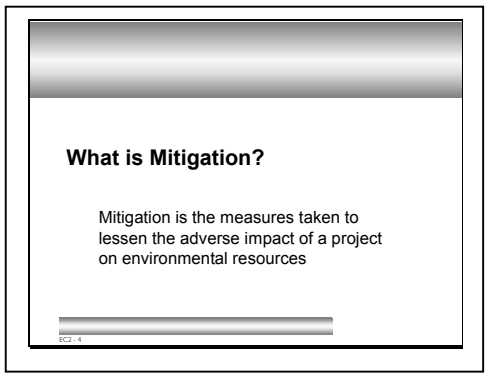
While the next slide is displayed you should briefly discuss the 5th Amendment Takings Clause. Project impacts that give rise to a "taking" can significantly constrain plan formulation. The following slide will facilitate discussion of the "takings" issue associated with the Modified Water Deliveries Project and the 8-½ square mile area. This example offers a good opportunity for discussion of the Fifth Amendment and the art of compromise and consensus building in developing implementable plans.

Module EC2: Mitigation – Policies and Strategies





What is Mitigation?



This module covers mitigation. Mitigation and restoration are defined and mitigation policies and strategies are discussed. Mitigation is the measures taken to lessen the adverse impact of a project on environmental resources; it is measured as the difference between the with- and the without condition with respect to an environmental resource. Mitigation must be an integral part of plan formulation. Section 906 of the Water Resources Development Act of 1986 provides that, for new projects, necessary mitigation measures shall be undertaken before or concurrently with project construction, as determined appropriate by the Secretary of the Army. It provides general authority to undertake mitigation measures for projects, whether completed, underway, or unstarted, including acquisition of any needed related lands (excluding condemnation in connection with projects already completed or underway). Mitigation costs are to be allocated to the project purposes and cost shared accordingly. It requires that feasibility reports contain a specific plan to mitigate fish and wildlife losses, unless a determination is made that there would be negligible adverse impact. Mitigation (environmental mitigation) must be justified. While the Corps goal is 100 percent mitigation, the actual amount of mitigation finally recommended must be justified by comparing the tangible and intangible benefits to the tangible and intangible costs. The 100 percent mitigation goal is just a goal, not a requirement.

We mitigate for the shortfall between the with- and without condition. If habitat units (or other measure of environmental quality) is greater in the without condition, then we have to look for mitigation measures. With and without analysis is not the same as before and after analysis. With and without conditions are both considered over time and reflect and describe the differences expected with- and without the mitigation. Corps policy is that mitigation is provided to the extent that the monetary and non-monetary benefits exceed the monetary and non-monetary costs. We do not mitigate losses at any cost! Mitigation must be justified.

The without project condition is the most likely condition to occur if no action is taken. For mitigation purposes, you want to project the most important environmental values. Since all future projections are uncertain, you want to determine the sensitivity of your mitigation plan to alternative futures.

Without Project Condition

- Most likely condition if no action is taken
- Developed from the inventory and forecast step
- Forecast most important variables
- Sensitivity of selected plan to alternative futures

EC2 - 5

This example is meant to reinforce your understanding of the role of with and without analysis in determining the level of mitigation attributable to the underlying project purpose. A deteriorating without condition implies less mitigation, but perhaps a real opportunity for ecosystem restoration. Planning area XYZ is characterized by a deteriorating without condition, while planning area ABC is characterized by a fairly stable without condition. As can be seen from the differences between column 1 and column 2 the impact of a traditional Corps project in XYZ is less than the impact of a project in area ABC, while the differences between column 1 and column 3 indicate that an ecosystem restoration project in area XYZ would contribute more to ecosystem restoration than would a project in area ABC.

Look at the Table in the Next Slide

- Which plan requires the most mitigation?
- Which restoration plan has the most benefits?

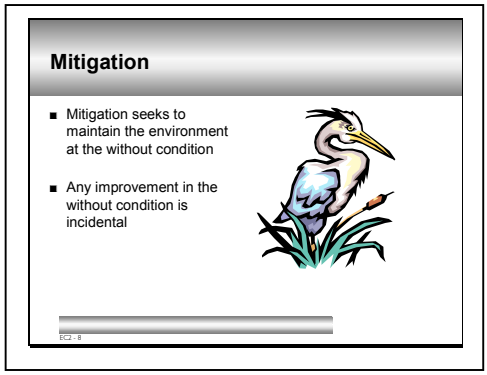
EC2 - 6

Habitat Units Over Time

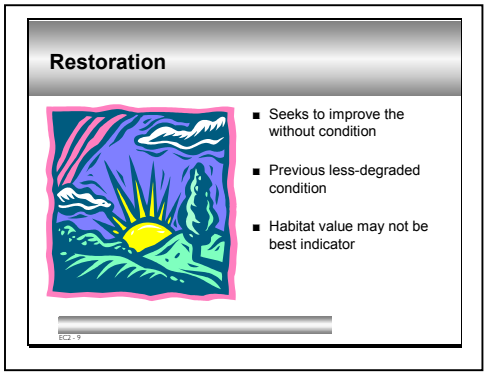
YEAR	WITHOUT PROJECT	WITH PROJECT	RESTORATION
		PLANNING AREA XYZ	
1900-1950	4000	4000	4000
1990	3200	3200	3200
2000	3000	3000	3000
2010 (BASE)	2800	2300	2900
2050	2000	1800	2700
		PLANNING AREA ABC	
1900-1950	4000	4000	4000
1990	3200	3200	3200
2000	3400	3000	3400
2010(BASE)	3600	2300	3700
2050	3800	1800	4000

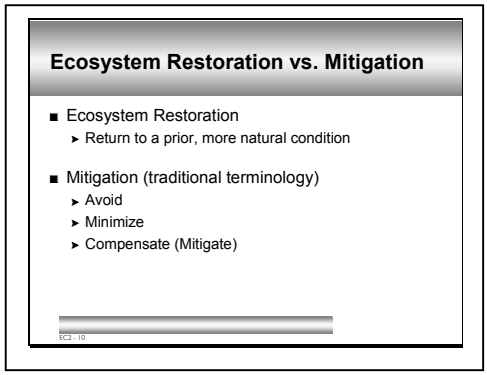
EC2 - 7

Mitigation seeks to maintain the environment at the without condition. Any improvement in the without condition is incidental. Remember, we are not formulating an NER plan; we are formulating a plan to mitigate for the harm that will be caused by a plan we are considering for implementation.

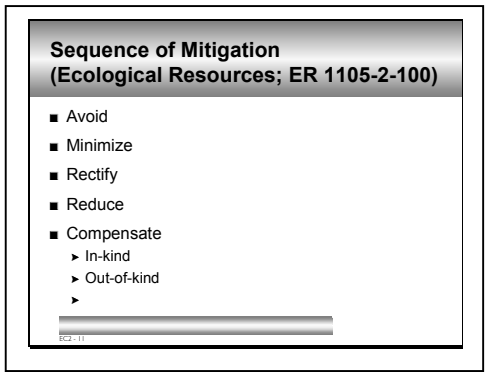


National Ecosystem Restoration (NER) means we are trying—for fish and wildlife—to improve the without condition to a previous less-degraded condition. CAUTION: habitat values may not be the best way to capture this benefit, since habitat methods may focus on one or several favored species, rather than on an in-balance ecosystem. Detailed measurement of restoration outputs is covered in other courses.





This slide lists the sequence of mitigation, as specified in ER 1105-2-100, Appendix C, for ecological resources. Here we are just trying to get some terms on the table to facilitate discussion and understanding. We will have more to say about the process later in this module:



1. Avoidance means that you should limit impacts on significant habitats and resources. Often this can be achieved by minor design changes early in the planning process.

2. Minimize is close to avoidance—it implies a minor impact, perhaps requiring further mitigation, but not much.

3. Rectify implies that the construction will cause a disturbance, but the effect of the disturbance will disappear over time, either on its own or more likely because of some restorative action.

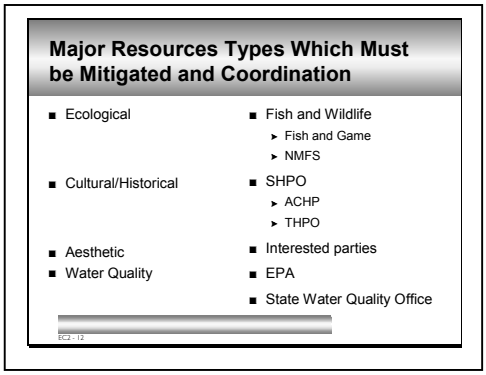
4. Reduction is a less complete form of rectification. It almost totally rehabilitates a temporarily disturbed resource.

5. Compensation (older planners may refer to this as "mitigation"). Compensation does not mean cash payment. It means provision of a resource in consideration of a resource that will be lost due to the project.

6. In-kind. This means that the resource provided is the same kind of resource as was lost, in the same area.

7. Out-of-kind. This means that the resource provided is a different kind. It should be as similar as possible. It should be a near as possible.

There are four kinds of resources that must be mitigated. Each tends to have its own proponent, responsible agency. They are:



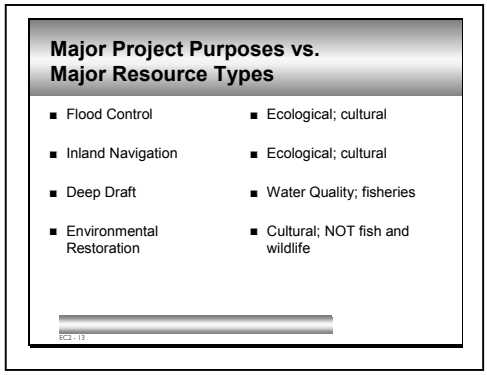
1. Ecological. Terrestrial and inland riverine aquatic resources fall under the jurisdiction of the U.S. Fish and Wildlife Service and the State Fish and Game agency. The National Park Service has responsibility for resources that are found on its lands and waters, although the U.S. Fish and Wildlife Service or National Marine Fisheries Service often work with the National Park Service where impacts can affect a National Park holding. Marine resources, including anadromous species, fall under the jurisdiction of the National Marine Fisheries Service.

2. Cultural/Historical. The State Historic Preservation Office (SHPO) is the key player for coordination. However, in the case of dispute, the Advisory Council on Historic Preservation (ACHP) will become a major player. The Tribal Historic Preservation Office (THPO) replaces the SHPO for tribal lands.

3. Aesthetic. There is no real proponent agency for this resource.

4. Water Quality. The regional Environmental Protection Agency is the lead player. The State water quality office, which goes by different names in different states, will be a major player especially if a 404r exemption is not used (NOTE: The Corps has the option of submitting an evaluation of its plan (called a 401b evaluation) to the state for a water quality certificate (most states have taken over the permitting part of the Clean Water Act (CWA) from EPA, as allowed by the CWA)). Dumping in the Ocean may be done in EPA designated sites under Section 103b of the Marine Sanctuaries Act.

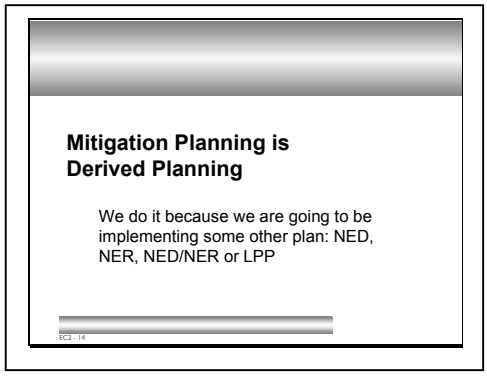
Another useful way to group resources types is by major Corps' purpose:



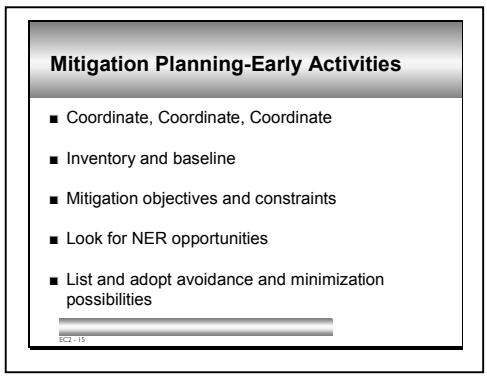
1. Flood control projects usually impact ecological, aesthetic, and cultural resources primarily.
2. Inland navigation likewise tends to impact ecological and cultural resources.
3. Deep draft projects tend to impact marine and estuarine resources, along with water quality.
4. Like other Corps projects ecological restoration can impact cultural resources. By its nature, it should not negatively impact fish and wildlife resources; however, it can in the case, for example, of aquatic restoration that must remove streamside vegetation to return a stream to its original course. The resources that use the streamside vegetation may be significant and require mitigation. This has already happened on some Corps projects.

The real point of slides EC2-12 and 13 is that we have a few players; a few project purposes, and a few types of resources that we have to be alert to. Since Districts tend to have the same types of projects repeated and tend to have many studies going on simultaneously, there is a real opportunity to build trust with the resource agencies over a period of years and over a number of projects. The same problems and opportunities will tend to repeat themselves. Differences will probably continue to exist, but trust and consistency will facilitate case-by-case solutions. Good relations with the resource agencies reward districts that build trust usually.

Mitigation planning is derived planning. We do it because we are potentially going to be implementing some other plan: NED, NER, NED/NER or LPP. Nevertheless it is not much different than any other kind of planning. However, because it has the potential to either stop a project—if we get into a serious dispute with an environmental agency—or at least to increase the costs significantly, we proceed somewhat differently.



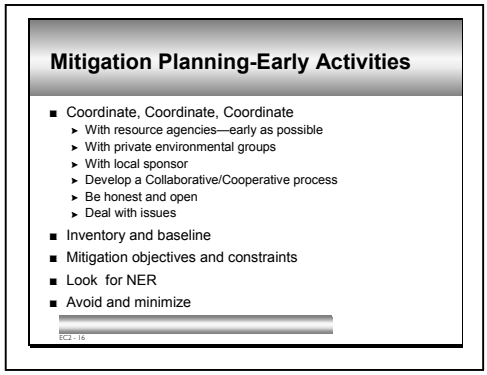
There are five early activities that we want to undertake. Our intent is to build environmental sustainability into our primary plan. In order to do this we need to:



1. Coordinate with resource agencies. Often, based on past coordination we will have a pretty good idea of where they are coming from.

   a. We need to keep our local sponsor on board.

   b. We need to keep private environment groups on board.



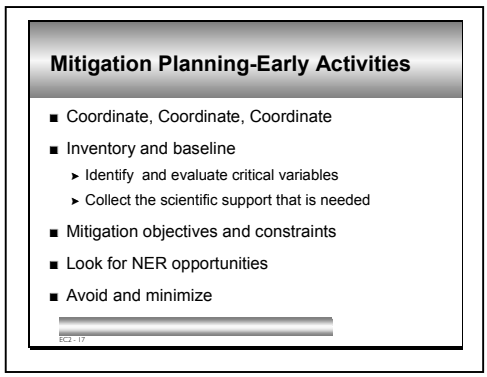
2. We need to get our inventory and baseline data done early, focusing on

   a. Identifying and evaluating critical variables.

      i. The resource agencies will be critical in this endeavor—they are the agency experts

      ii. Our in-house environmentalists will be our interpreters and translators

   b. Collect scientific support that is needed.

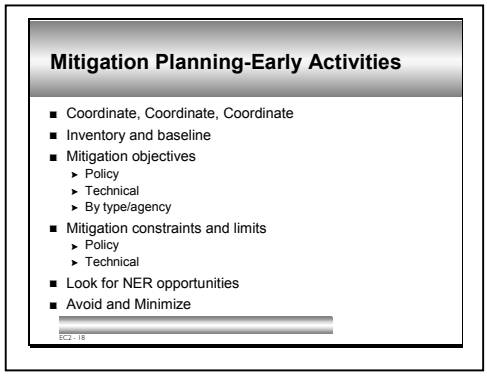


3. Mitigation Objectives

   a. Policy

      i. Federal. An example is "no net loss of wetlands"

      ii. State. Examples include groundwater infiltration zones (New Jersey), agricultural/open space zone and salinity intrusion (Pennsylvania)



      iii. CAUTION: most of these are not absolutes, but they do indicate what the state feels its critical resources are.

   b. Planning

      i. These are site specific. They delineate the resource I might damage, the location of the resource, and the extent of the damage.

ii. They are also categorized by type, especially where there is an agency proponent involved.

4. Mitigation Constraints

a. Policy

i. Federal

1. We only mitigate for direct, primary impacts. We do not mitigate for cumulative effects or remote/ uncertain impacts, induced damages and past damages.

2. We don't mitigate for associated features.

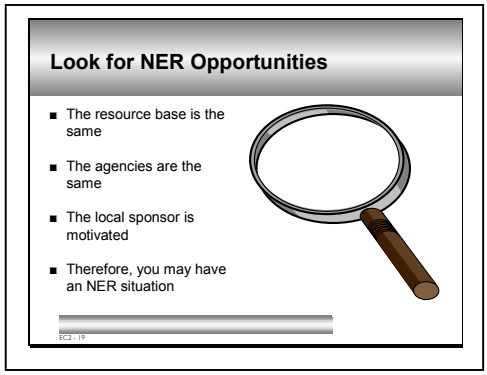
3. We have e a limit of 1% on archeological data recovery (the 1% is Federal cost; beyond that we need a cost sharing partner).

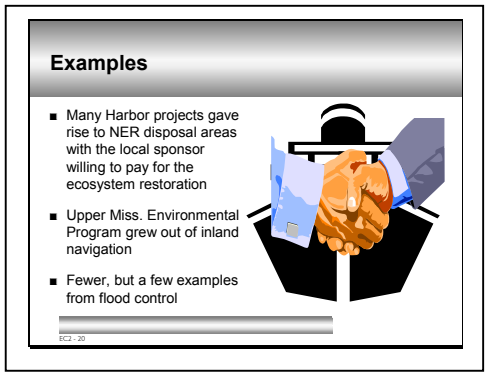
ii. State

1. Coordination with state resource agencies is essential to determine if the particular state or states that you are working with have laws or policies that constrain the possible range of mitigation options open to you.

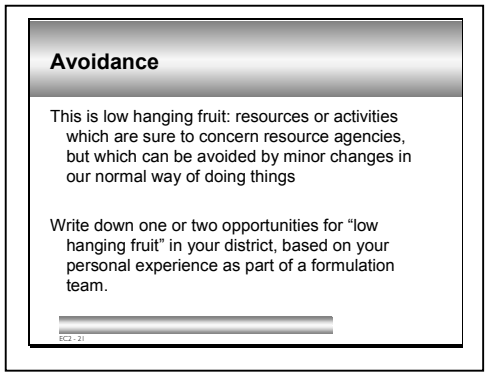
b. CAVEAT: We are discussing constraints on mitigation. Mitigation planning may lead to Planning Constraints for the main project purpose. More likely they will lead to "avoidance objectives": avoid the Dismal Swamp area or Yellowstone Park. An avoidance objective is not an absolute constraint but a red flag.

5. NER Opportunities. Since the basic resources are the same, mitigation planning may surface NER opportunities. When the local sponsor is willing to pay for the primary purpose and the NER purpose, a lot of the cost-sharing tension goes away and the various parties can come to the best solution on a more impartial resource-based analysis. This has happened in numerous harbor navigation studies, although the process has not always been pretty.





6. Avoidance. Early in the process is a good tie to list out avoidance possibilities.



   a. This is "low hanging fruit": resources or activities which are sure to concern resource agencies, but which can be avoided by minor changes in our normal way of dong things.

      i. Environmental windows

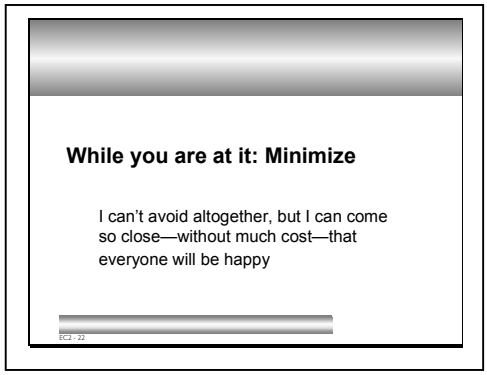
      ii. Turtle screens on dredges

      iii. Location of route of access road

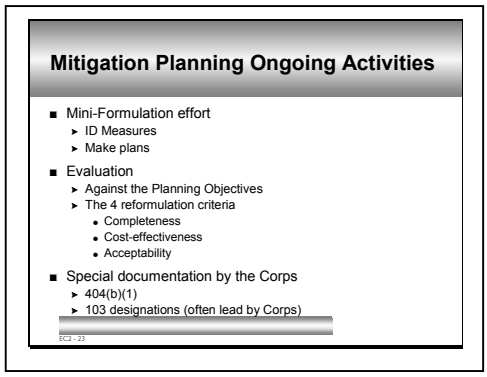
      iv. Time of day restrictions on bridge work

         1. This did not lead to major cost overruns in the bid package (St. George's Bridge, Delaware).

7. Minimize. In this case, I cannot avoid the valued resource altogether but I can minimize my impact on it. For example, where I put my recreation facilities may minimize impacts on fragile, nearly ecosystems; often this costs little in project costs.

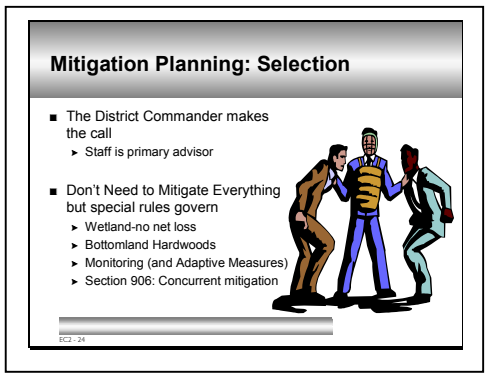


We now look at the mitigation planning which is carried out along with project planning. Such planning represents a "mini-formulation" effort in which in-kind and out-of-kind measures are identified, built into plans, then evaluated and reformulated. The evaluation is against the planning objectives and constraints. Since there are no monetary benefits involved, cost effectiveness is the primary evaluation tool. Outputs may be measured in several way; habitat values are commonly used. The primary plan is not considered to be complete until the mitigation package for it is also completed. Any special documentation, such as 404b(1) must also be completed.



The District Commander is responsible for selecting the mitigation plan. The District Commander has a positive duty to consider the conflicting concerns, if any. Primarily the staff will advise the Commander. The Commander should rely upon his own environmental experts to interpret the concerns of the Resource Agencies.

The Commander does not have to mitigate everything. However:



1. Regulations state that there will be no net loss of wetlands and this is applied project by project.

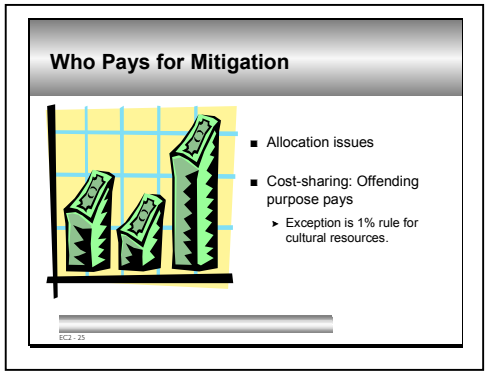
2. Where compensation for loss of Bottomland Hardwoods is undertaken, the law (WRDA 1986, Sec. 906) requires that damages to bottomland hardwoods be mitigated in-kind, to the extent possible. That is also what current Corps policy is. Riparian Hardwoods are not compensation for Bottomland Hardwoods.

3. Corps policy encourages monitoring programs, at least if the cost is reasonable. Often such monitoring is coupled with adaptive measures—if the monitoring shows a problem, the measure for dealing with it has already been agreed upon and is implemented without further

Congressional action. Current Corps guidance limits the cost of monitoring to 1 percent of total project cost and the cost of adaptive management to3 percent of total project cost.

4. Mitigation measures must be implemented before or concurrently with the primary purpose (Section 906, WRDA 1986). Obviously this may conflict with the most cost effective overall schedule, which the Commander is also supposed to determine and adhere to. The former is a statutory requirement and takes precedence.

Who pays for mitigation?

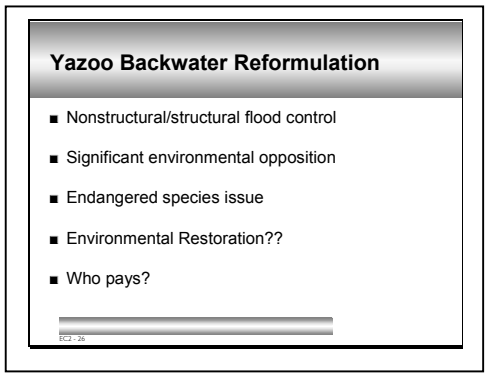


1. Allocation. The first step is to assign specific mitigation feature costs to the primary project purposes. If the costs are not specific, see if they are separable. If not separable, then they are joint. Separable and joint costs are discussed in later sessions.

2. All mitigation costs are assigned to the offending purpose and cost shared in accordance with that purposes rules.

   a. Exception: one percent of project costs may be spent on cultural resources data recovery and documentation, at Federal expense.

The Yazoo Backwater Area project is designed to benefit a 1550-square mile segment of the south Mississippi Delta. In addition to a very large pump, the project consists of structural and non-structural flood control. Through the use of low cost, voluntary measures, like stop logs, the plan will provide food sources for migratory waterfowl.



Currently, the reformulation of the Yazoo Backwater Project is the focal point for discussions at the national level on flood protection, the environment, economic development, and social enhancement and change in the project area. It is strongly opposed by environmental interests and the resource agencies.

The Corps of Engineers is working with state and Federal agencies, local and national groups, and its sponsors to find forward-thinking solutions that meet the needs of all concerned.

FWS has disagreed with the Corps' conclusion that the project is not likely to adversely affect pond berry (Lindera melissafolia), a federally listed endangered species. The FWS believes that the magnitude of reduction in flooding caused by the project is likely to adversely affect the pond berry, and the Corps should initiate formal consultation with the Service to insure that the project will not likely jeopardize the continued existence of pond berry, as required by section 7(a)(2) of the Endangered Species Act.

The project itself is part of the Mississippi River and Tributaries; it is not cost-shared except for lands, easements and rights of way. Therefore all mitigation costs are Federal. The project was formulated for single purpose flood control, but the District believes that there are significant, though "incidental" environmental benefits.

Is there a workable solution? Could this situation have been avoided?

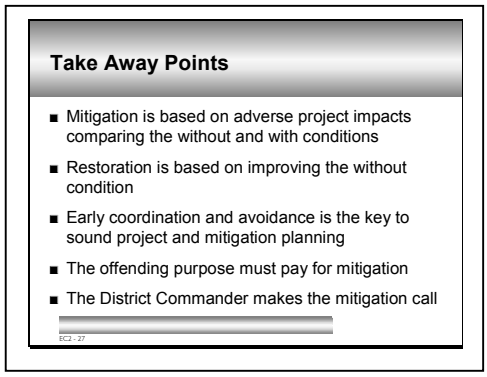
Review Questions

1. When is mitigation likely?
2. Habitat values are 2000 in the with condition and 1700 in the without condition. Is the project an NER project or an NED project?
3. Who pays for the project in #2?
4. List the four major resources for which the Corps must mitigate.
5. Which of the four major resources in #4 has no direct agency proponent?
6. What is the advantage of early coordination with resource agencies?
7. Who pays for mitigation?
8. What is the preferred sequence of mitigation for ecological resources?
9. There is no requirement to fully mitigate except for what resource?
10. Who is responsible for recommending mitigation for a Corps project?

Section Summary and a Look Forward

Section Summary

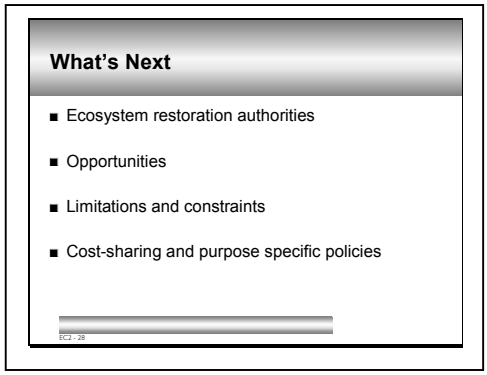
- Mitigation is based on adverse project impacts comparing the without and with conditions.
- Restoration is based on improving the without condition.
- Early coordination and avoidance is the key to sound project and mitigation planning.



- The offending purpose must pay for mitigation.
- The District Commander makes the mitigation call.

Look Forward

We now turn to the project specific purpose. The first one will be the newest one: National Ecosystem Restoration. Module ER 1 will cover authorities and related matters.



References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Environmental Quality – Procedures for Implementing NEPA, March 1998, ER 200-2-2, CECW-PO.

The Civil Works Environmental Desk Reference retrieved from http://www.usace.army.mil/inet/functions/cw/cecwa2/environ.htm.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will be able to define mitigation
    a. Student will be able to distinguish environmental restoration
    b. Student will be able to list the 5 mitigation activities to take early in the study process
2. Student will be able to list the four major resources for which the Corps must mitigate
3. Student will be able to explain the importance of early identification of mitigation objectives including
    a. With and without project conditions
    b. Early Agency Coordination
4. Student will understand who pays for mitigation measures and how the amount of payment is determined
5. Student will know who is responsible for recommending mitigation for a Corps project

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Instructor Notes and Exercises:

This module should take about an hour. It covers basic material that can easily become preachy and dry. Therefore, start with an exercise and engage the students with some of the potential "fun" with the "without" condition. Without analysis takes us a long way, but there are some logical limits. The idea that our project should only pay mitigation for a few years because in the long run the resource would have been lost anyway has only one saving grace: no one outside the Corps could possibly understand what we are saying.

Perhaps more real is the idea that the determination of the without condition becomes a critical test of values. After all, if it is mitigation, someone else pays; if it is restoration, the environmental proponent might have to pay. This is the real point of the questions at Slides EC2-6 and 7. The answers to the questions are: The ABC plan has the most mitigation; the XYZ plan has the most restoration. This answer assumes that the value of a habitat unit does not change over time; it could be argued that the value does change because of relative scarcity in the region. The issue of the potential impact of cost sharing on mitigation determination is picked up again on the Yazoo Reformulation example. CAUTION: do not imply that the resource agencies are "bending" the truth because of cost sharing; rather cost-sharing reinforces their natural and understandable agency biases (remember that the Corps has its own complex set of agency biases

The rest of the presentation is straightforward. The avoidance question at slide EC2-21 might elicit some response, or it might be that the students have zero experience. If you get a "bite", stay with the positive example, even if you have to cut the lecture itself short.

I have tried to arrange the material in a sequence that encourages some fresh ways of looking at mitigation: by resource type and by coordinating agency; as a bridge to NER; and as an ongoing agency relationship.

Slides EC2-6 and 7

This example can be modified easily to illustrate different points. The worse the without condition, the less mitigation is likely to be necessary. This means that the environment would have deteriorated anyway. You could set the with- and restored conditions at the same levels in each area. Then vary the without condition to see how we shift between mitigation and restoration.

Slide EC2-26

There is no sure answer to the questions. However, one possible answer is that the local sponsor could have agreed to pay for the incremental NER measures to enhance and support the Flyway aspects of the project. This is a relatively low cost item. Perhaps the State could have joined the financial partnership. This plus more up-front analysis of the pond berry problem might have made the issue of mitigation seem less pressing. Other possible items include: monitoring and adaptive measures; lowering the rhetoric between project proponents and the resource agencies; and reduced reliance on hardball political solutions. It should also be recognized that the environmental opposition to this project is long-standing and intense. This may be one of those situations.

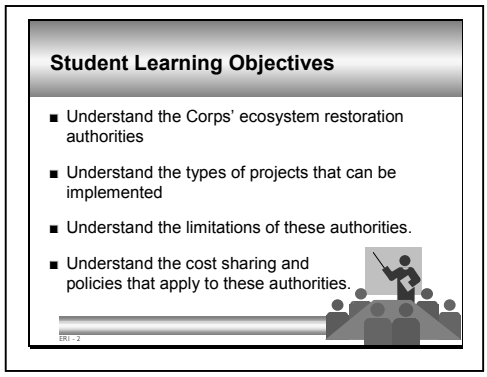
Chapter 4 – Ecosystem Restoration

Ecosystem Restoration. The five modules that comprise this section of the course are designed to provide the novice/apprentice plan formulation specialist with a basic understanding of the plan formulation process as it relates to the authorities available to the Corps to implement ecosystem restoration and to the 6-step Corps planning process.

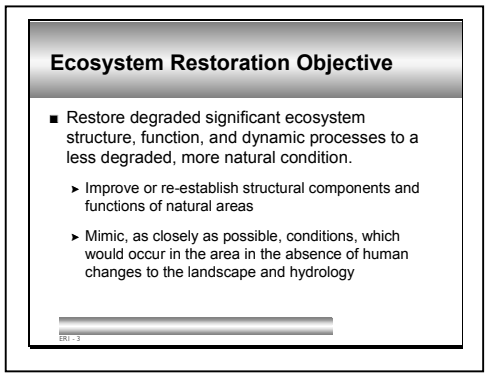
Module ER1: Authorities and Policies

Numerous Federal laws and executive orders establish National policy for the Federal interest in the protection, restoration, conservation, and management of environmental resources. These provisions include compliance requirements and emphasize protecting environmental quality. They also endorse Federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is to be given to the opportunities that projects afford to ecological resources. Recent environmental authorities have enhanced opportunities for Corps involvement in studies and projects to specifically address objectives related to the restoration of ecological resources and ecosystem management.

Learning Objectives



The Ecosystem Restoration Objective



Ecosystem restoration is one of the primary missions of the Corps of Engineers Civil Works program. Engineering Regulation 1165-2-501 describes the Civil Works ecosystem restoration policy. The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Ecosystem restoration efforts will involve a comprehensive examination of the problems contributing to the system degradation, and the development of alternative means for their solution. The intent of restoration is to partially or fully reestablish the attributes of a natural, functional, self-

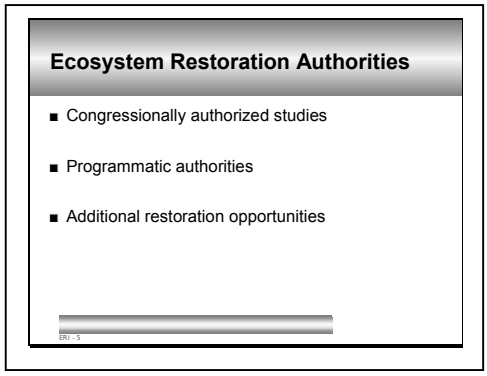
regulating system. Ecosystem restoration projects can range from site specific restoration efforts like the restoration Poplar Island in Chesapeake Bay to very large restoration efforts like the restoration of the Kissimmee River in Florida and the restoration effort for the Florida Everglades and the South Florida ecosystem.

Ecosystem Restoration Policies

Restoration projects should be conceived in a systems context. Rather than limiting objectives to habitat for a single species or resource commodity, such as mallard ducks or bass harvest, ecosystem restoration initiatives should consider interrelationships of plant and animal communities and their habitats in a larger ecosystem context. Ecosystem restoration projects should be designed to avoid the need for fish and wildlife mitigation. They should provide benefits that are in the overall public interest and do not accrue primarily to property owner. Land acquisition must be kept to a minimum. As a target, land value should not exceed 25 percent of total project cost. Projects with land costs exceeding this target level are not likely to be given a high priority for budgetary purposes. Generally, in association with ecosystem health, Corps restoration projects may involve cost effective solutions to improve aeration, temperature, turbidity, acidity, sedimentation, and other water quality parameters. The Corps will not propose projects or features that would result in treating, or otherwise abating pollution problems caused by other parties where they have, or are likely to have, a legal responsibility for remediation or other compliance responsibility. Recreation features should be appropriate in scope and scale to the opportunity provided by the project and the anticipated recreation development must be consistent with the ecosystem restoration objective of the project. Monitoring costs should be included in total project cost; cost shared, and should generally not exceed 1 percent of the first cost of the ecosystem restoration features. For complex projects adaptive management costs of up to 3 percent of total project cost (excluding monitoring) can be included in the project.

Corps activities in ecosystem restoration should concentrate on engineering and other technical solutions to water and related land resources problems, with emphasis on improving degraded ecosystem function and structure. Because self-regulation is a key goal of ecosystem restoration, it is generally more desirable to pursue ecosystem restoration projects that have limited maintenance requirements.

Ecosystem Restoration Authorities

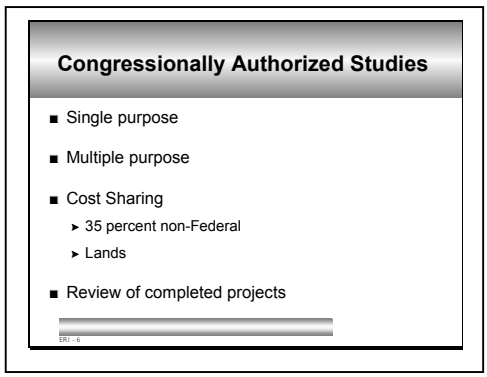


Study authorities follow a hierarchy. For new areas, authorization in a water resources development act is required. For areas previously studied, a resolution can provide for the review of prior reports. In cases where there is an existing project, Section 216 can be used. Ecosystem restoration studies and projects may be undertaken in response to either a study-specific authority or a standing authority in the same manner that flood damage reduction and navigation studies and projects are authorized. Study-specific authorizations may be

provided in resolutions from the House Committee on Infrastructure and Transportation, or the Senate Committee on Environment and Public Works, or included in a public law. A standing authority to review completed projects is contained in Section 216 of the 1970 River and Harbor and Flood Control Act. Section 216 is a standing authority that authorizes studies to review the operation of completed projects and recommend project modifications when found advisable due to significantly changed physical or economic conditions and for improving the quality of the environment in the overall public interest. The Water Resources Development Act of 1986 and subsequent Acts included several authorities that provide guidance relevant to the implementation of ecosystem restoration projects and mitigation components of other water resources projects. These authorities are discussed below.

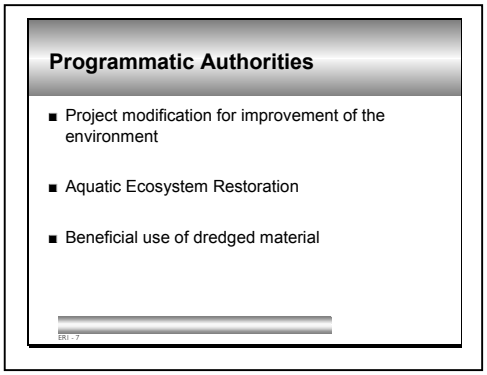
There are several authorities similar to the Continuing Authorities Program (Section 1135 of the Water Resources Development Act of 1986, as amended, for project modifications for improvement of the environment, Section 206 of the Water Resources Development Act of 1992, as amended, for aquatic ecosystem restoration, and Section 204 of the Water Resources Act of 1992, as amended, for beneficial use of dredged material) that authorize the Secretary of the Army, acting through the Chief of Engineers, to plan, design, and construct projects for the purposes of restoring and protecting ecological resources. These projects do not require individual Congressional authorization. The legislative authorities for each of these programs specify annual appropriations limits, non-Federal cost-sharing requirements, and for most, a Federal per project funding limit. These items will be discussed more completely in this module. Opportunities to contribute to ecosystem restoration objectives exist in other areas of the Civil Works program. A number of these opportunities may be addressed through management at existing operating projects. Additional opportunities for ecosystem restoration and protection may also be pursued through existing project authorities for the management of operating projects; e.g., through water control changes, or as part of natural resources management. Additionally, dredging of contaminated sediments may be possible through Section 312 of WRDA 1990.

Individually authorized studies and projects may be either single purpose or multipurpose, depending upon the authorization. As such, some projects may be formulated to address only ecosystem restoration objectives, while others may address both ecosystem restoration objectives plus some other purpose, e.g., flood damage reduction, or a suite of purposes. Multipurpose plans, with both economic and environmental tradeoffs and outputs, can be developed and recommended. During a feasibility study, consideration should be given to the integration of environmental features in the project, in accordance with the guidance contained in ER 1105-2-100, rather than proposing separate projects.



Section 210 of the WRDA 1996 establishes the cost sharing rules for projects authorized after 12 October 1996. Accordingly, the non-Federal share will be 35 percent of the implementation costs allocated to ecosystem restoration. Non-Federal sponsors shall provide 100 percent of lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas (LERRD), and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). The value of LERRD shall be included in the non-Federal 35 percent share. Where the LERRD exceeds the non-Federal sponsor's 35 percent share, the sponsor will be reimbursed for the value of LERRD that exceeds their 35 percent share. Ecosystem restoration projects authorized by WRDA 1996 and prior legislation will be cost shared in accordance with the provisions of the authorizing legislation.

Section 216 of the 1970 River and Harbor and Flood Control Act authorizes investigations for modification of completed projects or their operation when found advisable due to significantly changed physical or economic conditions and for improving the quality of the environment in the overall public interest. Following the initial appraisal, the 216-studyprocess is that of a normal General Investigations study. A feasibility study under Section 216 authority would be appropriate for large scale ecosystem restoration projects linked to existing Civil Works projects, but whose costs would be too large for Section 1135, Section 206, or Section 204 authorities. Additional guidance can be found in ER 1165-2-119.



A programmatic authority is an authority that authorizes an entire set of potential projects, usually without requiring specific Congressional authorization of each individual project. An example is Section 205, which permits Secretary of the Army approval of small flood control projects.

Environmental awareness, coupled with an increased recognition that Corps' activities open opportunities for ecosystem restoration, has lead to a significant increase in specific programmatic authorities for the Corps, as well as related admonitions from the Congress to consider environmental factors and restoration in project development (e.g., Section 907 of the Water Resources Development Act of 1986 says environmental benefits equal environmental costs). See ER1165-1-501 and 502 for more details.

In this course, our intent is to review the more significant of these programmatic authorities. Some of these are covered in the navigation modules as well.

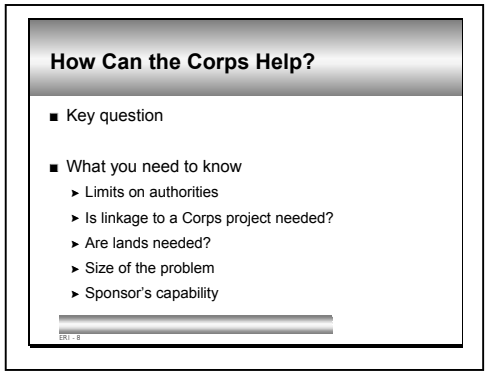
Before we get to the specific programmatic authorities, we should review the nature of programmatic authorities. The nature of programmatic authorities is limited. Congress does not like to delegate its project specific authority over the Corps program(s) and therefore will usually place limits on Secretary of the Army discretion (the Secretary of the Army usually delegates discretion to the Assistant Secretary of the Army for Civil Works (ASACW)).

- Usually there is a project cost limit
  - For example, $5.0 million for Section 1135 and Section 206
- Usually there is a programmatic funding limit per year
  - For example, $25 million for Section 1135 and Section 206

In addition to funding limits, the specific responsibility sharing and application rules are usually tightly crafted.

The specific limits of each authority, both monetary and programmatic, should be strictly adhered to. Congress has trusted the Secretary to live within specific rules. When in doubt, seek higher authority assistance.

Let's face it. You are about to get a little dizzy. There are a lot of programmatic authorities and there is a lot of guidance associated with them and it is hard to remember it all. So it may help you to know that you are not expected to be an encyclopedia.



REMEMBER: as a formulator, it is your job to take these authorities as well as our generic policies for budgeting and project specific authorizations, and advise local interests as to the possible approaches to their specific problem. In other words, you are answering the question: **HOW CAN THE CORPS HELP?**

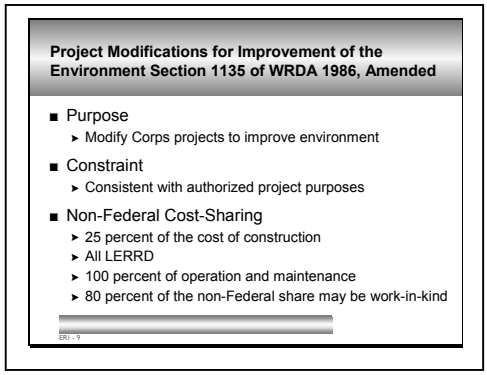
You have to know enough about each authority to recognize that it may apply. For example, Section 1135 is usually used in a flood control context, but it is not limited to flood control.

Therefore, it is helpful to categorize the authorities for your region. For example:

1. What project purpose does this authority apply to? (A lot of the authorities involving direct funding apply to navigation, for example)
2. Do I need a "linkage" to a Corps project? This linkage may be
    a. A Corps project caused the harm (Section 1135). Contrast Section 206, where linkage to Corps project is not necessary.
    b. The authority assumes a Corps project in place (beneficial use of dredge material). In the case of a Corps O&M project: how big a coordination effort is the ecosystem restoration add-on going to take; will it slow the next dredging cycle; or necessary flow releases?
3. How big is the problem? Remember those project and programmatic monetary limits.
4. Will I need additional lands (Corps policy is to minimize land acquisition for ecosystem restoration projects)?
5. Does the potential local sponsor understand the level of financial commitment that may be involved (just because a Corps project "caused" the problem does not mean the Corps will fund restoration without the required local share)?
6. How do I get started? Sometimes what will really help is a little bit of exploration, thinking, coordination and existing data. You really aren't sure how big the problem is; you are not sure what caused the harm, etc. In such cases, consider initiating a preliminary restoration plan under Section 1135 (funding limit $10,000) or an initial appraisal under Section 216 (funding limit $20,000).

Well, there is no avoiding it. The following slides highlight key programmatic authorities.

This section provides authority to review and modify the structures and operations of water resources projects constructed by the Corps for the purpose of improving the quality of the environment when it is determined that such modifications are feasible, consistent with the authorized project purposes, and will improve the quality of the environment in the public interest. If it is determined that a Corps water resources project has contributed to the degradation of the quality of the environment, restoration measures may be implemented at the project site or at other locations that have been affected by the construction or operation of the project, if such measures do not conflict with the authorized project purposes.



A project must fit at least one of the following categories and may incorporate elements that fit more than one of these categories. All projects proposed must be consistent with the authorized purpose.

(1) Modification of an existing Corps project. These are projects that incorporate modifications in the structures; project fee or easement lands; or operations of a permanent water resources project constructed by the Secretary of the Army in response to a Corps construction authority. For projects in this category, there is no requirement to demonstrate that the Corps project contributed to degradation.

(2) Restoration projects may be undertaken at those locations where the construction or operation of an existing Corps project has contributed to the degradation of the quality of the environment. These projects do not need to modify an existing Corps project.

(3) Joint projects. Where a project was constructed or funded jointly by the Corps and another Federal agency, those elements constructed or funded by the other Federal agency may be modified using the section 1135 authority. Where the construction or operation of the joint project has contributed to the environmental degradation, projects may be undertaken which contribute to the restoration of the degraded ecosystem.

The non-Federal share of the costs of section 1135 modifications shall be 25 percent. The sponsor shall provide lands, easements, rights-or-way, relocations, and disposal areas required for the restoration project, which are not otherwise available due to the construction and operation of the existing project. For all section 1135 projects approved subsequent to 12 October 1996, not more than 80 percent of the non-Federal share of the total project cost may be credit for work-in-kind.

Operation and maintenance is usually 100 percent non-Federal. However, if the entire section 1135 modification is on lands for which the Corps has the necessary real estate interest and is responsible for operation and maintenance (i.e. the land has not been leased to another agency for fish and wildlife purposes), the Corps may assume responsibility for the OMRR&R of the section 1135 project modification. The ecosystem restoration features are in addition to authorized project purposes, and they are not for mitigation. Therefore, the costs of the project modifications shall not be allocated to other project purposes, but should be considered solely as ecosystem restoration costs and shared in accordance with the provisions of Section 1135 of WRDA of 1986, as amended.

The purpose of the program is development of aquatic ecosystem restoration and protection projects that improve the quality of the environment, are in the public interest, and are cost effective. The non-Federal share of the costs of aquatic ecosystem restoration projects shall be 35 percent. The non-Federal sponsor shall provide all LERRD required for the restoration project and shall also be responsible for 100 percent of the OMRR&R. Section 210 of WRDA of 1999 states that before October 1, 2003 the Federal share of the cost may be provided in the form of reimbursements of project costs. The guidance implementing this provision is yet to be developed. The entire non-Federal share of the total project cost may be credited as work-in-kind.

Aquatic Ecosystem Restoration
Section 206 of WRDA 1996

- Purpose
  - Aquatic ecosystem restoration that improve environment
- Non-Federal Cost-Sharing
  - 35 percent of the cost of construction
  - Lands, easements, rights-of-way, relocations, and disposal areas
  - 100 percent of OMRR$R
  - 100 percent of the non-Federal share may be work-in-kind

ER1 – 10

Section 204 authorizes the Secretary to "carry out projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance by the Secretary of an authorized navigation project."

Beneficial Use of Dredged Material
Section 204 of WRDA 1992, Amended

- Purpose
  - Habitat restoration using dredged material
- Base plan
  - Least costly disposal method
- Non-Federal Cost-sharing
  - 25 percent of construction cost above the base plan
  - 100 percent of OMRRR for ecosystem restoration
  - No credit allowed for work-in-kind

ER1 – 11

Disposal of dredged material associated with the construction or maintenance dredging of navigation projects should be accomplished in the least costly manner consistent with sound engineering practice and meeting all Federal environmental requirements. This constitutes the base plan for the navigation purpose. If the ecosystem restoration project is part of the base plan, it is a navigation (harbor or inland system) construction or maintenance cost and funded accordingly. Where the ecosystem restoration project is not part of the base plan for the navigation purpose, the base plan serves as a reference point for measuring the incremental costs of the ecosystem restoration project that are attributable to the environmental purpose.

Ecosystem restoration projects under Section 204 are funded as navigation construction or operation and maintenance costs up to the level of the base plan. For costs above this baseline, the non-Federal share of the project shall be 25 percent of the incremental costs associated with construction of the ecosystem restoration project, including provision of all LERRD. The non-Federal sponsor shall also be responsible for 100 percent of OMRRR associated with the ecosystem restoration. No credit is allowed for work-in-kind.

The purpose of Section 933 is the placement of dredged material on beaches in partnership with a state or political subdivision of a state when requested to do so by a state. The Non-Federal Cost-Share is 35% of the incremental cost over the cost of the least costly method of disposal when placement is to obtain economic outputs.

Placement of Dredge Material on Beaches (§933 WRDA 1986)

- Purpose
  - Placement of dredged material on beaches
- Non-Federal Cost-Sharing
  - 35% of the incremental cost over the cost of the least costly method of disposal when placement is to obtain economic outputs

ER1 - 12

The purpose of Section 312 is the removal and remediation of contaminated sediments from Navigable waters. The Non-Federal Cost-Share is normal O&M project cost sharing when project related and 50% when not project related but in navigable waters. The authorities of Section 312, as amended, will not be used to remove or remediate contaminated sediment which are classified as hazardous, toxic and radioactive wastes.

Section 312, WRDA 1990, Environmental Dredging as Amended by Section 205 WRDA 1996

- Purpose
  - Removal and remediation of contaminated sediments from Navigable waters
- Non-Federal Cost-Sharing
  - Normal O&M project cost sharing when project related
  - 50% when not project related but in navigable waters

ER1 - 13

The Federal funding limits for the Section 1135, Section 206, and Section 204 are provided in the table.

Federal Funding Limits

Authority	Project	Annual
Section 1135	$5 million	$25 million
Section 206	$5 million	$25 million
Section 204	N/A	$15 million

ER1 - 14

The Water Resources Development Act of 1986 and subsequent Acts included several authorities that provide guidance relevant to the implementation of ecosystem restoration projects and mitigation components of other water resources projects.

Additional Ecosystem Restoration Authorities

- Section 906 of WRDA 1986 – Fish and Wildlife Mitigation
- Section 907 of WRDA 1986 – Benefits and Costs Attributable to Environmental Measures
- Section 306 of WRDA 1990 – Environmental Protection Mission

ER1 - 15

Section 907 of the Water Resources Development Act of 1986 states that in the evaluation of benefits and costs of a water resources project, the benefits attributable to environmental quality, including improvement of the environment and fish and wildlife enhancement, shall be deemed equal to the costs for measures to produce those benefits. You still need to justify mitigation and restoration based on monetary and non-monetary benefits but the cost of ecosystem restoration measures included in a project will not depress the benefit-cost ratio for purposes with economic outputs. The Corps uses a cost effectiveness/incremental cost analysis to analyze ecosystem restoration project features. This approach will be discussed in detail in module ER4 later in this course. Section 306 of the Water Resources Development Act of 1990 directs the Secretary to include environmental protection as one of the primary missions of the Corps of Engineers in planning, designing, constructing, operating, and maintaining water resources projects. Protection consists of measures undertaken to protect and preserve elements of an ecosystem's structure and function against further degradation. Most appropriate for Corps involvement if Corps expertise is required to avoid the degradation.

Additional Ecosystem Restoration Authorities (Cont.)

- Section 307 of WRDA 1990 - Wetlands
- Section 203 of WRDA 1992 – Voluntary Contributions for Environmental and Recreation Projects
- Section 210 of WRDA 96 – Cost Sharing for Environmental Projects
- Section 212 of WRDA 99 (Challenge XXI)
  - Flood mitigation and riverine restoration program

ER1 - 16

Section 307 of the Water Resources Development Act of 1990 establishes, as part of the Corps water resources development program, an interim goal of no overall net loss of the Nation's remaining wetland base, as defined by acreage and function, and a long-term goal to increase the quality and quantity of the Nation's wetlands as defined by acreage and function.

Section 203 of the Water Resources Development Act of 1992 authorizes the Secretary, in carrying out water resources projects for environmental protection and restoration, or a water resources project for recreation, to accept contributions of cash funds, materials, and services from persons, including governmental entities, but excluding the sponsor.

Section 210 of the Water Resources Act of 1996 established 35 percent non-Federal cost sharing for costs allocated to environmental protection and restoration.

Section 212 of the Water Resources Act of 1999 establishes a program for conducting projects to reduce flood hazards and restore natural functions and values of rivers throughout the United States. The law requires 35 percent non-federal cost sharing for ecosystem restoration and nonstructural flood control. WRDA 86 cost sharing is required for structural flood control. The Congress has not funded this program. Projects consistent with this program can be implemented though specific congressional authorization.

If you have not already, it is important for you to recognize at this point that the whole of the individual Corps' environmental authorities is more than the sum of the parts. In short, Ecosystem restoration is a high priority budget item within the Corps. Of course, specific rules govern specific authorities, such as Section 1135. Nevertheless, there is almost always at least one way to consider NER and often you have several approaches.

Most importantly, you have substantial agency support, so there is a strong likelihood that your creative formulation thinking will be successful.

Implications for formulation of National Ecosystem Restoration Project

- High budgetary priority
- Program more than the sum of its parts
- Many authorities
- Creativity pays off

ER1 - 17

Group Exercise

- Problem
  - Existing WPA Levee has degraded a local creek
  - Local Community wants the creek restored
- Tasks
  - Develop a list of "planning issues"
  - Develop an approach to help the local sponsor within Corps authorities.

ER1 - 18

The ecosystem restoration objective is to restore a degraded environment to become self-sustaining. The more Corps expertise is used in this endeavor—and the less land is—the more likely you will receive funding through the budget process.

The NER objective enjoys a high priority in the budget process.

There are important policy limits on NER. For example, NER cannot be used for mitigation and we don't expect fish and wildlife mitigation to flow from NER projects. Ecosystem restoration projects should be designed to avoid the need for fish and wildlife mitigation. Close coordination with the resource agencies and higher authority will be required when mitigation for an ecosystem restoration project is needed.

Summary

- Authorities
- Implementable projects
- Limitations
- Cost Sharing and policies

ER1 - 19

There are many program authorities, especially in the dredging area, which you can use without specific project authorization from Congress. Each of these programs has their own rules, limits, cost sharing, and funding sources.

As a formulator, you need to be aware of the various authorities in order to better serve your client/partner/sponsor. The authorities will also limit what projects, as to size, linkage and type, you can formulate.

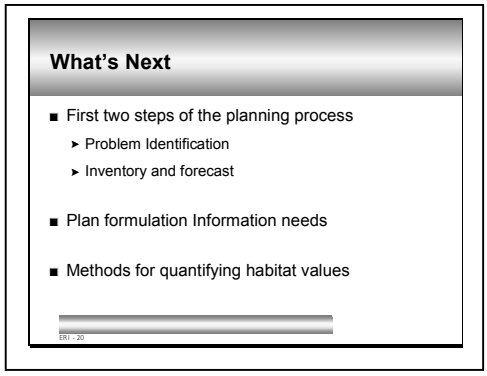
The authorities will also control cost sharing. Whatever the specifics, local responsibilities are significant for the ecosystem restoration plan.

Review Questions

1. What is the purpose of National Ecosystem Restoration?
2. What is the budget priority of National Ecosystem Restoration?
3. What is the cost sharing for National Ecosystem Restoration?
4. Name the major 2 programmatic authorities which pertain to non-navigation situations.
5. Is there any programmatic authority I can use for a major restoration project involving maintenance dredging or must I seek Congressional modification of the existing project.
6. Can I add recreation features to ecosystem restoration projects?
7. Is there mitigation for Ecosystem Restoration projects?
8. What additional restoration authorities are there beyond the regular program and programmatic authorities?
9. What do all these authorities mean to me as a Formulator?
10. How does ecosystem restoration relate to watershed planning?

Section Summary and a Look Forward

The next three modules will discuss plan formulation for ecosystem restoration projects in the context of the Corps 6-step planning process. The first module (ER2) will focus on the first two steps of the planning process (problem identification and inventory and forecasting). We will also cover information needs for plan formulation and the methods that are used to quantify habitat values.



References and Suggestions for Further Reading

Water Resources Policies and Authorities – Digest of Water Resource Policies and Authorities, July 1999, EP 1165-2-1, CECW-AG.

Water Resources Policies and Authorities – Civil Works Ecosystem Restoration Policy, September 1999, ER 1165-2-501, CECW-A.

Water Resource Policies and Authorities – Ecosystem Restoration – Supporting Policy Information, September 1999, EP 1165-2-502, CECW-A.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P, Section U.

Selected Notes to the Instructor

Student Learning Objectives:

1. The student should understand the authorities available to the Corps to restore degraded ecosystems
2. The student should understand the types of projects that can be implemented with these authorities
3. The student should understand the limitations of each of these authorities
4. The student should understand the cost sharing and purpose specific policies that apply to each of these authorities

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Instructor Notes and Exercises:

The learning objectives for this module are shown above and again below with slide ER1-2. This module, module ER2, Problem Identification/Inventory and Forecast for Formulation, module, ER3, Formulation – Measures and Strategies, ER4, Reformulation – Optimization, Incremental Analysis, and Selection of the NER Plan, and XER, Incremental Analysis Exercise with IWR PLAN make up the ecosystem restoration section of the course and are very closely related. Accordingly, you have flexibility in allocating time between the five modules provided all the material is covered and the total time for the two modules does not exceed 4 hours. You have some flexibility to adjust the start time for lunch, based on the flow and tempo of the class. This module provides the basic background on the Civil Works ecosystem restoration authorities that the student will need for the remaining modules in the ecosystem restoration portion of the class. Specifically, this module is designed to review the Corps' ecosystem restoration authorities and to highlight the project specific policies that impact formulation. The focus of this module is on the process a planner must go through under the different authorities to get to a project. Specific project examples will be used to highlight the significant plan formulation aspects of the different authorities and the opportunities that these authorities present to restore degraded habitat and to formulate acceptable plans.

Slide ER1-2
Briefly discuss the objective of ecosystem restoration.

Slide ER1-4
Briefly discuss ecosystem restoration policies.

Slides ER1-9 to 16
Go through this quickly. It is hard for the student to retain and the student will have to research it again in a real life situation.

Slide ER1-18
Exercise ER1.1 Group Exercise
The following exercise should be done in teams. It would be very helpful if EP 1165-2-502 were available, one for each group.

Local sponsor walks in the door. She is concerned that the old WPA levee, built in 1937, has really messed up the natural beauty of the creek over a 4-mile stretch. This is really hurting the potential for tourism and retirement homes that the Town of White Mountain is relying on to replace the decline in mining in the region. This creek is quite an eyesore, especially in contrast to the beautiful woods in the vicinity. The creek has become overgrown with time and she doesn't think there is much flood control left. The State Fish and Game folks tell her that historically this stretch of creek was the most productive in the region, but the hydrologic regime was blocked by the levees.

How Can the Corps Help?

Break into teams, hopefully interdisciplinary (or at least with students who have some experience in NER planning). Your task is to come up with a list of "planning issues" and an approach to help the local sponsor within Corps authorities.

Hopefully the student's will recognize several issues:

1. Is this a Corps project and therefore, for Section 1135, is there linkage?
2. If there is not a Corps linkage, does Section 206 apply?
3. Neither local economic development nor recreation is the purpose of ecosystem restoration, so the sponsor will have to recognize that our solutions will be geared to a healthy and self-sustaining restored ecosystem. Planned growth or extensive recreation may conflict with the Federal objective and jeopardize our involvement
4. We will have to see about the flood problem and the levee effectiveness. Section 1135 does not allow us to abandon prior purposes.

At this point, we don't have a good feel for how big the problem is, but four miles of stream can be expensive to restore. Given the uncertainty of Section 1135 applicability, we should probably be leaning toward a new study authority (we should check on Section 1135 and Section 216 as funding sources for more exploratory work; Section 22, the old standby, may also be a good vehicle). Note that Congress has not funded the Section 212 program.

The Fish and Game statements offer some hope that the restoration issue is real. We'll have to see how significant they regard the degradation.

Finally, don't forget that there will be a local share for this project (and maybe for the study too). The potential sponsor needs to know this now, so she can bail out now without any embarrassment.

What did you find out? Can you use any of the continuing authorities? What about our overall policies for restoration (did you remembered that Section 212 has not been funded). Did you find that ecosystem restoration is incompatible with local goals and therefore did you turn the potential sponsor away? What do you think your chances are of finding a Federal interest in this situation? Do you think the local sponsor is a viable financial partner; does this matter at this time (HINT: Yes).

Obviously you don't have enough facts to solve the problem. But you do have enough facts to get started exploring issues and checking out funding sources for further study. You probably can compete for a new study start through the budget process, even if nothing else is available. Ultimately, it looks like you will wind up in the regular program (you will need a specific authorization for your project). And don't overlook the possibility of a multipurpose study if flooding is still a legitimate concern in the region.

Slide ER1-19

The ecosystem restoration objective is to restore a degraded environment to become self-sustaining. The more Corps expertise is used in this endeavor—and the less land is—the more likely you will receive funding through the budget process.

The NER objective enjoys a high priority in the budget process.

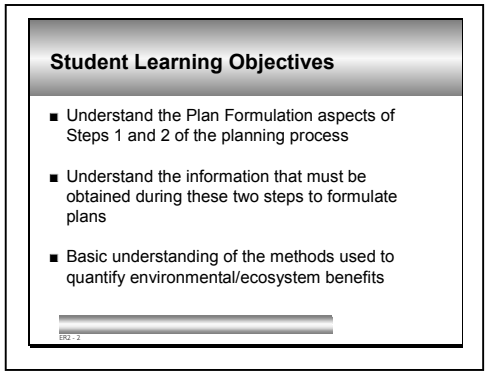
There are important policy limits on NER. For example, NER cannot be used for mitigation and we don't expect fish and wildlife mitigation to flow from NER projects. Ecosystem restoration projects should be designed to avoid the need for fish and wildlife mitigation. Close coordination with the resource agencies and higher authority will be required when mitigation for an ecosystem restoration project is needed.

There are many program authorities, especially in the dredging area, which you can use without specific project authorization from Congress. Each of these programs has their own rules, limits, cost sharing, and funding sources.

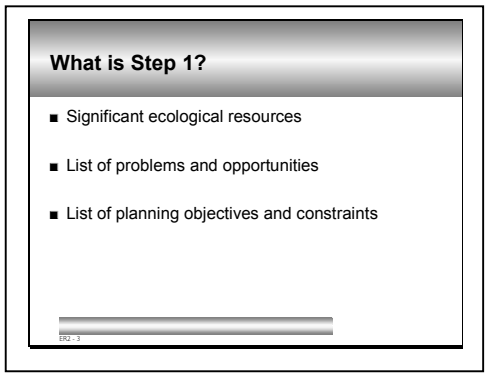
As a formulator, you need to be aware of the various authorities in order to better serve your client/partner/sponsor. The authorities will also limit what projects, as to size, linkage and type, you can formulate.

The authorities will also control cost sharing. Whatever the specifics, local responsibilities are significant for the ecosystem restoration plan.

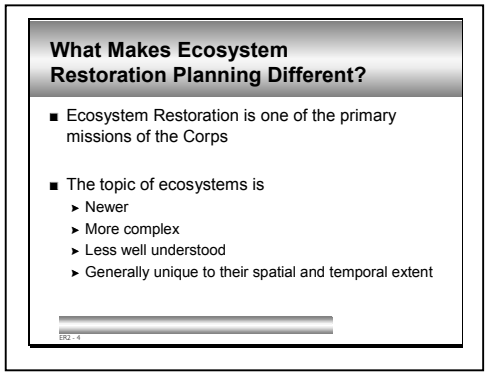
Module ER2 - Problem Identification/Inventory and Forecast for Formulation



Step One



Corps planning studies follow the established 6-step process that is defined, explained and illustrated in the Planning Guidance Notebook and the Planning Manual. All projects start with Step 1 – Identifying Problems and Opportunities. This is the step where obviously problems and opportunities are identified with the outcome being the project objectives and constraints. Planning ecosystem restoration projects have another component in Step 1 that set it apart from the other type of planning projects. The difference is significant ecological resources. Without significant ecological resources there would not be a need for an ecosystem restoration project. Only significant resources define problems of interest to ecosystem restoration studies. These problems and opportunities lead to the formation of objectives and constraints that are used to guide and direct the planning process.



Public interest regarding environmental conditions has lead to the development of environmental laws and legislation. In response, the Corps has been assigned ecosystem restoration as one of the primary missions of the Corps. Ecosystem restoration planning is intended to restore the condition of significant ecological resources.

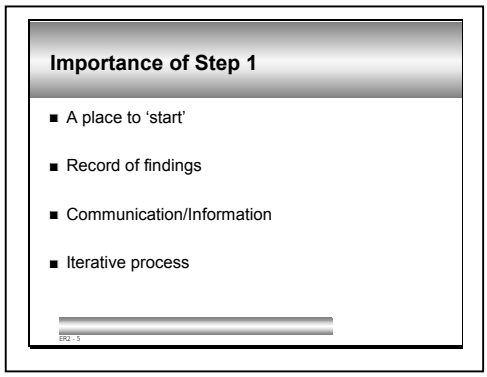
Chapter 2 paragraph 2-2 b. of ER 1105-2-100 states:

> *The Corps objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Contributions to national ecosystem restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indexes (but not monetary units). These net changes are measured in the planning area and in*

the rest of the Nation. Single purpose ecosystem restoration plans shall be formulated and evaluated in terms of their net contributions to increases in ecosystem value (NER outputs), expressed in non-monetary units.

Ecosystem restoration planning is a relatively 'new' concept and it is taking time to define and establish the Corps approach. Also, it is more complex than the other types of planning efforts. Complex in that the entire planning process begins with the significant resource. Not just a resource, but a significant resource. We will elaborate on what a significant resource is further on in this module. Also, ecosystem restoration studies require knowledge and skills beyond those associated with basic planning. For example, the planner needs an understanding of the biology of significant species and ecology. The complexity and newness of ecosystem restoration add to the issue that ecosystem restoration is less well understood than the other study types. More over, complexity is due to the fact that nature presents many uncertainties and external effects that we cannot control or anticipate.

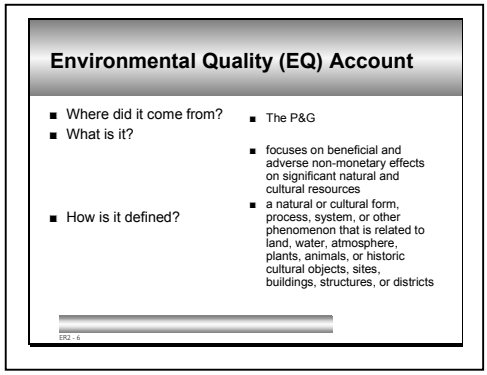
Importance of Step One



As with all study types, step 1 is the place to start. It is a point of reference to establish what the problem is and how to fix it. From step 1 the entire planning process will emerge. Not only will problems be identified but also the interested parties, stakeholders, and appropriate federal and state agencies. Open communication and current information between all parties facilitates the execution of an effective planning process. But perhaps most important to realize is that step 1 is a starting point and what is identified and discussed in the beginning will most likely change as more information becomes available. It is an iterative process and the early steps in the process must be revisited. However, if the study team does not do a good job identifying and defining the objectives and constraints, the rest of the planning process can be undermined.

Environmental Quality Resource

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) established the environmental quality (EQ) account that focuses on beneficial and adverse non-monetary effects on significant and cultural resources. The P&G defines EQ as a natural or cultural form, process, system, or other phenomenon that is related to land, water, atmosphere, plants, animals, or historic or cultural objects, sites, buildings, structure, or districts; and has one or more EQ attributes. EQ attributes, in turn, may be ecological, cultural, or aesthetic.

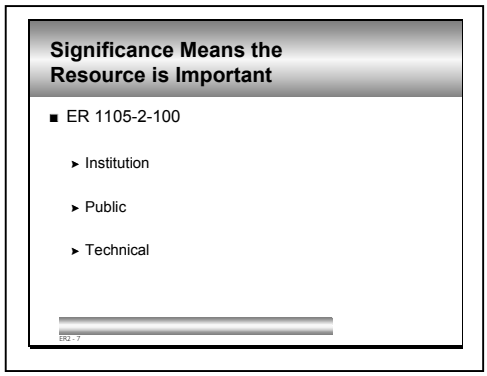


Ecological attributes are components of the environment and the interactions among all its living (including people) and nonliving components that directly or indirectly sustain dynamic, diverse, viable ecosystems. This includes functional and structural aspects of the environment. Cultural attributes are evidence of past and present habitation that can be used to reconstruct or preserve human lifeways. This includes structures, sites, artifacts, and environments. Aesthetic attributes are perceptual stimuli that provide pleasant surroundings for human enjoyment and appreciation. This includes sights, sounds, scents, tastes and tactile impressions. Ecological attributes of the environment are the focus of the Corps ecosystem restoration program.

A significant resource is integral to ecosystem restoration plans. Its condition presents a problem or improving its condition presents an opportunity. Objectives, the things a plan must do, involve significant resources, as should constraints, the things a plan must avoid. A significant resource is an explicit part of the decision making process. Decisions will alter the conditions of significant resources.

Significance Means the Resource is Important

A significant resource is one that is likely to have a material bearing on the decision making process. That means it plays an important role in the problems and opportunities The Nation, a region, or community faces. Significance means the resource is important. That importance can be recognized in one of three ways: institutionally, publicly, or technically. The importance of a resource may be recognized in the laws, programs, policies, actions, and intentions of public agencies or private groups.



The Endangered Species Act of 1973 formally expresses the importance of threatened and endangered animal and plant species. Corps policy identifies ecosystem restoration as a high priority budget output. State and local budgets allocate funds to restore, protect, preserve, enhance and create environmental resources. Many private organizations from the National Audubon Society to the many local zoological societies created specifically to recognize the significance of resources and to bring that significance to the attention of others. These are all examples of institutional recognition of significant resources.

A resource's importance may come to light because some segment of the general public recognizes its importance. When the mottled ducks disappear from a marsh where they have lived for years, you can expect controversy. There will be people who care about the ducks. They may be hunters, wildlife conservationists, bird watchers, or neighbors. The resulting controversy results in public recognition of the importance and significance of the resource.

Save the Bay, Save the Whales, and similar support groups have emerged globally and they interact with all levels of government in the United States. These groups are distinguished from the institutional groups above by their volunteer nature and grass roots origins. The existence of a support group is a clear expression of the public's judgment that a resource is significant. Few activities are as assured of leading to conflict as an attempt to develop land that has been devoted to natural uses. Controversy over the use of resources is a dependable indicator of a resource's importance. Opposition is another indicator of public recognition of a resource's significance. When a segment of the public says that a resource is important that is a public recognition of importance.

Ecological and environmental sciences, human and animal health sciences, and the biological and life sciences, are all capable of pointing out the importance of an environmental resource to us. Science has provided us with a wealth of information about how ecosystems and other natural and physical systems function. Science tells us wetlands are the kidneys of vast and varied ecosystems. Science has identified the temperature, pH and dissolved oxygen ranges in which a small mouth bass can survive. Science-based habitat suitability models publish lists of resources important to the survival of specific species of wildlife. The Natural Systems Model used for the Everglades Restoration Study has demonstrated the importance of having the right quantity of water in the right place at the right time. These are examples of the technical recognition of the significance of an environmental resource.

Institutional, public and technical recognition of a resource's importance are often interrelated. People often come to recognize the importance of a resource because of its scientific importance. When the sediment load in a stream changes, when the salinities in a marsh change, when the flow in a stream changes, the delicate balance of the ecosystem is disrupted. The changes in the ecosystem may result in changes that capture the public's attention; scarcity of once abundant fish species, less biodiversity in plant species, the disappearance of ducks and so on. As the causes of these noticeable impacts are identified, people begin to care about sediment loads, salinities, flows and such things. Institutions often respond to the public's concerns with laws and regulations aimed at preventing damaging actions or encouraging protective actions. Thus, some resources are recognized as significant for more than one of these reasons.

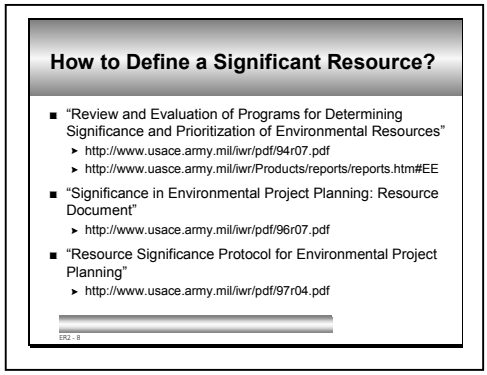
In summary, a resource can be important because science tells us it is important. It can be important because some group has taken some official action to stress its importance. Or a resource can be important because people think it is important. Thus, we can use a three-dimensional space of resource importance based on three kinds of recognition to help us think about and judge the significance of a resource. If a resource is significant for any one of these reasons, it is significant for an ecosystem restoration study. Being significant for two or three reasons lends no greater gravity to a resource. A significant resource is a significant resource.

The identification of resources for a planning study depends entirely on one's level of resolution. Are we looking at ecosystem level resources? When setting National priorities and establishing programs, the answer may well be yes. When planning on a landscape level we may resolve down a level. In a watershed study we may define resources at yet another level of resolution. For a very localized Section 1135 study we will be yet at another finer level of resolution.

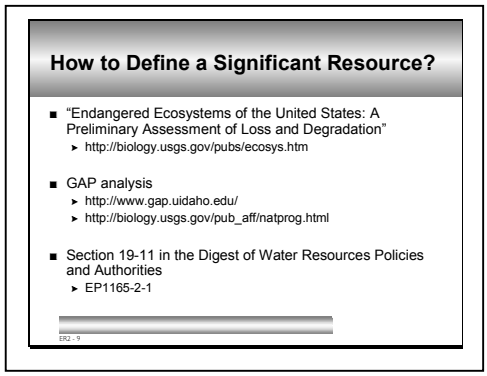
How we define resources in a study, to a great extent depends on one's desired level of resolution. The bottom line is that the distinction of resources, attributes and outputs does not matter as long as it makes sense. And how do we know if it makes sense? If it helps us identify the problems and opportunities the study is going to address, then it makes sense.

How to Define a Significant Resource

The three specific publications listed here provide detailed and valuable guidance to defining significance.



The loss and degradation publication identifies communities by geographic location and categorizes their decline. Appendix A presents decline in area loss and degradation. Appendix B presents decline in reference to destruction, conversion to other land uses, or significant degradation of ecological structure, function, or composition since European settlement. The listed communities are candidates for restoration and protection.



The GAP analysis is a significance resource definition tool at the community or regional level. The by-products of this analysis are distribution of resources maps. These maps are graphic representations that can be provided to decision-makers and the public. The Gap Analysis Program (GAP) is a national effort at the state level. The intent is to provide information on the geographic distribution of native plants and animal species and communities.

Section 19-11 in the Digest of Water Resources Policies and Authorities contains the following text that describe some conditions under which wetlands would be considered significant:

19-11. Wetland Policy. The Corps recognizes that certain wetlands constitute a productive and valuable public resource. Their unnecessary alteration or destruction is discouraged as contrary to the public interest as these wetlands perform functions important to the public interest. Wetlands that perform important public interest functions include:

a) Wetlands that provide significant natural biological functions, including food chain production, general habitat, and nesting, spawning, rearing, and resting sites for aquatic or land species.

b) Wetlands set-aside for the study of the aquatic environments or as sanctuaries or refuges.

c) Wetlands, the destruction or alteration of which, would detrimentally affect natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics.

d) Wetlands, that are significant in shielding landward areas from wave action, erosion, or storm damage. Such wetlands are often associated with barrier beaches, islands, reefs, and bars.

e) Wetlands that serve as valuable storage areas for storm and flood waters.

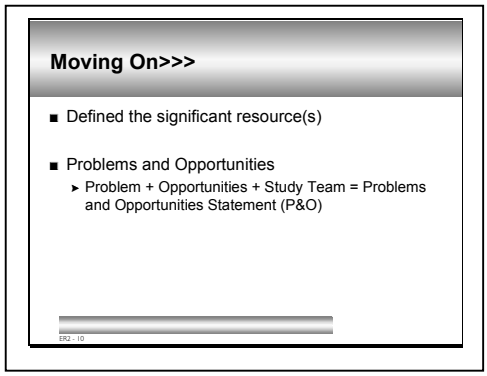
f) Wetlands that are groundwater discharge areas that maintain minimum base flows important to aquatic resources and those that are prime natural recharge areas. Prime recharge areas are locations where surface and groundwater are directly interconnected.

g) Wetlands that serve significant water purification functions through natural water filtration processes.

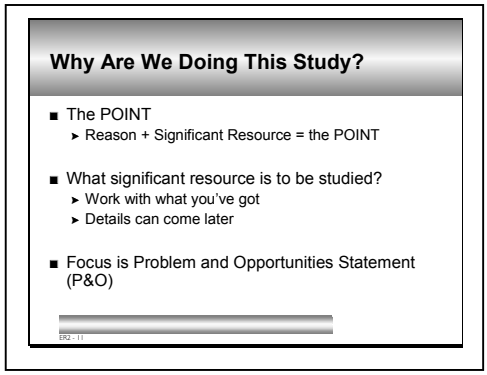
One of the first things you want to do when you start an ecosystem restoration study is determine the significant resources in your study area. At the end of this process, which you complete for the very first time on day one of your study but which extend the length of the study, you are to have a paper. Across the top of the paper is written, "Significant Resources." The paper is dated and identified for your study. On it are listed all the resources you consider significant at the time. This is the first and most important information you'll use to identify problems and opportunities. Expect it to change over the course of your study; that is okay. The current one should always be available to all study team members and stakeholders.

Moving On

So far we have discussed what sets ecosystem restoration apart from other planning studies, significant resources. Now we will discuss how the significant resources are utilized in generating the Problems and Opportunities Statement.



Why Are We Doing this Study?



How do you start a study? You begin by asking "Why?" Why are we doing this study? If your answer involves the words authority, WRDA, resolution, letter, previous studies, District Engineer, and the like you may be technically correct, but you're missing the point. There is a reason for doing the study and it has something to do with significant resources. That is going to make that list mighty handy. More than likely there are problems with some resources or opportunities to do better with others. You begin your study by trying to identify and state those problems and opportunities. In fact, identifying significant resources is actually a part of the problem and opportunity definition. It is, however, an important step in ecosystem restoration planning and has been identified as a separate activity to stress its importance.

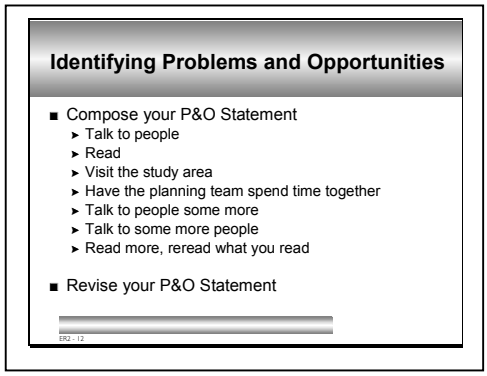
You assemble as many of the study team members as you can identify, you sit down together, take out your list of significant resources and ask, "What are the problems here?" Then you ask, "What opportunities do we have to improve conditions here?" You may start with very little information. You may know nothing about significant resources. You may know no more than what the letter that requested this study says, that is your starting point.

Problems are often the easiest place to start. But while you have your team assembled in one place, you need to think about what opportunities you might have. Write them down too. Never mind that you might not have the authority to 'do' what is listed or that you are not sure anyone "out there" wants to do it. You need a place to start and this is it. Now you have a "Problems and Opportunities Statement (P&O)."

When people ask why you are doing this study you will have a response. The takeaway point here is that you must have a clear understanding of why you are doing what you are doing and analyzing problems and opportunities develops that. At this point it is better to be clear than to be right. There will be time to refine your understand of the problems and the opportunities as the study matures. In time you can be both clear and right. Planning is always best when its purpose is not vague. Its purpose will and should change and evolve. That is a good planning process.

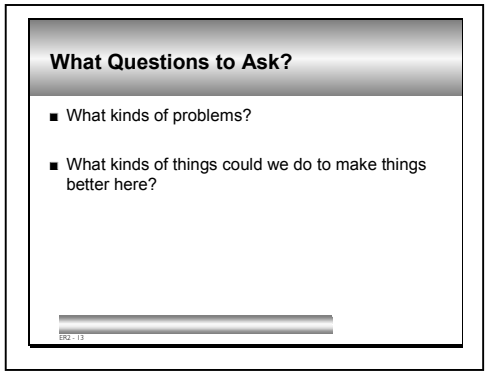
The Problems and Opportunities statement is the "why" of what you are doing. Expect it to change.

Identifying Problems and Opportunities



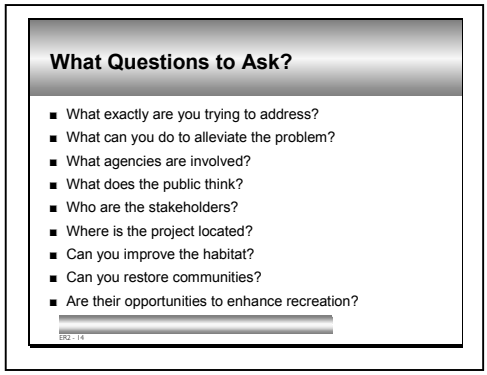
The first step in identifying problems and opportunities is determining "why". The next steps are increasing your comfort level with your initial problems and opportunities statement and your understanding of the problems and opportunities in the study. How do you do that? You talk to people, read, visit the study area, have the planning team spend time together, talk to people some more, talk to some more people and read more, reread what you read. Then revise your P&O Statement. Not only is the process iterative, the individual steps in the process are iterative.

What Questions to Ask?

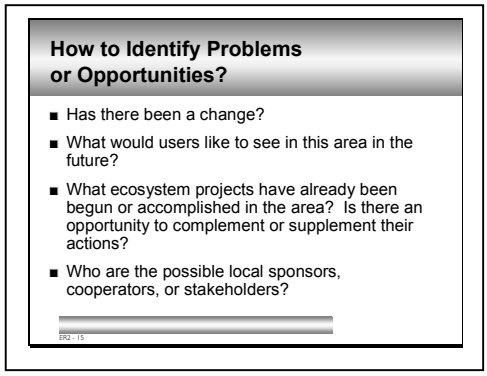


"What kinds of problems are you having here?" is a nice icebreaker when you're in this stage of the study. Don't worry about whether you have the authority to solve the problems or not yet. Be interested in every problem you hear about. Authorities and such can be sorted out later.

"Beyond problem solving, what kinds of things could we do to make things better here?" is another question that can turn up some useful information. Don't worry about evaluating ideas and information in the early going, Just collect them.



How to Identify Problems or Opportunities



When asking 'Has there been a change?', consider the following:

Soil stability (erosion or sediment deposition)
Shore or bank stability
Hydrologic conditions, e.g., flow
Water quality, e.g., temperature, salinity
Vegetation structure or composition
Density of desirable vegetation
Production of undesirable plants or animals, invasion or spread
Fish or wildlife or other biotic populations
A loss or reduction in another desirable ecosystem component

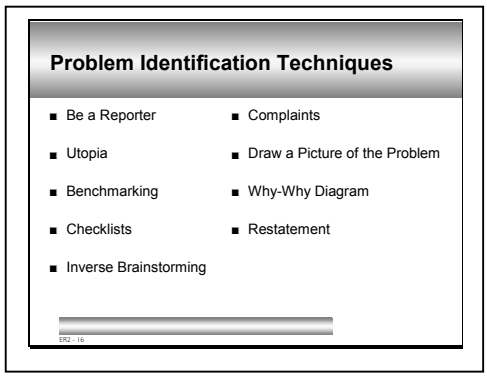
What about 'What would users like to see in this area in the future?' Reponses might be:

More variability in water flow or flooding patterns
More wetland vegetation, higher diversity in the type of wetlands that occur
Existing habitats functioning better as a complex of habitats
Corridors to connect habitats that used to be connected and are now fragmented
Reduction in invasive plant species, and increase in native species

Then, 'Who are the possible local sponsors, cooperators, or stakeholders?':

Who owns the land in question?
Is there a regulatory concern?
Is there a local or regional planning effort?

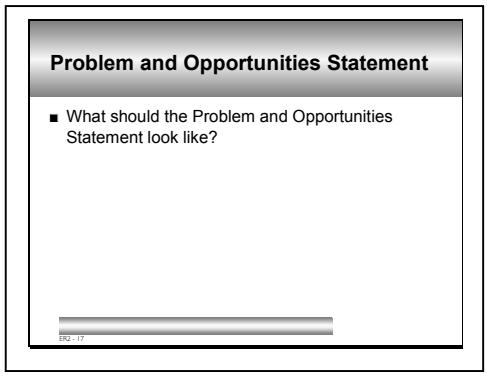
Problem Identification Techniques



There are many ways to identify problems and opportunities. Make sure yours involves that list of significant resources you are seeking to restore. Good planners find their favorite ways and refine them. Even good planners are stymied sometimes and it is helpful to have a few techniques to fall back on to generate ideas. The nine listed are sample techniques that can be helpful in identifying problems and opportunities. A more detailed discussion of the aforementioned problem identification techniques is provided in Appendix B.

You want to make sure the planning effort solves real problems rather than merely eliminating their symptoms. Planning objectives, discussed in the next section, determine what will constitute evidence that the real problems are being solved. The success of your planning effort hinges on a good identification of the problems to be solved. Use these techniques. Invent your own. Be systematic in your approach to this planning step and you will never regret it. Haphazard approaches are often regretted.

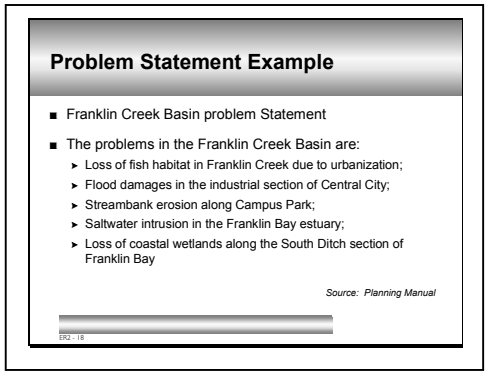
Problem and Opportunities Statement



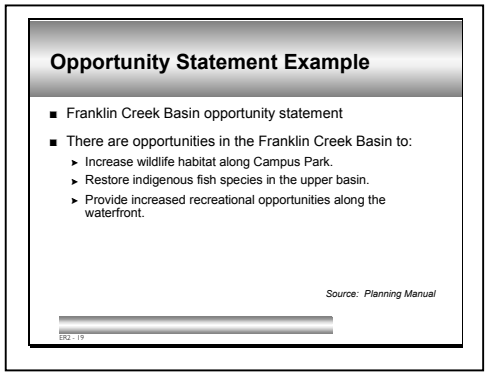
The P&O Statement is intended to focus the team and crystallize the attention of the study participants. It is to enable you to say why you are doing the study. The report can still weave a story and explain the problems and opportunities in as much detail as necessary. But your P&O statement needs to be a clear, concise, and complete reason for the study.

It is written down. It is short, a page or two at most. Each problem and opportunity is succinctly stated in a sentence or two at the most. They are numbered for convenience. There may be an expanded P&O statement. In the expanded statement each sentence may be supplemented by additional details. Eventually, you may develop an expanded profile and description of each statement.

A problem statement need not be elaborate. It can be as simple as the Franklin Creek basin problem statement on slide ER2-18. The definition of these problems will take considerably more explanation. Each problem should be thoroughly developed in the report text. It is important, however, that planners understand exactly what problems they are addressing and that interested parties can see a clear statement of the problem under consideration.

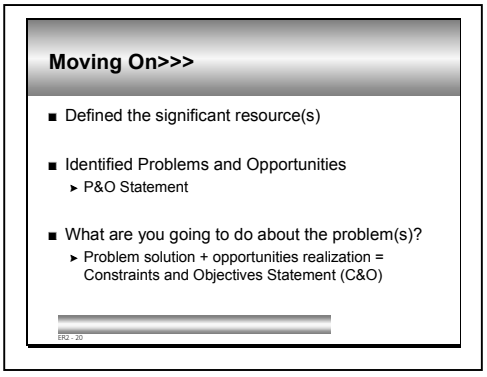


Likewise opportunities should be clearly stated and need not be elaborate. Slide ER2-19 is an example opportunity statement.



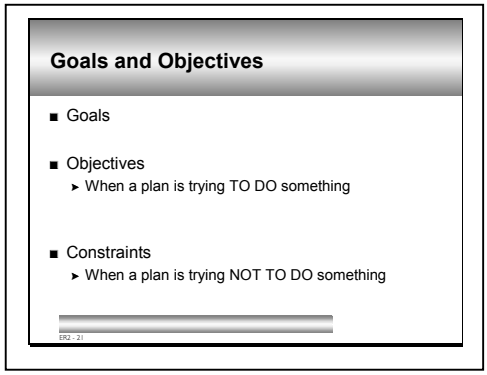
Moving on

Following the definition of the significant resources and identification of the problems and opportunities is determining the constraints and objectives. We look at the problem solution and possible opportunities.



Goals and Objectives

Established policies and directions usually provide the guidance of the project goal. ER 1105-2-100 (Appendix C) states:



> *Ecosystem restoration consists of separable features undertaken to return a degraded condition to a less degraded condition. The goal of ecosystem restoration is to reverse the adverse impacts of human activity and restore ecological resources, including fish and wildlife habitats, to previous levels of productivity but not a higher level than would have existed under natural conditions in the absence of human activity or disturbance.*

Now that you have an idea what the problems and opportunities are, what are you going to do about it? What in general, not specifically, do you want to try to do about solving these problems and realizing these opportunities? You start with listing objectives and constraints as an approach to attaining the goal.

In order for a planning study to attain the goal of improving environmental quality, restoring ecosystem values, or any other goals for that matter, it must achieve its objectives. But what are its objectives? A planning objective is a statement of the intended purpose of the planning process. It is a clear, statement of a desired end that an alternative plan should be trying to accomplish. For example, "Reduce salinity levels of the marsh."

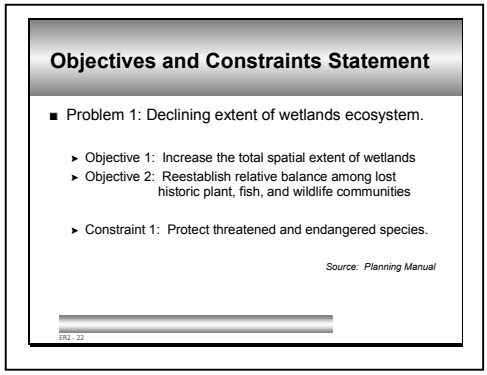
Sometimes a plan is trying to do something, like reduce salinity levels. Other times a plan is trying not to do something. The former, in planning jargon, is a planning objectives; the latter is a planning constraint. Overall, a good objective or constraint is one that works. To work means that people understand it and it is useful to the planning process. Some characteristics of an understandable and useful objective or constraint are that they are specific, flexible, measurable, attainable, congruent, and acceptable.

Objectives identified in step 1 are used in the remaining steps (steps 2, 3, 4, 5 & 6) of the planning process. As stated in the P & G, they are used to let people know what the study is about. In step 2, they are used as guides to the information gathered. In step 3, they are used as reasons for identifying management measures and formulating plans. In step 4, objectives and constraints are used to identify plan effects to be evaluated. In step 5, objectives are used to compare the relative effectiveness of plan qualifications. Finally, in step 6, the objectives and constraints are used as reasons for selecting a plan.

The list of significant resources was the springboard for developing the P&O statement, which is the reason for the plan. The Objectives and Constraints Statement (C&O) tells people what the intent is to do about the problems and opportunities that have been identified.

Objectives and Constraints Statement

How do you identify planning objectives and constraints? You examine values. Look at what is important to people. Where do you start? Start with your resources, your problems and opportunities. Start at the beginning with the study authority. The study authority, where your P&O Statement begins, may provide some clues about what Congress thinks the problems are in your study area. Although they are rarely specific they do provide general categories of problems and opportunities that are suggestive of planning objectives. Another good source to consider is correspondence from non-Federal interests to the Congress requesting the study. These letters generally provide information on the problems and on the objectives on the non-Federal interests.



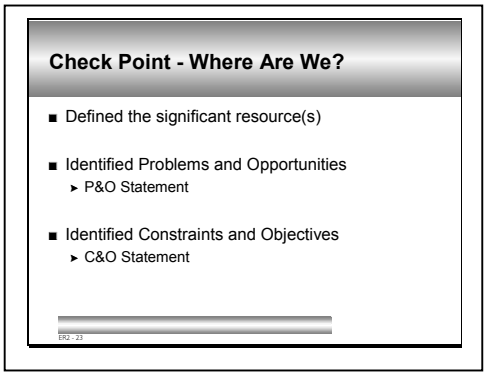
The process is iterative. So be prepared to go through several iterations to 'get to' the objectives and constraints statement. Developing an O&C statement is a team activity. It is not the project manager's job. Like the P&O statement, it requires the team to spend time together in the same place discussing the objectives and constraints. Participation in generating these statements consists of technical input, approval and refinement. In might take an experienced hydrologist to provide some technical information, but everyone on the team can contribute to the approval and refinement of the objectives and constraints.

ER 1105-2-100 Appendix C also states:

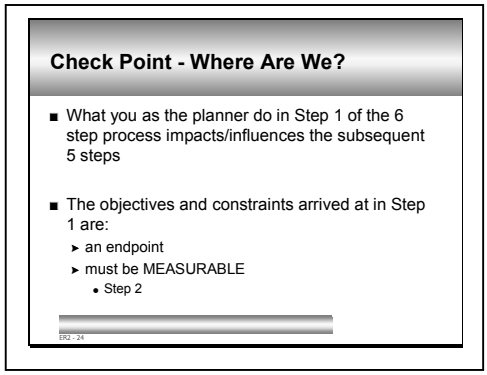
> *Ecosystem restoration objectives are clearly written statements that prescribe specific actions to be taken to improve the ecosystem, or fish and wildlife resources, and describe units of measurement (e.g. habitat units), to be used to evaluate contributions proposed actions make toward the stated objectives.*

Check Point – Where Are We?

Everyone on the planning team should participate in the preparation of these statements, especially the O&C Statement precisely because it is the partnership's mission statement. By getting input from every team member in developing the significant resources, P&O Statement, and C&O Statement you get the team thinking, talking, communicating, and interacting on things that really matter to the study team and the people in the study area. This statement becomes the framework for thinking about the other planning steps and for conducting the study. When problems arise the O&C statement is there to fall back on. It is a constant reminder of what matters most to people and it provides direction for solving problems and taking advantage of opportunities. Plans developed to meet objects and satisfy constraints are plans based on correct principles.

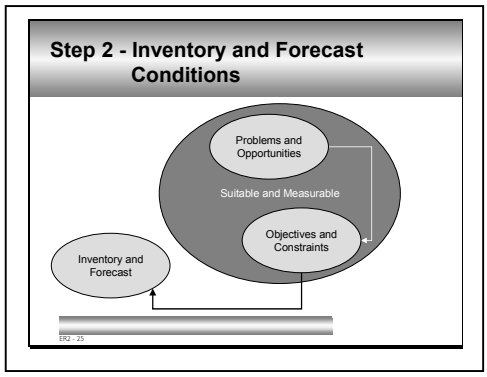


What do you do with objectives and constraints? Use them. Refine them. Use them. They are your guides through the other five steps of the planning process. They are the most important output of the planning process. It is worth recalling that objectives and constraints are based on the problems and opportunities that evolve from the conditions of significant resources. So when we focus on objectives and constraints it is understood that it can only be done if a good P&O Statement has been prepared. Objectives and constraints are to be used throughout the remaining steps.

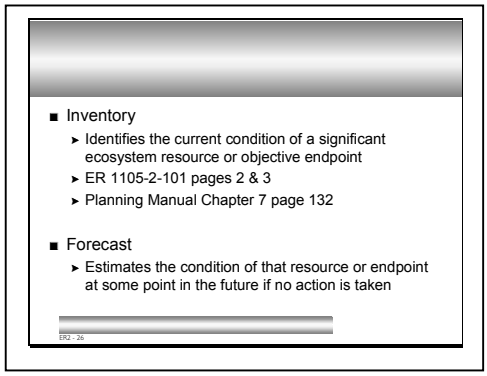


Step Two – Inventory and forecast conditions

Objectives and constraints describe where we want to be, where we want to go. They are endpoints and if we have any hope at all of seeing how well our plans meet out objectives and constraints these endpoints must be measurable. Identifying suitable and measurable endpoints for each objective and constraint and then inventorying and forecasting them are the essence of step two.



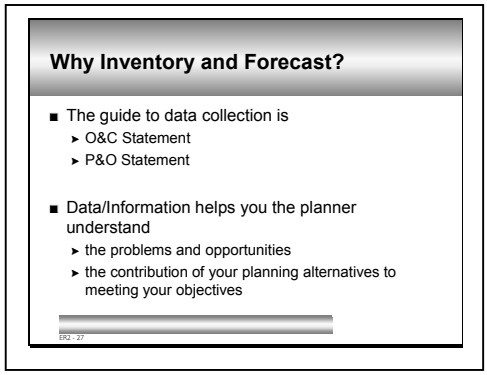
An inventory identifies the current condition of a significant ecosystem resources or objective endpoint. The forecast at this stage of the study estimates the condition of that resource or endpoint at some point in the future if no action is taken.

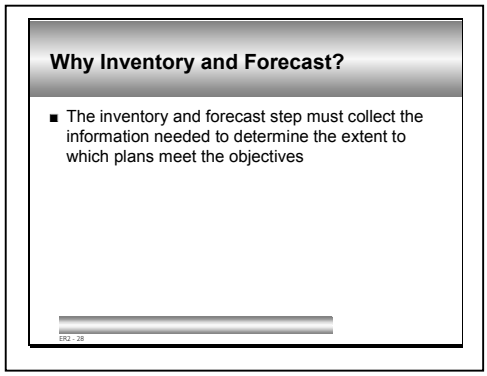


Why Inventory and Forecast?

Thus, in the early stages of the planning process the O&C Statement and the P&O Statement guide your data collection. You need information to help you understand the problems and opportunities and the contribution of your planning alternatives to meeting your objectives. The inventory and forecast step must collect the information needed to determine the extent to which plans meet the objectives.

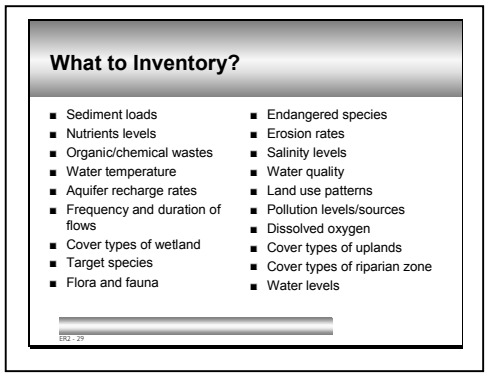
The inventory and forecast step describes the historic, existing, base year, future without project and future with project conditions. Also, this step characterizes and re-defines the problems and opportunities.





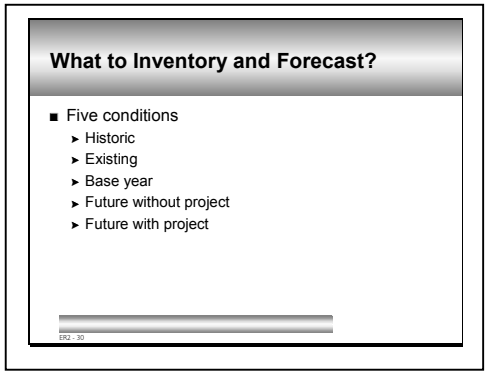
What to Inventory?

What to inventory is based on what has been identified as the significant resource and the objective endpoint. The items on slide ER2-29 give an idea of what can be inventoried. The key to inventorying is items for which data can be collected and analyzed. But the intent is not to just collect data, it is to collect data that is relevant to describing problems and determining that the alternative plans make a difference.

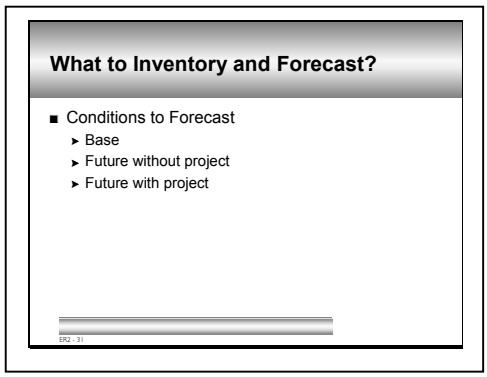


What to inventory and forecast?

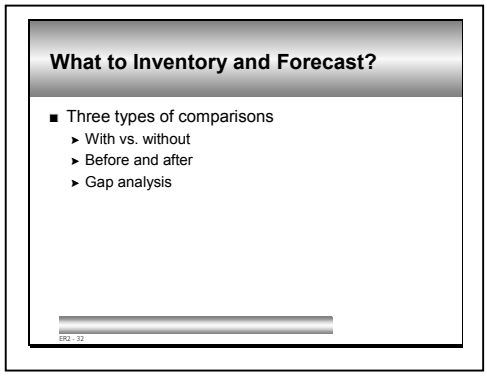
There are five conditions 1) historic, 2) existing, 3) base year, 4) future without project condition, and 5) future with project conditions. The historic condition represents past conditions. Existing are conditions at the time of the study. The base year is the year when the project is complete and fully operational. Future without project is the condition expected to prevail in the planning area in the future if the no-action alternative is selected. The project area's future if no Federal action is taken to solve the problem at hand. Finally, the future with project conditions is the condition expected to prevail in the planning area in the future if a particular plan is implemented.



There are three conditions or target time periods to forecast. The without project condition describes what is expected to happen if no action is taken to solve the problems or take advantage of the opportunities at the site. The with-project condition describes what is expected to happen if the alternative is implemented at the site. The same important resources described in the historic and existing conditions are also described for the various future conditions in order to identify differences among the various futures. The future without project condition is the condition if no action takes place.

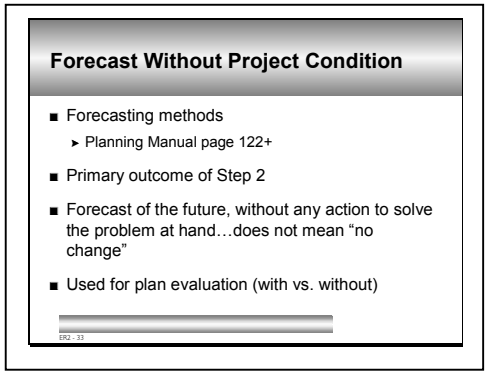


The three types of comparisons are with versus without, before and after, and Gap analysis. Gap analysis is useful in identifying shortfalls or changes from some historical dimension. The general public often thinks in terms of "before and after" analysis that measures an activity at one point in time and again at a later point in time. "Before and after" and gap analysis do not have a cause and effect dimension. "With and without" analysis introduce cause and effect analysis and is always required for a Corps of Engineer study.



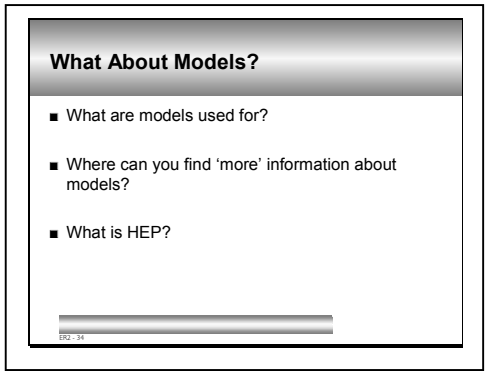
Forecast Without Project Condition

The forecast without project condition is the primary outcome of step 2. It is a forecast of the future, without any action to solve the problem at hand. But keep in mind, it does not mean "no change". Also, the forecast without project condition is used for plan evaluation in the with versus without analysis. The future without project condition forms the basis from which alternative plans are formulated and impacts are assessed.



What are Models Used for?

Models are powerful tools used to help define the problem or in determining forecast conditions. They are used to quantify environmental outputs. Environmental outputs should reflect the planning objectives and provide human valued benefits. ER 1105-2-100 Section V E-33 b (1) states:



> *Selection of Assessment Methods. Many methods and models are available to measure existing ecosystem resource conditions and to estimate future conditions of those resources. Habitat models developed for individual species may have limitations when used to assess ecosystem restoration problems and objectives. They do not consider communities of organisms and typically consider habitat in isolation from its ecosystem context. Single species habitat models may be limiting if used to optimize for a particular species, but they can be useful when carefully applied in the ecosystem context in which the habitat is situated. They can be helpful in identifying important influential functions or structural components for ecosystem projects to address. The assessment methodology chosen for a study should be governed by how well the technique meets the needs of the study goals and objectives and level of detail for a given study. The assessment methodology may include habitat models, or information derived from community or ecosystem assessment using other specifically based methods that are generally accepted by state or Federal resource agencies.*

Where Can You Find More Information About Models?

The Corps Engineer Research and Development Center (ERDC) has assembled several models that are applicable to ecosystem restoration. As powerful and useful as models are, they are dependent upon the input information and human interpretation of results. The results should not be considered the 'answer' to the problem or forecast but used in conjunction with professional experience and judgment. It is highly recommended that you visit their website at http://www.wes.army.mil/el/emrrp/emris/emrishelp.htm.

This is the Ecosystem Management and Restoration Information Systems (EMRIS) site. On this site, the majority of the habitat evaluation models for species and communities and a batch of wetland assessment models are provided.

Of particular relevance to ecosystem restoration are the decision support tools. The website http://www.wes.army.mil/el/emrrp/emris/emrishelp.htm contains information under 'decision support tools' on the selection of classification systems, decision framework on vegetation mapping, selection of wetland assessment methods and habitat evaluation methods. Also, under 'models' are HSI models, Other Species Models, Community Models, and Function Models. The Function Models lists 'Selecting a Wetland Assessment Procedure' click on this choice and then 'Wetland Procedure Descriptions'. The Wetland Procedures lists the following 39 specific wetland procedures:

- AREM – Avian Richness Evaluation Method
- Coastal Method
- CT Method – Connecticut Method
- Descriptive Approach – Wetland Functions and Values: A Descriptive Approach
- EPW – Evaluation for Planned Wetlands
- HAT – Habitat Assessment Techniques
- HEP/HIS – Habitat Evaluation Procedure and Habitat Suitability Indices
- HGM Approach – Hydrogeomorphic Approach
- Hollands-Magee Method – A Method for Assessing the Functions of Wetlands
- IBI – Index of Biological Integrity
- Interim HGM
- IVA – Indicator Value Assessment
- Larson Method – Method for the Assessment of Wetland Function
- ME Tidal Method – Maine Citizens Tidal Marsh Guide
- MNRAM – Minnesota Routine Assessment Method
- MT Form – Montana Wetland Field Evaluation
- NBM – Narragansett Bay Method
- NC-CREWS – North Carolina Coastal Region Evaluation of Wetland Significance
- NC Guidance – Guidance for Rating the Values of Wetlands in North Carolina
- NEFWIBP – New England Freshwater Wetland Assessment Method for the New Jersey Pinelands
- OFWAM – Oregon Freshwater Wetland Assessment Methodology
- PAM HEP – Pennsylvania Modified 1980 Habitat Evaluation Procedure
- PRC – Process for Assessing Proper Functioning Condition
- Rapid Assessment Procedure – A Rapid Procedure for Assessing Wetland Functional Capacity
- Synoptic Approach – Synoptic Approach for Wetlands Cumulative Effects Analysis

- VIMS Method – Technique for the Functional Assessment Of Virginia Coastal Plain Nontidal Method
- Washington State Wetland Function Assessment Method (WAFAM)
- WCHE – Wetland Community Habitat Evaluation
- WET – Wetland Evaluation Technique
- WEThings
- WHAMS – Wildlife Habitat Assessment and Management System
- WHAP – Wildlife Habitat Appraisal Procedure
- WIRAM – Wisconsin Rapid Assessment Methodology
- WQI – Wetland Quality Index
- WRAP – Wetland Rapid Assessment Procedure
- WVA – Wetland Value Assessment

The above list is provided to give you an idea that there are many different tools. Most important though is the point that they are just that, tools. Experience and judgment must be the final factor in the decision. The website and talking with others will provide information and guidance on how, which and when the tools are appropriate and applicable.

What is HEP?

Species-based models of environmental outputs, such as the United States Fish and Wildlife Service (USFWS) Habitat Evaluation Procedure (HEP), are well recognized throughout the environmental planning community. HEP has been applied many times to describe the outputs of a wetland or environmental region, and the model has also been revised quite often or adapted for a particular case.
Just to mention one, HEP/HIS. As stated in EMRIS:

> *The primary purpose is "to document the quality and quantity of available habitat for selected wildlife species. HEP may be used in three planning activities: wildlife habitat assessments (including both baseline and future conditions), trade-off analysis, and compensation analyses."*
>
> *Expertise needed is "team with designated voting members from each of the review agencies: (e.g., U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, State, and applicant/action agency). These individuals must have training and experience in the basic principles of fisheries and/or wildlife biology and be certified in HEP."*
>
> *Applicable habitat types are "most terrestrial, wetland, and aquatic habitats in the United States."*

The intent here is to get the point across that for each of the methods/procedures, information is provided to guide the planner on how they can use the method/procedure and what they would need to know to use it. Also provided on the specific method/procedure page is a contact person(s).

In this section, HEP is referenced as a tool to be used in step 2 of the 6 step planning process to assess baseline and impact (future with and without action) conditions. A HEP analysis is structured around the calculation of habitat units (HU) for each evaluation species in the study area. The unit of measure for this procedure is the habitat unit. The number of HU's is defined as the product of the Habitat Suitability Index (quality) and the total area of available habitat (quantity). The objective of defining total area of available habitat is to delineate only those areas that require Habitat Suitability Index (HSI) determinations. The fundamental step in determining HU's is to estimate or calculate HSI's for each evaluation species. The technique for determining HSI values must be clearly described in a HEP study in order to establish credibility, optimize the usefulness of the analysis in decision-making, and provide a permanent record of the basis for a decision.

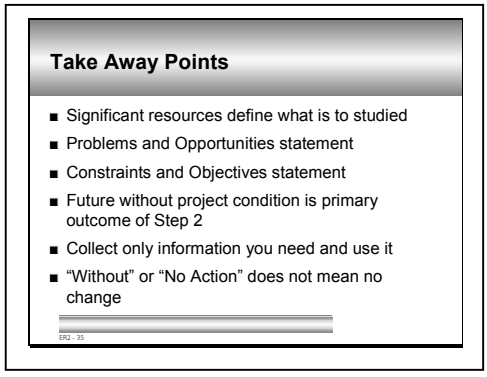
Review Questions

1. What are the three Environmental Quality (EQ) attributes?
2. Why are significant resources identified in ecosystem restoration plan studies?
3. What sets ecosystem restoration apart from other planning studies?
4. What does an inventory identify?
5. What is a commonly used unit of measure for ecosystem restoration objectives?
6. What is the primary outcome of step 2?
7. What should environmental outputs reflect?
8. What are the three planning activities where HEP may be used?

Section Summary and a Look Forward

Section Summary

The list of significant resources and the P&O and C&O Statements, are the first and perhaps most significant products of the planning process. Preparing them is not a task to be accomplished and set aside. With this information you know why you are planning and you know what you are trying to accomplish. This understanding and knowledge form the keystone of the planning process. Now that you have compiled this information, it is your job to use them.



Everyone on the planning team should participate in the preparation of these statements, especially the O&C Statement

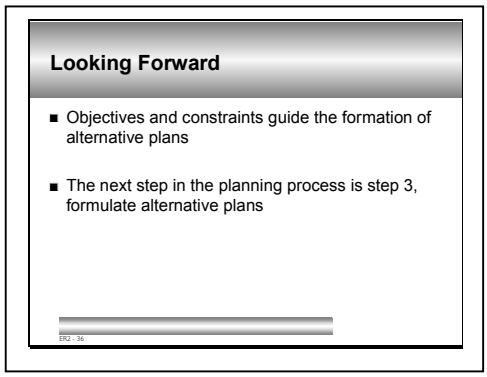
precisely because it is the partnership's mission statement. This statement becomes the framework for thinking about the other planning steps and for running the study. When problems arise the O&C statement is there to direct the study. It is a constant reminder of what matters most to people and it provides direction for solving problems and taking advantage of opportunities. Plans developed to meet objects and satisfy constraints are plans based on correct principles.

Problem and opportunity statements and objective and constraint statements are developed in an iterative fashion. Good ones are current, useful and used. The problem and opportunity statement forms a good basis for developing planning objectives and constraints.

You need information to help you understand the problems and opportunities and the contribution of your planning alternatives to meeting your objectives. The inventory and forecast step must collect the information needed to determine the extent to which plans meet the objectives.

Looking Forward

Objectives and constraints guide the formation of alternative plans. The next step in the planning process is step 3; formulate alternative plans. Plan formulation is guided explicitly by objectives and constraints. The O&C Statement is a concise statement of what you intend to do about the problems and opportunities you face. Formulation is the process of identifying actions that can be taken to achieve your objectives subject to your constraints.



References and Suggestions for Further Reading

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

"Review and Evaluation of Programs for Determining Significance and Prioritization of Environmental Resources", http://www.wrsc.usace.army.mil/iwr/pdf/94r07.pdf, http://www.wrsc.uasce.army.mil/iwr/Products/reports/reports.htm#EE.

"Significance in Environmental Project Planning: Resource Document," http://www.wrsc.usace.army.mil/iwr/pdf/96r07.pdf.

"Resource Significance Protocol for Environmental Project Planning," http://www.wrsc.usace.army.mil/iwr/pdf/97r04.pdf.

"Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation," http://biology.usgs.gov/pubs/ecosys.htm.

GAP analysis, http://www.gap.uidaho.edu/, http://biology.usgs.gov/pub_aff/natprog.html.

Water Resources Policies and Authorities – Digest of Water Resources Policies and Authorities, July 1999, EP 1165-2-1; Section 19-11, CECW-AG.

Project Operations – Environmental Stewardship Operations and Maintenance Policies, November 1996, ER 1130-2-540, CECW-ON.

Ecosystem Management and Restoration Information Systems (EMRIS) site, http://www.wes.army.mil/el/emrrp/emris/emrishelp.htm.

Environmental Database System site,
http://www.pmcl.com/iwred
The Environmental Database System is designed to provide environmental information more easily and effectively. It is composed of two elements, a prototype Corps Environmental Performance Atlas which uses state of the art web mapping capabilities to gather and analyze data, and an Environmental Encyclopedia which provides convenient access to more traditional web based environmental information systems. In the next few years, some of the Encyclopedia data will be integrated into the Corps Environmental Performance Atlas.

The Encyclopedia is a very broad information base. Ultimately to be designed to help Corps planners identify environmental trends and do better, faster, cheaper EA's and EIS's. It will include website linkages and ratings that hold environmental information. The Atlas is a high tech interactive map based database system that can answer questions about the Corps environmental performance. The prototype covers just Corps ecosystem restoration programs (1135, 1103, 204, 206 and 601).

Another significant aspect of the Environmental Database System is the reference library. The Environmental Database System "Reference Library" is a collection of files and web links to documents and information about the laws, policy, and processes involved in assessing the environment, evaluating agency environmental performance, and the planning and managing environmental resources. The following is a list for the website of files and web links.

- General Environmental Information Gateways
- Environmental Law
- Maps, Statistics and Documents
- Evaluating Environmental Performance
- Planning & Management
- Environmental Reports
- Institute of Water Resource Environmental Reports
- Environmental Organizations
- Journals of Environmental Assessment, Management and Policy
- The Government Performance and Results Act of 1993 (GRPA)

Selected Notes to the Instructor

Student Learning Objectives:

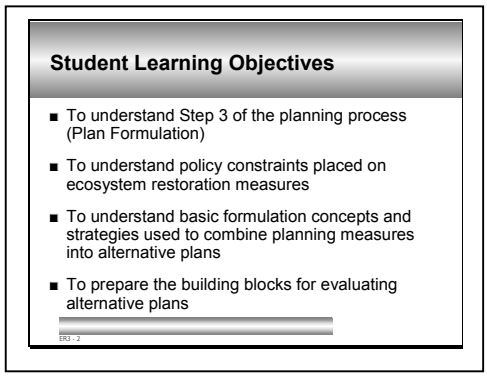
1. Students should understand the plan formulation aspects of steps 1 and 2 of the planning process (Problem Identification and Inventory and forecast).
2. Students should understand the information that must be obtained during these two steps to formulate plans.
3. Students should have a basic understanding of the methods used to quantify environmental/ecosystem benefits.

Instructor Notes and Exercises:

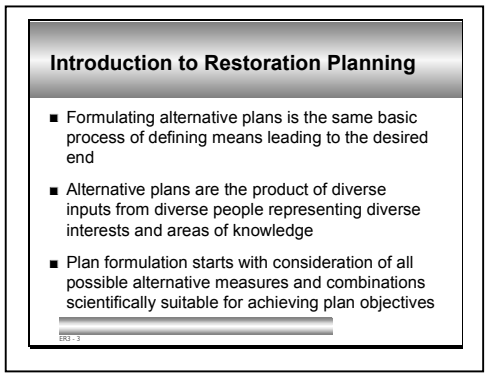
The focus of this module is on the process a plan formulation specialist should go through during the first two steps in the planning process. Specific project examples will be used to highlight the significant plan formulation aspects of steps 1 and 2 of the planning process. In addition to highlighting the plan formulation needs the instructor will provide a brief review of the methods used to quantify habitat values (e.g. acres, HEP, HMG, etc.).

Module ER3: Formulation–Measures and Strategies

The goal of this section is to introduce and familiarize you with plan formulation within the context of ecosystem restoration. After a brief overview, we will review restoration planning policy and policy constraints. Next we will define the components of plan formulation in terms of various concepts that organize a hierarchy of steps that lead to development of ecosystem restoration plans. These concepts will form the building blocks for evaluating the cost-effectiveness of alternative plans, which will be covered in the next section. Emphasis will be placed on the characteristics of measures that are used to create plans that achieve ecosystem restoration planning objectives.



Ecosystem Restoration is a relatively new mission for the Army Corps of Engineers and it brings new challenges and opportunities. Although planning for ecosystem restoration has its own unique requirements, it has much in common with planning for more traditional economic outputs.

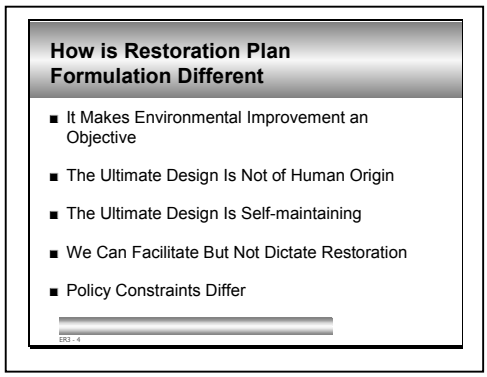


Formulating alternative plans is the same basic process whether the objectives are achieved through creative artificial means (traditional structural solutions), restoring more natural means, or protecting existing means leading to the desired end. For example, the basic choices among planning objectives for sustaining wildlife resources are to artificially enhance natural habitat, to restore habitat to a more natural condition, or to protect existing habitat. Ecosystem restoration is suitable when restoration to a more natural habitat is the most cost-effective choice. This approach differs in numerous ways from approaches that artificially enhance natural services, such as the traditional engineering that has been relied on to improve navigation, flood damage reduction, water storage, and much wildlife-based recreation. This does not mean that ecosystem restoration cannot make use of structural as well as non-structural measures. Engineered structures can be used in a wide diversity of ways to restore ecosystem properties to a more natural ecosystem condition without artificially enhancing the natural services.

Alternative plans typically are the product of diverse inputs from diverse people representing diverse interests and areas of knowledge. Plan formulation deals with the tactics used to corral these inputs and assemble the best set of alternative plans from which to choose the best plan based on specified criteria. If done well, plan formulation casts the widest net possible over candidate alternative plans. Included in that array is the best set of alternative plans based on which are the most complete, effective, efficient, acceptable, and justified plans for achieving project objectives while accommodating project constraints.

Plan formulation starts with consideration of all possible alternative measures and combinations scientifically suitable for achieving plan objectives, regardless of policy constraints, agency authorities, or other preconceived notions of appropriateness. If scientifically feasible, plan candidates should include alternatives approached through means other than ecosystem restoration, such as creation of new

ecosystems or preservation of existing ecosystems, or some combination. While the emphasis in this workshop is on ecosystem restoration requirements and compatible measures, the widest variety of possible alternatives should be included in plan consideration. For that reason, more general references (Yoe and Orth 1996 to start) and other specialized references should be consulted in addition to this handbook.



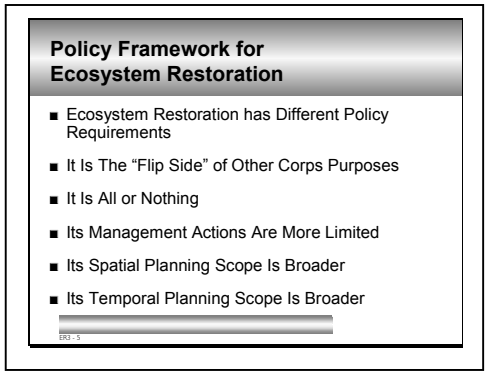
The characteristics of restoration objectives and constraints differ in a number of important ways from other Corps missions. The most fundamental difference between ecosystem restoration and other Corps authorized missions is that more natural environmental outputs are the objectives of plan formulation. Any national economic development (NED) benefit is derived incidentally. For traditional purposes, outputs with monetary value that contribute to National Economic Development are the objectives of plan formulation. Any nonmonetary environmental value generated by the project is incidental. This often means that past measures, taken for navigation, flood-damage reduction or any other NED action, need to be modified to restore the altered ecosystem function and structure to a more natural condition.

In restoration ecology, nature is the ultimate design engineer. Traditional engineering minimizes uncertainty through detailed design standards and protocols. There are no design standards for the ecological engineering of natural ecosystems, only ecological principles in development. The inner workings of artificial water-control structures have been defined in great detail. The inner workings of natural structure are in many ways still a mystery. When it comes to design details, experts on ecosystems are more likely to say, “we don’t know” than are experts on artificially engineered structures. This makes development of planning alternatives more exploratory and less “tried and true” than for more traditional purposes.

Much of what is valued in ecosystem function is the cost-effectiveness of the self-maintaining environmental services they provide. This self-maintenance often makes restorations of natural structure and function more cost-effective alternatives to conventional engineering solutions even when results are less certain. The need is not to rebuild ecosystems, but rather to facilitate restoration of the ecosystem self-design, self-reconstruction, and self-maintenance of the aggregate service value that justifies the initial restoration investment. Engineered structures depend on human design, human operators, and human maintenance.

It is not so important to understand the internal workings and intricacies of design for natural systems as long as we can generally predict system performance in terms of environmental service. Planning alternatives focus on the ways by which artificial measures can most effectively and expeditiously facilitate a self-restorative process. However, nature is full of surprises, and expectations need to be accommodating.

Ecosystem restoration is one of several water resources management purposes assigned in congressional law to the Corps. The same planning regulations apply to all purposes, and the basic planning steps are the same. Just as with all Corps projects, Corps policy requires the benefits of restoration projects to exceed the costs, and all actions and activities need to be in compliance with all laws, including environmental laws.



The ecosystem restoration purpose is the opposite, yet complementary side of other Corps project purposes and activities. To succeed, restoration must reverse, at least in part, the past influence of human action. Instead of creating something entirely new through engineering, it attempts to reestablish a close approximation of some previous more-natural condition, or some part of that previous condition. Restoration requires at least some reversal of past conversion of natural ecosystems by the Corps or others. Instead of human operation and maintenance, ecosystem restoration reestablishes a self-operational and self-maintaining state. Instead of monetary value, it is justified based on non-monetary increase in the quantity or quality of ecosystem resources. Instead of focusing on purpose, while complying with environmental law, ecosystem restoration places natural environmental values first while complying with property, public safety, and other law.

The entire ecosystem is the target of transformation by restoration. It is neither restoration of a specific species nor restoration of habitat alone. It is restoration of the biotic community together with its physical environment, considered as an integrated unit (EP 1165-2-502). It reestablishes the complete set of past environmental services associated with the restored ecosystem, often including some services that are not especially desirable.

In contrast, for most NED purposes, such as for flood damage reduction, the alternatives available include a range of creative and restorative engineering solutions to the water resource problem, or even preservation of the present state where appropriate. Flood-damage reduction, for example, can be addressed by creating water control structures, removing water control structures to restore floodplain storage, or preserving floodplain area for flood damage reduction purposes. In contrast, the range of alternatives suitable for an ecosystem restoration purpose is limited to measures that ultimately lead to a restoration of self-design, self-operation, and self-maintenance of ecosystem structure and functions.

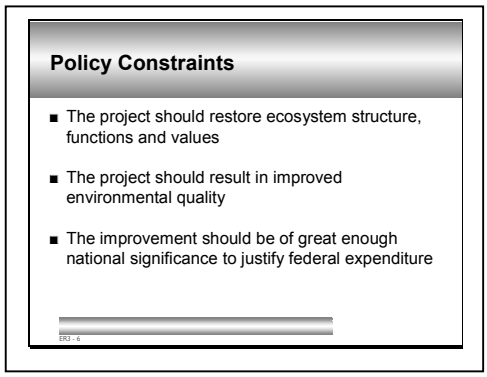
Restoration design takes careful stock of landscape setting and especially the connections of the restored site to natural processes critical for restoring and sustaining natural functions. It is analogous to an organ transplant, which needs to be connected to other organs and physiological systems to function properly. Because of its multidimensional considerations, ecosystem restoration has an inherently broader scope to consider. Most other Corps project scopes extend only to the boundaries of the watersheds or coastal processes determining project hydrology and materials supply. Ecosystem restoration projects frequently need to consider ecological processes that extend beyond the watershed, such as wildlife migratory routes and the proximity of natural plant and animal colonization sources.

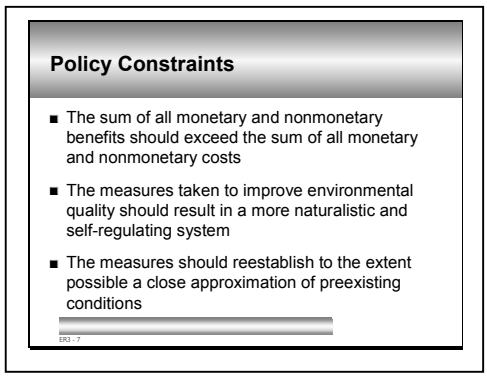
Most other Corps projects consider finite time spans determined by the physical integrity of the structures they build. The time span or study period over which we evaluate projects is normally 50 years. Consistent with other project purposes, the current Corps guidance allows environmental benefits to be considered for only a 50-year period of analysis. However, it is interesting and important to note that restoration planning horizons are more open because the basic intent is to restore the sustainability of natural processes. Natural, restorative, measures may be very gradual and take a long time to generate benefits. Further, some feel that restoration benefits, if they are maintained, may accrue for much longer

periods of time than 50 years. Finally, cumulative effects are at least if not more important considerations in ecosystem restoration. In the past, cumulative impacts of development on the performance of existing engineered projects were accommodated through new engineering maintenance and operation.

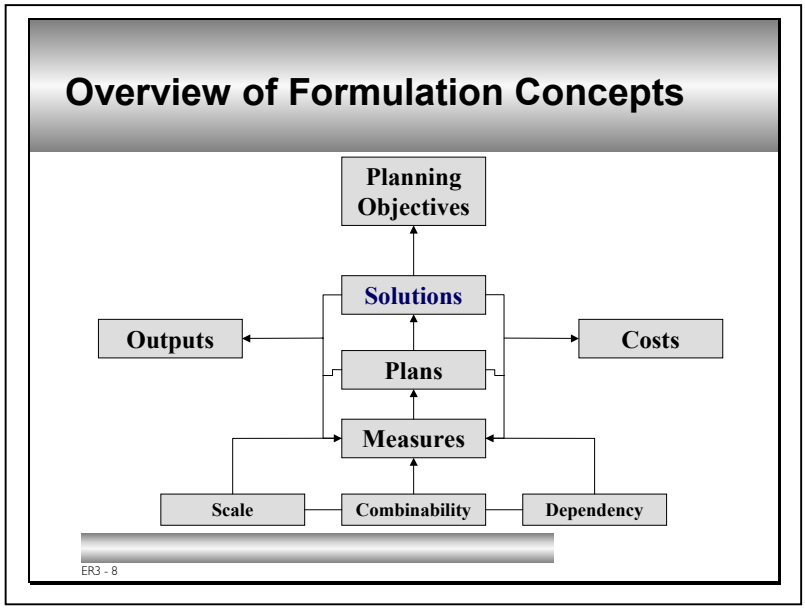
Planning Guidance (ER 1105-2-100) and Ecosystem Restoration Guidance (EP 1165-2-502 in support of ER 1165-2-501) and the P&G (WRC 1983) indicate that project designs qualifying for ecosystem restoration funding should conform to the following policy constraints.

- The project should restore ecosystem structure, functions and values.
- The project should result in improved environmental quality.
- The improvement should be of great enough national significance to justify federal expenditure.
- The sum of all monetary and nonmonetary benefits should exceed the sum of all monetary and nonmonetary costs.
- The measures taken to improve environmental quality should result in a more naturalistic and self-regulating system.
- The measures should reestablish to the extent possible a close approximation of preexisting conditions.





Ecosystem plan formulation consists of a hierarchy of inter-related steps. The process of formulation is guided by the planning objectives. Arriving at a solution that meets objectives requires formulation of plans and plan elements (i.e., measures). In order to evaluate and select from alternative plans requires tracking of measures, what they produce, and how much they cost. The differentiation of the meaning of these terms is critical to understanding the sequencing of plan formulation as it pertains to ecosystem restoration and is necessary to set the stage for criteria for plan evaluation, comparison, and selection.



As suggested before in the discussion of policy constraints, the general objectives of a restoration plan will be to attain (1) a close approximation of some previous and more preferred condition, (2) less degradation in how an ecosystem functions, and/or (3) to develop a more natural and self-regulating ecosystem function.

Ecosystem Restoration Objective

- The objectives for an ecosystem restoration project should include
  - Close approximation of a previous ecosystem condition
  - More natural and less degraded ecosystem function
  - More self-regulating ecosystem function

ER3 - 9

Planning objectives will involve and be founded in expressions of ecosystem values, services, functions, or structures. Value is anthropocentric, in that ecosystem values relate to goods or services that derive human benefits and satisfaction and affect human choices. One may consider ecosystem values to reflect what people demand. Ecosystem services are broad classes of products and life-support services that ecosystems provide or supply. Functions are processes that work to supply services—the working elements of the system. Finally, structure refers to the working materials that are used and transformed in the functioning of the system and production of services. Whether you detect it or not, your planning objectives and the means by which you achieve will involve these elements.

Ecosystem Restoration Objective

- The objectives for an ecosystem restoration project should be built upon and distinguish among:
  - ecosystem values
  - ecosystem services
  - ecosystem functions
  - ecosystem structures
- Objectives lead the development of measures, plans, and solutions

ER3 - 10

This table shows how one can distinguish among ecosystem values, services, functions, and structure. This example pertains to wetlands restoration. We may experience lower food prices from wetland restoration (a value, or human benefit). The service that is provided by the wetland is food production (supply). Plants and animals develop and thrive within the wetland system, operating functionally to produce more food. The material, or genesis, of this function lies in the soil, air, water, and biomass that comprise the wetland. Another example is the desirable experience we have from the recreation service of the wetland. Production of plants, animals, and their diversity function to produce the recreational setting. The living materials and water, of course, represent the structures.

Ecosystem Values, Services, Functions, and Structure

EXAMPLES OF A WETLAND ECOSYSTEM VALUE, SERVICE, FUNCTION, AND STRUCTURE ASSOCIATED WITH RESTORATION OF A MORE NATURAL ECOSYSTEM CONDITION

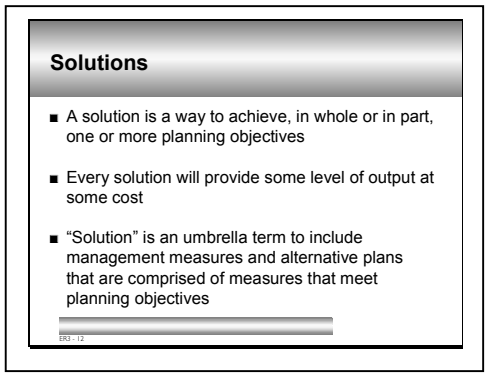
Ecosystem Values	Ecosystem Services	Wetland Functions	Wetland Structure
Reduced damage from climate change	Climate regulation	Carbon cycling and storage	Living biomass, peat, dead wood
Reduced flood and erosion damage	Disturbance regulation	Wind, wave & flood alteration	Vegetation, roots, basin/channel form
Water price	Water supply	Water retention and transmission	Basin form, linked aquifer, vegetation
Reduced sediment damage	Control sedimentation	Soil and sediment movement	Roots, basin form, debris dams
Potable water price	Waste treatment	Material trapping; decomposition	Biomass, sediment/soil form, basin form
Reduced pest damage	Biological pest control	Predation, disease, competition	Community species composition
Food price	Food production	Plant and animal production	Biomass, soil, air, water
Wood and peat price	Wood and peat supply	Production of raw materials	Wood, peat, shell, fiber
Resource development options	Maintenance of genetic information	Diversification, self-maintenance	Threatened & endangered species
Desirable experience	Recreation	Production and diversification	Fish & wildlife, vegetation, water

ER3 - 11

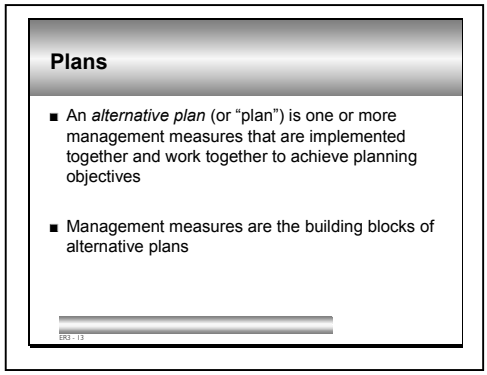
Any planning actions and measures taken should restore to a less impaired state all of the impaired ecosystem functions and structures in support of those services captured in the planning objectives. Think

of the services as the significant outputs of ecosystems that justify a project–often an assemblage of unique species. The supporting functions and structures are those previous conditions of the ecosystem that existed before impairment, or a close approximation. Keep in mind that restoring just one of numerous limiting functions and structures may not restore the justifying outputs.

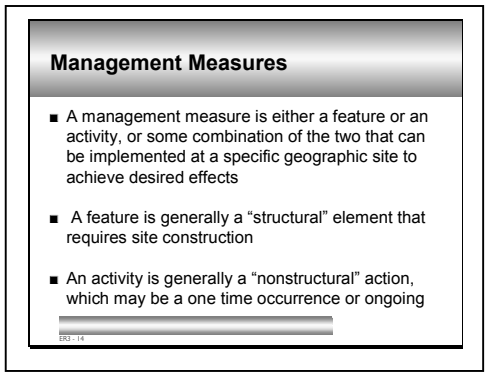
What we want to do is formulate solutions that meet our objectives that revolve around these types of values, services, and functions. A solution is a way to achieve, in whole or in part, one or more planning objectives. Every solution will provide some level of output at some cost. "Solution" is an umbrella term to include management measures and alternative plans that meet planning objectives.



A "plan" is one or more management measures that are implemented together and work together to achieve planning objectives. Management measures are the building blocks of alternative plans. If a plan achieves the planning objectives, then it is a solution. Although not listed in the flow chart, a *program* is a set of one or more plans (or "projects"), usually located or implemented over a large geographic area.

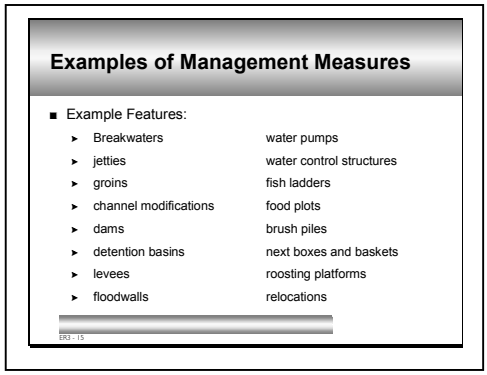


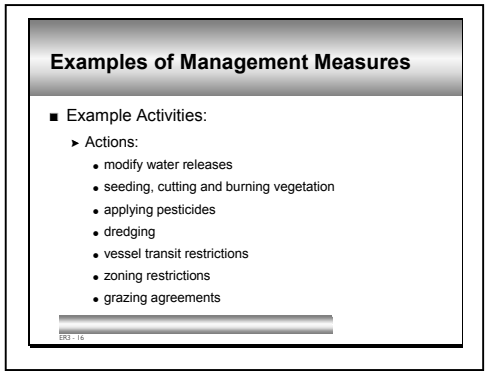
Management measures are the activities taken and features installed at a specific geographical site or sites to achieve study-planning objectives through plan implementation. They are the means to an end. "*A feature is a 'structural' element that requires construction or assembly on site. An activity is defined as a 'nonstructural' action"* (Yoe and Orth 1996). The features and activities can be natural as well as of human origin.



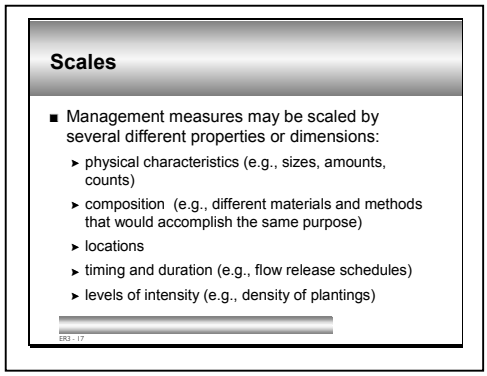
A feature is generally a "structural" element that requires site construction; for example, a detention basin. On the other hand, an activity is generally a "nonstructural" action, such as vegetative planting, which may be a one time occurrence or ongoing. A site is a place on land or water for implementation of features or activities.

Examples of management measures that might be used for environmental restoration include aerators, bank stabilization, contouring, detention basins, dredging, fencing, fertilizing, fish ladders, planting, sedimentation basins, water control structures, water pumps, and weirs. Dozens or hundreds more management features or activities could be listed, depending on the environmental restoration objectives of a given project. To reiterate, management measures are the building blocks of alternative plans.





Scales pertain to the different possible dimensions of the features and activities (i.e., management measures) included in a plan. They include the *physical properties* of the plan, such as the *size* of the restored site and the area of different vegetation types to be restored. Scales also have to do with the *composition* of materials, such as the particle size of sediments to be restored and the oxygen concentration at each water depth. Scales also have to do with *location* of features and activities, such as the location of plantings for riparian restoration or channels in a side-channel restoration. Scales pertain to *time duration and timing* of activities and construction of features.

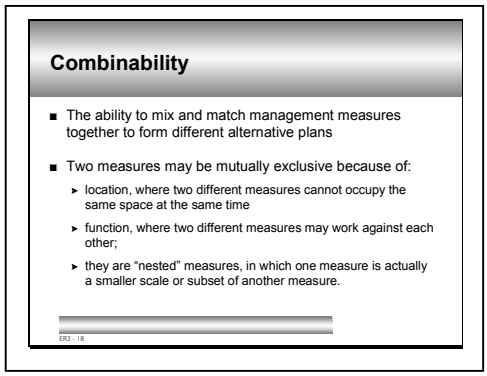


While scales can be categorized, they are more difficult to separate in ecosystem restoration, which depends greatly on the reintegration of features and processes at the original scales of ecosystem integrity. When the size of a restored area is refined in a plan, the location of measures, composition of materials, and timing of events may all change because ecosystem form and function vary spatially and temporally in patterns "recognizable" to the communities that have evolved there.

Differences in plan scale do not result in a different plan. Scale has to do with plan refinement in each alternative plan. However, the scale of measures taken in a plan is critical detail necessary for evaluating plan effectiveness, and the "devil is often in the details." For example, one alternative for restoring a river side-channel is to divert water from the river. The more that is diverted up to a full side-channel restoration, the greater is the cost. The variation in discharge is a variation in scale only, not plans.

Pumping water from the underlying aquifer is an alternative plan. Similarly, choosing among different locations to divert water into side channels is a matter of scale. But choosing three sites in various combinations of diversions and pumps (e.g., one with pumps, one with diversion, one with a combination) would provide alternative plans.

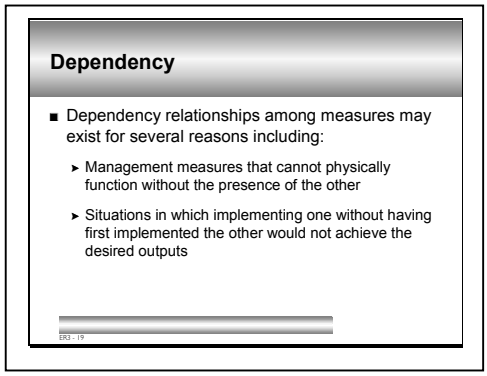
Total reversal of degradation rarely is accomplished through a single measure. Ecosystems function through many pathways, and degradation often spreads through them. Ecosystem restoration often requires a combination of numerous measures to treat a combination of impairments. Even removal of a simple structure (e.g., a small diversion dam) is typically accompanied by enabling activities and enhancement (e.g., clearing channels of debris) of the natural measures' effect on environmental service (e.g., the effect of natural stream flow once a dam is removed).



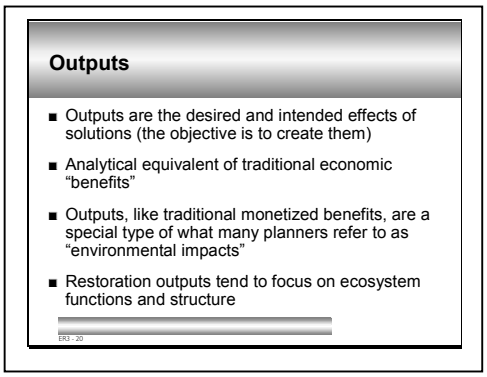
The ability to make plans from measures, and programs from plans, is governed by two types of relationships: combinability and dependency. In a typical Corps study, management measures may or may not be mutually exclusive, and it is the property of *combinability* that allows you to mix and match measures into different plans. Conversely, some measures may preclude others, and this will limit your ability to mix and match them. In thinking about combinability, you should consider whether two measures might be mutually exclusive because of:

- *Location*, where two different measures cannot occupy the same space at the same time. For example, at a particular stream site, you could create a calm slackwater area by either excavating the channel or by constructing a dam across the channel; you can do one or the other at the same site.
- *Function*, where two different measures may work against one another. For example, at Site A, it probably would not make sense to both build a retaining dike to hold water at the site and install drains to speed the removal of water from the site.
- "*Nested*" measures, where one measure is actually a smaller scale or a subset of another measure. For example, you could not combine a 4 acre wetland with a 5 acre wetland to produce a 9 acre wetland if the two wetlands are not physically separate and any part of the 4 acres is physically included - or "nested" - in the 5 acres.

Ecosystem integrity—that is the completeness of function and structure—is all about the interdependency of function and structure. In addition to being combinable, many measures may be dependent on other measures in order to be implemented. *Dependency* relationships between two measures may exist for several reasons, including:

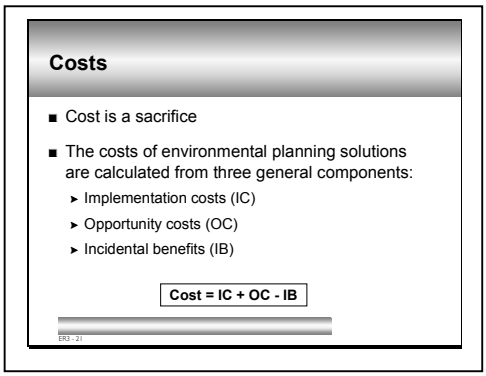


- *Necessary to function*. For example, the survival of willow tree plantings may be dependent upon an irrigation system; without irrigation the plantings will die. In this case, irrigation is necessary for the willows to function.
- *Reduce risk or uncertainty*. For example, we may wish to establish 50 willow trees per stream mile. However, because previous planting programs in the area have shown that about one-third of willow plants will not survive the first critical growing year, we elect to plant 75 trees per stream mile to account for the survival risk. The 50 trees per mile that we expect to survive are actually dependent on the additional 25 trees per mile that experience has shown are not likely to survive.
- *Improve performance*. For example, we may also elect to improve the growth rate of willow plantings by fertilizing them. The fertilizer is not necessary for the plants to function, nor will it reduce any risks or uncertainties of survival. However, it will improve the willows' performance by producing more mature trees faster.



The term output means an *intended, beneficial, nonmonetary effect*. An output is the means by which we measure how well we achieve a planning objective. Usually, we identify one type of output for each objective. For example, you may decide to measure progress in restoring a wetland in terms of changes in its habitat quality.

Outputs are the intended results of implementing solutions. In this sense, they are the analytical equivalent of traditional economic "benefits". Outputs, like traditional dollar benefits, are a special type of what many of us refer to as "environmental impacts". The difference is that "outputs" are the desired and intended effects of solutions (we're trying to create them), while "impacts" usually refer to the full range of effects, both undesirable and desirable, and unintended and intended. Note that, although our primary concern here is with environmental outputs, the full range of effects, including other environmental and social impacts, must be assessed for environmental restoration and mitigation solutions. For example, the impacts of a wetland restoration project on lost upland habitat, displaced upland wildlife, relocated structure and utilities, and other impacts should also be assessed.



Cost is a sacrifice that must be made in order to do or acquire something. The costs of environmental planning solutions have three components: *implementation costs*, *opportunity costs, and incidental benefits*.

Implementation costs are what economists might refer to as explicit costs; they are the out-of-pocket, cash outlays for producing environmental outputs. Examples of implementation costs include outlays for preconstruction engineering and design, real estate, construction, OMRR&R (operation, maintenance, repair, replacement and rehabilitation), and

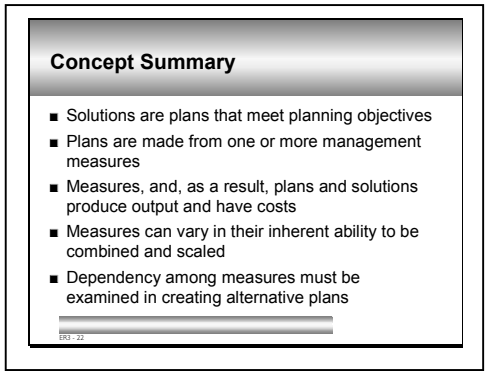
monitoring. Implementation costs include what are typically thought of as the cost estimate and the real estate appraisal.

Opportunity costs of foregone benefits are what economists might refer to as implicit costs; they don't cost us money we already have in pocket, but rather they cost us the opportunity to have done something else. For example, restoration of a riparian corridor may require removal of a levee, which would reduce flood damage reduction benefits provided by the levee. In Federal water resources planning, opportunity costs typically refer to foregone National Economic Development (NED) benefits.

Incidental benefits are monetary benefits that occur as unintended consequences of an environmental planning solution and incur no additional implementation costs. In some ways, they can be thought of as the opposite of opportunity costs. Incidental NED benefits are incidental benefits in the same eleven categories listed above. For example, restoration of a wetland, upstream from an urban center, may provide incidental flood damage reduction benefits to the urban area.

Although incidental benefits are not costs, ignoring them is keeping what may be pertinent information out of the decision process. If a solution provides significant incidental benefits, a way to account for those benefits is to treat them as a negative cost in computing the solution's total cost.

To summarize the principal concepts and elements of plan formulation, we want to develop solutions to our planning objectives. These solutions represent alternative plans that are made up of one or more management measures, which may be combined to form different plans of various scales, and which may have inter-relationships, or dependency, on one another. Every measure will produce an estimable level of environmental output at some cost.



When you are done formulating, you should be prepared to move into evaluation, comparison, and selection among the alternative plans. To do so, you need to end up with something like this for each restoration plan. However you arrange the data, you will need to define the objective, the management measures, the outputs, and the cost. A matrix approach, like this one, that gives room for notations on scale, combinability, and dependency, will prove to be valuable as you explain the elements and anticipated results of your alternative plans. With these basics in mind, lets turn to more specific details and guidance on the formulation process.

Example of Where You Want to End Up

Objective: Increase sustainability and diversity of native riparian habitat at location Y

Alternative Plan X: ECORESTORE

Measure (and scale)	Output	Cost	Dependency and Combinability
1. Pump 8 acres of Diurnal Wetlands	250	120	Must have measure 3
2. Construct 2000' Riparian Corridor	375	2000	Combination of two joining streambeds
3. Construct 2 acre open water marsh	175	325	Must have measure 1
	800	2445	

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These guiding principles should influence how you go about developing measures that lead to alternative plans and solutions. Generally, objectives are formulated based on deficiencies of natural services dependent on restoration of more natural ecosystem function and structure. Ecosystems are systems, so you need to think systems when you are formulating. Understanding the system that produces desired services will lead you to the functions and structure that would be targeted by your measures.

Guiding Formulation Principles

- Use a systems context
- Adopt a watershed perspective
- Avoid the need for mitigation
- Keep land acquisition to a minimum
- No remediation or pollution abatement where others have legal responsibility
- Limit monitoring and adaptive management

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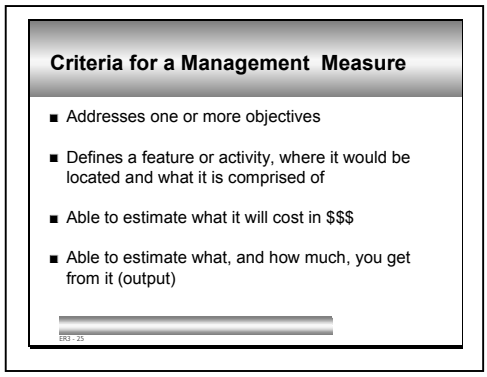
The systems you are investigating will be linked over geographical space. The watershed, as a geographical planning unit, may allow you to bound your problem, while recognizing interdependencies over space. The watershed perspective fostered in the Corps planning process is intended in part to lead planners back from proposed project locations to the sources of forces and materials constraints in the effective landscape.

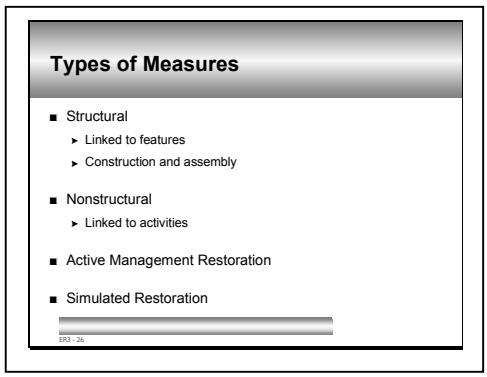
Management measures formulated for environmental restoration must adhere to the following general policies related to restoration. Remember, we are restoring and not mitigating. Do not develop measures that may lead to unintended needs for future mitigation efforts. Land acquisition should not exceed 25 percent of total project costs. Be creative and free to develop measures, but keep in mind that land costs can add up and may preclude an otherwise good plan. Naturally, if someone else is responsible for environmental damages, do not pursue remediation measures that are not the Corps' responsibility.

Finally, most ecosystem restoration projects are dynamic and often influenced in hard-to-predict ways. This may lead to the need for monitoring that what we have done is working and resultant fine-tuning of measures. Practical limitations and uncertain science in ecosystem restoration process may indeed require

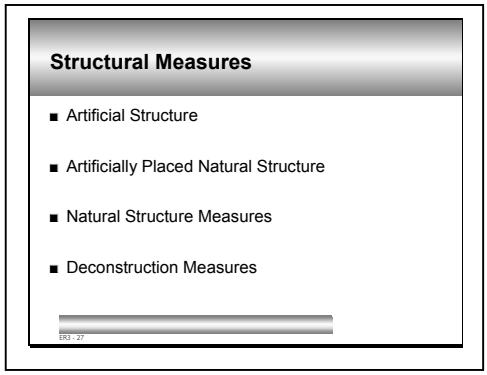
a more adaptive management approach to reestablishing improved ecosystem outputs of national significance than do the traditional Corps activities. If monitoring of measures associated with a plan is required, then it will have to be justified and limited to five years after completion of construction or initiation of the activity. Monitoring cost should not exceed one percent of the first cost of the ecosystem restoration feature. An adaptive management strategy may generally be pursued for complex, specifically authorized projects with high levels of risk and uncertainty. However, cost associated with adaptive management cannot exceed 3 percent of total project cost excluding monitoring costs.



These items aside, here are a set of criteria that will help you know if you have a useful measure. As stressed throughout, it should address the objective. It should be specified such that you can clearly explain the feature or activity—where it will be placed and what it is made of. For the sake of formulation, you cannot consider a feature or activity a measure unless you have an estimate of what it costs and what you will get from it. Restoration measures can be natural, facilitated by active management, or artificially simulated. They should not be structures or activities that permanently enhance instead of restore natural process. However, in the earliest phases of formulating alternatives, all measures should be included that might end up being most cost effective in achieving objectives, regardless of whether they meet the requirements of ecosystem restoration policy. The best plan may not be one that should be implemented under ecosystem restoration policy, once all costs, uncertainty, and risks are considered.



The measures you choose in the restoration setting will represent structural measures or nonstructural measures. As mentioned before, structural measures will include those features that require construction or physical assembly. Structural measures include all actions resulting in artificially engineered features. Such structures include the great diversity of water control structures, such as dams, levees, conduits, pipes, locks, gates, retaining walls, and shore armor. They also include structures used to manage natural populations and communities such as birdhouses, nesting platforms, artificial fish and wildlife cover, and fences. Nonstructural measures will largely be defined by activities. There are two other kinds that may function within either of these common Corps constructs, active management restoration and simulated restoration.



Depending on the output of significance that justifies the project, the most cost-effective measures may rely on artificial structures. Artificial structural enhancements of ecosystem services are effective and acceptable restoration measures when they are compatible with partial or full restoration of more natural, self-regulating functions. Artificial structure is unavoidable where a restored ecosystem is linked to a modified ecosystem. Various diversion structures, for example, typically are necessary to route water in a more naturalistic way, resulting in partial ecosystem restoration of degraded ecosystem function and structure. An artificial fish ladder is another common example. While the fish ladder itself needs long-term maintenance to function as long as the dam is in place, and is therefore not self-regulating, the access provided to the fish facilitates restoration of a more naturalistic, self-regulating ecosystem upstream from the dam. (This meets the requirement of **partial** ecosystem restoration. A more complete but still partial restoration would breach the dam. A complete restoration would remove the dam entirely. In each case, the result is a return toward a more natural process and greater ecosystem self-regulation.)

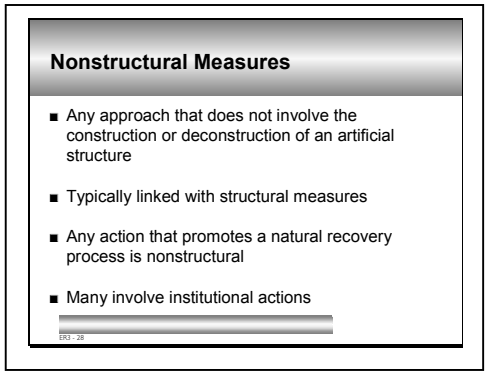
Artificial structures also have a large role to play wherever they may increase the rate of ecosystem restoration within the project area, then "fade away." Low-elevation levees that are designed to eventually erode away once a natural wetland has become established are an example. So is artificial installation of wood, netting, or other biodegradable materials placed to reduce erosion and encourage reestablishment of roots and other ecosystem stabilization. Structures such as nesting boxes may be appropriate where restoration is targeted on reestablishing nesting trees, but would be less justified where there is no such intent. Placing nest boxes in an artificial pond simply enhances the targeted species, such as wood ducks, but otherwise fails to restore functions of the swamp ecosystem condition that once existed where the pond is now.

Artificial structural measures can include natural structure that is artificially installed in the ecosystem. Examples include logs placed in streams, spawning gravel placed in lakes, riparian sapling and wetland plantings, bulldozed gravel bars in streams, natural topsoil on construction sites, and many other examples. Choosing natural materials and placement for construction is appropriate for ecosystem restoration because it enhances the eventual establishment of more natural conditions quicker than artificial means.

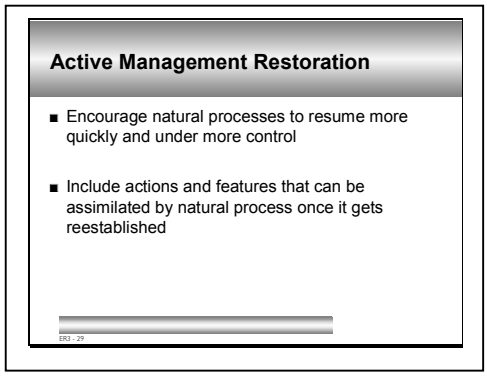
Any structure that is naturally generated and contributes to achieving the planning objectives is a natural structure measure. They include naturally formed stream channels, riffles, pools, bars and the like; wetland basins, vegetation, sediments; coastal mudflats, barrier beaches, sandbars, coral reefs and sea grass beds; and lake sediments, beaches, and fringe wetlands.

Any action taken to remove artificially engineered structure is a deconstruction measure. Common ones include removing dams and breaching levees. Reversal of past river channelization is another example. The Kissimmee River of Florida, for example, included removal of confining levees and other structure and artificial reconstruction of old meander bends. Another example of a deconstruction measure could be the restoration of a flowing river by removing a revetment. While deconstruction results in disassembly of an existing structure (usually artificial–but not necessarily) it results in a new and usually more natural structure that becomes a feature in the restoration process.

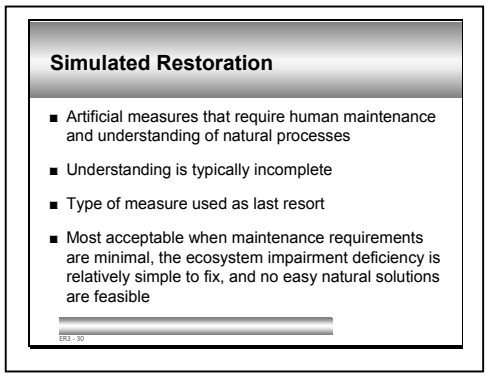
Any approach that does not involve the construction or deconstruction of an artificial structure is a nonstructural measure or activity. These typically are linked with structural measures, such as setting aside floodplain area before a levee is setback on the floodplain. Any control of pests to facilitate establishment of plants is a nonstructural measure, although it may involve short-term structural components, such as fence construction. Any action that promotes a natural recovery process is nonstructural. Stopping levee maintenance, for example, could be a measure taken to allow tree colonization or natural erosion leading to desired breaching and flooding behind the levee. Many nonstructural measures involve institutional actions, such as land purchase, easements, human access closure, and the like. Nonstructural measures may likely link in sequence with feature measures to achieve planning objectives. Seeds are planted and seed-eating wildlife controlled (activity) to initiate the establishment of sod (feature) to alter erosion rate (activity) to restore a more natural stream channel (feature) to facilitate habitat colonization (activity) to restore the justifying vulnerable species.



Active management restoration refers to a planned transition from man-made features and actions to natural forces and materials. Active management measures often are preferred because they encourage natural process to resume more quickly and under more control. The key to good active management measures is their temporary function. The best of them do their job, and then give way to nature. Biodegradable netting for retaining soil is an example. Using native materials in naturalistic ways is another tenet for choosing active management measures. Acceptable measures restore all previous services. Planting an exotic grass, for example, may rapidly restore previous erosion control service but impede the restoration of the original natural community. Knowing rates of structural degradation under different environmental conditions is critical.



Simulated restoration measures rely on human activity to encourage or stimulate natural services and functions. Such measures fall in the trial and error category. Simulated restoration is not preferred because it is artificial and requires human maintenance and understanding of natural process that typically is incomplete. It is the type of measure used as a last resort. It is most acceptable when maintenance requirements are minimal, the ecosystem impairment deficiency is relatively simple to fix, and no easy natural solutions are feasible.



This table shows some valuable examples of measures scattered among those that are structural, those that are nonstructural, and those that may be considered active management measures or simulated measures. If one wanted to develop a measure to restore past channel flow for fish, you might let an existing dam erode (natural), you might punch a hole in the dam (active management), or you might vary water releases downstream in hopes of finding the right balance (simulation). From a structural perspective, you might build an artificial channel to support the particular fish habitat. Aside from distinguishing among the concepts, this example and others in the table show that there are usually several ways (or measures) that you can take to create plans.

EXAMPLES OF NATURAL, ACTIVELY MANAGED, ARTIFICIALLY SIMULATED, AND ARTIFICIALLY ENHANCED RESTORATION OF ECOSYSTEM STRUCTURES AND FUNCTIONS

Measure Categories	Restoration Measures		Creation Measures	
	Natural	Active Management	Restoration Simulation	Structural Enhancement
Water Control				
Flow variation for fish	Let Dam erode	Breach Dam	Vary Dam Water Release	Build artificial channel habitat
Flood damage reduction	Let Levee Erode	Breach Levee	Open flood gates	Build and maintain Floodway
Restore fishery	Let Dam Erode	Breach Dam	Fish Ladder	Barging Fish
Oxygenate water	Let Dam Erode	Breach Dam	Add rock cascade to aerate below dam	Maintain electric air pumps to aerate
Sediment Control				
Developing Islands	Let river islands form Naturally	Build temporary partial levee	Maintain island with dredge material	Permanent island
Developing beaches	Eliminate Groins	Temporary retention	Beach Nourishment	Beach Construction
Developing wetlands	Let wetlands return naturally	Temporary levee	Dredge- material wetland	Sediment Dam
Erosion Control				
	Let plants establish naturally	Plant native species	Plant & maintain non-native species	Armor with concrete or stone
Water Treatment				
	Let Watershed recover naturally	Fence Watershed and seed	Zoned low-use watershed areas	Build sewage treatment plant
Habitat Development				
Nesting	Let nesting trees mature	Drill holes in trees	Install simulated tree boxes	Install bird houses
Spawning	Let fines clear from gravel naturally	Disturb gravel to hasten clearance	Routinely flush in simulated flood	Create and maintain gravel spawning beds
Pond	Let drain sediment in and pond refill	Fill drain artificially	Build natural-earth dam	Build Concrete Dam
Spring water	Let natural spring watershed recover	Buy land and evict cows to recover spring	Build guzzler	Install windmill pump and tank

There are several ways to help identify or formulate measures. The best way is to get people who know a lot about the topic and objective and start brainstorming. Of course, this is easier said than done. If you are successful enough to actually schedule a meeting, then you have to start posing the tough questions: What can we do? Where do we do it and at what scale? How does what we do depend on other things we might do? Can we combine certain activities? What do we get? How much does it cost? How certain are we? You have to keep track and write these questions and the answers down on paper. Lists or matrix tables are certainly valuable. You will likely continue to refine the list of measures in an iterative way until you get more sure of what is possible. Having several "straw-man" examples to focus on early in meetings may be advantageous, but be careful not to narrow the focus too quickly. Once all ideas are exhausted, the measures that do not meet objectives and constraints need to be weeded out or modified as needed. In applying the objectives test, the uncertainty of objective realization should be considered, especially that minimum performance needed to justify the project.

Tools for Identifying Measures

- Develop a list or matrix of possible measures
- Open "brainstorming" complemented by solicitations for outside input
- Physical and mathematical models

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Broadening the scope of possibilities can take place through invited study, focus groups, and proposal review. All plans are welcome for consideration, whether or not they originate in the Corps. The nonfederal sponsor often brings complementary breadth to the project and should be tapped for this resource. Outsiders are often not familiar with internal constraints, which can be positive as long as those in the know keep mum until later in the process of winnowing out ideas. Nothing cools imagination quicker than a disgruntled look accompanied by "we don't (can't) do it that way in the Corps."

The complexity of ecosystems will very likely necessitate the use of physical and mathematical models. Physical and mathematical models are crucial tools for identifying and screening potential measures for their suitability. The use of models will support analyses of scale, combinability, and dependency, inasmuch as the models reflect experience and data related to physical and biological systems. This table presents several examples and associated references that you can take home with you. It is provided as supplemental material in your workbook as Appendix C. The comments column gives an indication of the types of ecosystem services, functions, and structures to which the models pertain. Again, it is important to stress that you will need to involve persons with natural science backgrounds to help understand and interpret the array of measures that are available to solve any particular restoration problem or planning objective.

Example Models for Identifying and Analyzing Restoration Measures

EXAMPLES OF MODELS PROVIDING INSIGHT INTO ECOSYSTEM RESTORATION MEASURES

Model	Reference	Comment
Comprehensive Aquatic System Model	DeAngelis et al. 1989	Aquatic communities
Hybrid v3.0	Friend et al. (1997	Carbon balance model
Forest Vegetation Simulator (FVS).	Tech et al (1998)	Terrestrial communities
Population dynamics models	Pulliam et al (1992 Dewhurst et al. (1995) Murphy and Noon (1992),Van Manen et al. (1997)	population members behave in spatially explicit ways
Wetland community model	Poiani and Johnson (1993)	Spatially explicit for wetland plants.
Species-based Habitat Suitability Indices (HSI)	(USFWS 1981)	for a variety of individual fish and wildlife species
The Instream Flow Incremental Method (IFIM)	(Bovee 1981, Orth 1987, Nestler 1993).	applies a habitat-suitability index for aquatic populations in flowing waters
Vegetation-based species richness model	Anderson et al. (1978)	southwestern floodplains
Wetland Evaluation Technique (WET)	Adamus and Stockwell (1983) Adamus et al. 1987 and Adamus et al. 1991	Guide to wetland restoration of functions and values
Wetland Valuation Assessment (WVA)	Louisiana Coastal Wetlands Environmental Work Group (1998)	for use in restoring coastal wetlands
The Index of Biotic Integrity	(Karr 1991, Karr and Chu 1997)	Fish and aquatic invertebrate indices.
Bog community model.	Lindeman's (1942) Williams (1971)	Energy flow emphasis
Wildlife Community Habitat Evaluation (WCHE)	Schroeder (1996)	for deciduous forested wetlands
Riverine Community Habitat Assessment and Restoration Concept (RCHARC)	Nesler et al. (1995)	community model developed for rivers

In assessing opportunities to combine various measures, typically more than one measure is the rule. Ecosystems function through many pathways, and degradation often spreads through them. Total reversal of degradation rarely is accomplished through a single measure. Ecosystem restoration often requires a combination of numerous measures to treat a combination of impairments. Even removal of a simple structure (e.g., a small diversion dam) is typically accompanied by enabling activities and enhancement (e.g., clearing channels of debris) of the natural measures' effect on environmental service (e.g., the effect of natural stream flow once a dam is removed). Further, features cannot occupy the same space at the same time. The location of project elements for restoration of ecosystem function is analogous to proper placement of parts in a machine. In restoration management, this truism takes on special meaning because of the interaction between artificial and natural measures. When artificial measures are chosen, they must, at least temporarily, displace natural restoration measures.

Assessing Combinability

- More Than One Measure Is The Rule
- One Space, One Feature
- Artificial Verses Natural Measures
- Overlapping Measures
- Potential for non-additive costs and outputs

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Often, the acceptability of artificial measures that displace natural measures depends on the permanency of the artificial measure and the compatibility of artificial and natural functions. In restoration management, artificial measures are designed to work with natural forces and material supply rather than against them. The fundamental purpose of water *control* structures is to resist and redirect natural forces and material supply. The acceptance of permanent artificial structures among restoration measures

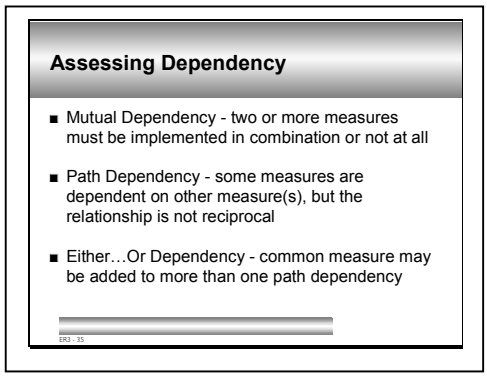
depends on the permanency of control intended within the area to be restored. Ordinarily permanent artificial structures are reserved for linkages—such as diversionary water control structures—between restored areas and culturally enhanced areas.

In ecosystems, combinability often translates into structural connections that facilitate original functions. A fish passageway around a dam is an obvious example. Location and combinability of measures are key considerations in alternative plan formulation. The nonmonetary natural service value that defines the primary purpose and the objective of an ecosystem restoration project ought to guide the consideration of alternatives, and especially project location and measures combinability. Real planning options are greatly narrowed when project location is excluded from the variables considered in alternative plans. There may very well be situations where such limited location choice exists, but a careful examination of all sometimes reveals that monetary services–such as recreation–determine location more than the nonmonetary service that will be performed. In the fish passageway example, the dam that most effectively results in the justifying ecological output should be among the best alternative plans, and any recreation benefits, or other NED benefits, should be entirely incidental to the justifying objective.

Differences in scale between artificial and natural measures leading to *overlapping* of the measures are difficult to avoid in ecosystem restoration. Uncertainty associated with natural process complicates project design. A common challenge, for example, is estimating the threshold habitat size and subset of conditions needed to assure that the community that justified the project actually becomes established. Small projects in particular incorporate risk associated with the effects of natural random process in determining colonizing rates and compositions.

An important point to remember in ecosystem restoration is that all natural features and activities operating to achieve the project objectives need inclusion among the measures, whether they are actively modified or not. All resulting interactions of natural or artificial measures need to be considered in the analysis of combinability. Taking for granted the combinability of measures is risky. It is also imperative that you not double-count or mistakenly ignore outputs and costs of combined measures. Combining measures will seldom be directly additive in both costs and outputs. Combining measures may result in a lower or higher joint cost. Further, dependency relationships may give you more or less than additive increments in output when you combine measures.

Because of a high degree of process integration, the measures taken to restore ecosystems invariably depend on other natural function and structure, or on the proper operation and maintenance of artificial structures. This latter form of natural process dependency on human artifact has in the past resulted in much unwanted degradation of ecosystems. This cause-and-effect dependency, whether natural or not, often is extremely complex and difficult to sort out. The ultimate success of a restoration project depends on the functional changes resulting from many artificial and natural changes in the effective landscape—that is, the sum of influential process that defines the management boundaries of an ecosystem.



Dependencies can occur in at least two different ways. *Mutual dependency* exists where two or more measures must be implemented in combination or not at all. For example, consider the following two measures:

- *Management Measure [A] = Vegetative Planting;*
- *Management Measure [B] = Irrigation System.*

If [A] will not work without [B], then [A] cannot stand-alone and cannot be a plan. Similarly, if [B] is only included because of the existence of [A], then [B] cannot stand alone as a plan. Here only the combination [A+B] is a viable plan. In cases where we have mutual dependency, it is best to group the two measures together and think of them as a single measure for the purposes of analysis. For example, in this case we could group management measures A and B together as a new measure C such that:

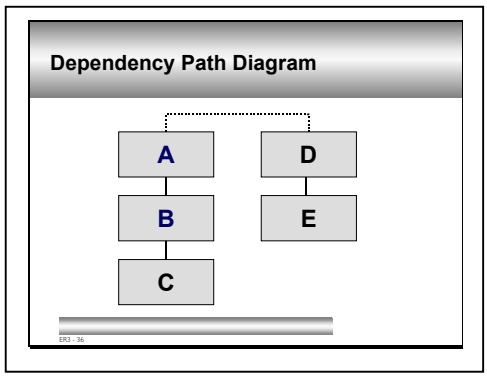
- *Management Measure [C] = Planting & Irrigating*

A different type of dependency is where some measure(s) are dependent upon other measure(s) but the relationship is not reciprocal. We can refer to this type of dependency as *path dependency*. Understanding path dependency relationships can help to assure that time and resources are not wasted evaluating plans that could not be implemented because they fail to meet a dependency path requirement. For example, consider a case where we have five management measures: A, B, C, D, and E. In this example, we must implement A before implementing B; if A and B are both present, we can then add C. Also, D must be present before we can add E.

Situations may arise where we are faced with *either...or* dependencies. Either...or dependencies occur when a common measure may be added to more than one dependency path. For example, consider that on a common plot of land we have two measures: P_1 - to plant one type of vegetation and P_2 - to plant a second type of vegetation. Assume that we could plant either alone, or both in combination. If we were to add to either (or both) planting measures a new measure: F - to fertilize; we would then put the same measure in two dependency paths.

Now, we can add measure F (fertilize) if *either* G *or* T is present. Similarly, F could be added if *both* G and T are present. In this case, we might only incur the cost of fertilizing once, but the effect of fertilizing on the planting may vary depending upon whether one or two types of planting are being affected. In such cases, the potential for improper estimates (either of cost, output, or both) is high. Where either... or dependencies occur between management measures, it is important to check the validity of the cost and output estimates of all combinations that include those measures to assure that costs or benefits are not being double counted.

The development of a dependency path diagram is often useful for packaging individual measures into plans and describing the reasoning for combining measures. As an example, consider the Dependency Path Diagram that illustrates the dependencies between plans A, B, C, D and E. B is dependent on A; C is dependent on both A and B; and E is dependent on D. The dashed line between A and D indicates that the two are not dependent but can be combined.



Recognizing dependency relationships among management measures can assist in screening out plans that are not feasible because they fail to meet dependency requirements when using the "all combinations of management measures approach" to plan formulation. In our example, there are 32 possible combinations of the management measures A-E. However, many of these possible combinations are not functionally feasible because they violate the dependency requirements. This table shows an example that includes all combinations with shading over those plans that are not feasible because they do not meet dependency path requirements. Out of the initial 32 possible plans, only 12 meet dependency path requirements and are functionally feasible. For only 32 possible plans, development of such a matrix is simple. However, it does not take many more to make this too difficult to do without supporting software.

Dependency Path Analysis

All Combinations of Management Measures
(with shading over plans which do not meet dependency path requirements)

NO COMBINATION	AD	ABC	BDE
A	AE	ABD	CDE
B	BC	ABE	ABCD
C	BD	ACD	ABCE
D	BE	ACE	ABDE
E	CD	ADE	ACDE
AB	CE	BCD	BCDE
AC	DE	BCE	ABCDE

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Choosing proper scales for alternative plans can be a very difficult planning problem because of the uncertainty often associated with natural restoration. The present state of science often falls short in the details of ecosystem restoration. This uncertainty is an unavoidable element in choosing scales for alternative restoration plans. Because it is often difficult to place boundaries on the influential forces and materials in ecosystems, a constant concern is that some remote process overlooked in a project of small geographical scale will deliver a fatal blow to project success. Careful attention to scale in ecosystem restoration means careful attention to all of the influential elements in the landscape that have remained the same and changed since the time of the targeted restoration condition. In any dynamic setting with widespread human influence (most locations where the Corps does business) the physical properties, materials compositions, locations and arrangements, and timing and duration of events have changed from what they were. Relying on "natural measures" to restore what was, without accounting for the changes in scales, involves substantial risk of project failure to restore the justifying outputs.

Considerations in Choosing Scales

- The Ecosystem Boundary Choice
- Funding Constraints
- Project Size, Risk and Cost

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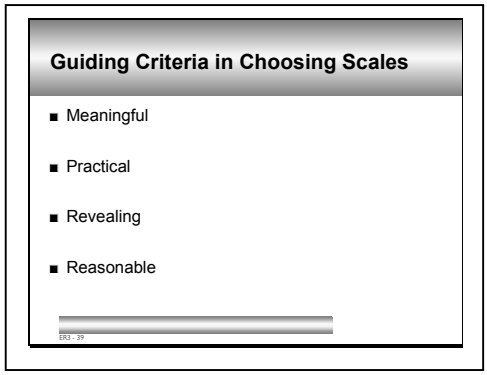
The difficulty in setting meaningful management boundaries on ecosystem process is one reason why a watershed perspective is advocated in planning regulations. As a general rule, watershed boundaries serve Corps planning well as an index to the effective landscape, especially where measures involve hydroregime. Yet the watershed perspective has its limits in coastal ecosystems, ecosystems defined by the needs of migratory animals that routinely cross-watershed boundaries, where groundwater aquifers

cross surface watershed boundaries, and other exceptions to the general rule. Usually, however, the effective watershed is a good starting place.

Policy constraints contribute to the challenge. Project expenditure caps can affect the scales of measures used to make the project fit the funding. When planned alternatives begin to appear too costly, selecting another scale is often the way to go. For projects obviously requiring larger geographical scale and individual authorization, funds often can be made available to do pilot work to assess the scales of measures needed to meet project objectives. This investment may include both physical and mathematical models for analyzing the effects of scale and planning alternatives. For projects constrained to smaller scales, typically under a continuing authority, a pilot study is typically prohibitively expensive.

An alternative plan may be scaled in terms of the measures that make up the plan - which measures are included in the plan, and in what order they would they be implemented. Many of the variables used in habitat-based evaluation procedures (see below) can be used to define scales of management measures. For example, if "percent herbaceous canopy cover" is a variable for a target species, and if planting herbaceous vegetation were being considered as a measure, then the measure could be sized in increments of the variable, such as: 30% herbaceous canopy cover, 40% herbaceous canopy cover, 50% herbaceous canopy cover, and so forth.



The number of possible solutions - and consequently the number of output and cost estimates - will rapidly increase as we consider increasing numbers of scales of measures. Therefore, the numbers of measures and their scales should be kept to a minimum to minimize study cost and time. There are no universal rules for determining the proper number of scales that should be considered in every case - the number that should be defined is a matter of judgment. In reaching that judgment, it is helpful to think about scales that are:

- *Meaningful*. For example, scales of a fenced-in area in increments of 0.01 of an acre, or in increments of 10,000 acres, are probably not correctly sized and would result in too many or too few solutions for most analyses. Also, there is no reason, beyond ease of comparisons and symmetry, that increments must be identical in size. For example, a scale of 10, 25, 50 and 100 units may be used in the same analysis if it makes sense to do so.
- *Practical*. Some solutions may be implementable over very few scales. Some measures may be "either-or" measures that are not possible, or reasonable, to size, and there is only one scale to consider. For example, although different sized areas may be considered, natural revegetation may be a single-scale measure (either it does or it doesn't naturally revegetate). Administrative actions, such as requiring a permit or a license, may also be single-scale measures (for example, either a license is required or it isn't). Equipment is often available in only a single size or relatively few sizes (for example: water pumps with fixed pumping capacities).

Minimum and maximum sizes could be a basis to bound a range of a scales. For example, a bird may require a deciduous shrub cover between 1.0 foot and 3.0 feet in height. Planting schemes that would provide lesser or greater cover heights would not meet the requirement and need not be considered.

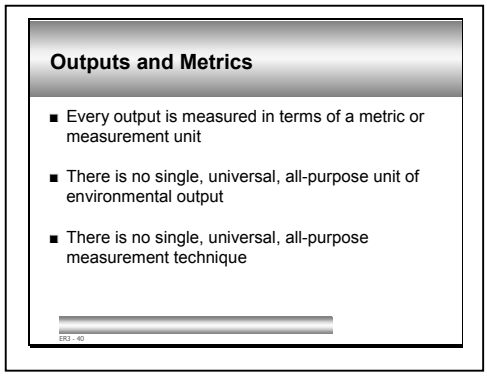
Where a large number of scales is possible, the analyses could be initially limited to analyzing only the largest and smallest sizes ("high-low" analysis), or high-middle-low sizes, to bound and scope the range of costs and outputs; subsequent iterations could then be conducted for the more promising scales.

- *Revealing*. The number of scales should be adequate to reveal significant changes in outputs and costs. A cost effectiveness curve or an incremental cost graph reflecting only two points is usually not revealing, and therefore not helpful, for decision making.

- *Reasonable*. The number of scales should strike a reasonable balance between the needs and constraints of the analysis and the burdens (cost, time, and understanding) imposed by large numbers of scales that are not sufficiently differentiated to make a difference in decision-making. In many cases, only a few will be reasonable. Additional scales should not be artificially created simply for the sake of analysis.

The most important consideration in defining scales is that changes in scale should result in changes in output, or cost, or both.

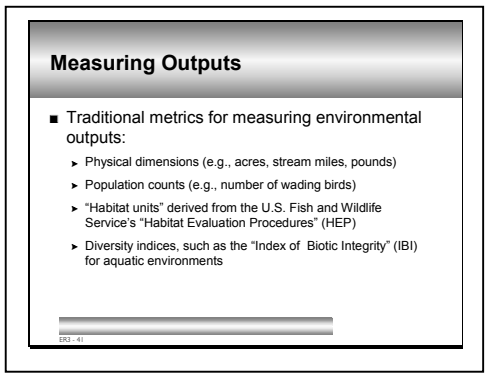
Recall that the term output means an *intended, beneficial, nonmonetary effect*. An output is the means by which we indicate how well we achieve a planning objective. In some cases, it may be important to look at more than one aspect of an objective, and, therefore, you may use multiple outputs for a single objective (for example, habitat quality and the presence of a keystone species). In addition, if your study is addressing more than one planning objective, then you may use a different type of output for each objective. Using multiple outputs will complicate, but not necessarily overwhelm, your analysis.



Every output is measured using a technique that measures changes in terms of a metric, or "measurement unit". There is no single, universal, all-purpose unit of environmental output, nor is there a single, universal, all-purpose measurement technique.

Traditional metrics for measuring environmental outputs have included:

- *Physical dimensions*, such as acres, miles, days, etc.
- *Population counts* of a species or guild (number of wading birds, for example).
- "*Habitat units*". Habitat units are a product of the "Habitat Evaluation Procedures" (U.S. Fish and Wildlife Service 1980; also referred to as "HEP"), as well as several other habitat-based evaluation methodologies derived from HEP. While the original HEP applications focused on single



species, recent HEP-like procedures focus on communities and may measure "community units" or similar metrics.

Other less commonly used metrics include measurements of biodiversity, productivity and risk. Again, there is no single way to measure environmental outputs that will apply in all cases. Each study must determine the best way to measure outputs to meet its unique decision making needs. These may be integrally linked to the physical and mathematical models that may be used to identify measures in the first place. Some output measurements are well known, understood and accepted within the Corps and OMB. Caution should be exercised in using output measurements that are not widely used. It is critical to thoroughly explain the measure if there is a question as to the definition or application of an output measure. If the measure is not understood or misunderstood by reviewers as HQ or OMB it could cause confusion resulting in review delays.

Later, in cost effectiveness and incremental cost analyses, output values are added, subtracted, and divided. Therefore, ordinal units of measurement (1st, 2nd, 3rd...) cannot be used in these analyses. However, cardinal units of output measurement, such as population counts and habitat units, can be used.

Ideally, we should first define the output to be measured (based on a planning objective); then define the unit in which we will measure change in the output; and finally select the measurement technique that will provide values in terms of the selected unit. Selecting the technique first will, by definition, select the measurement unit, which may or may not be the best indicator for the output. Analysts should recognize linkages among outputs, units and techniques in developing measurement frameworks for their studies. Appendix C of Corps engineering circular 1105-2-210 (1 June 1995) provides a good summary of current ecological measurement methods.

Ultimately, and as alluded to earlier in the context of an individual plan, you want to be able to array your measures to show the important parameters that you will ultimately judge in the evaluation, comparison, and selection of plans. The following three examples show arrays that are suitable summary representations of measures. The primary objective of the potential ecosystem restoration project in the examples is to restore degraded ecological resources of a large stream and associated floodplain. All of these examples pertain to measures before analyzing and defining combinability and dependency relationships.

Example of Measures Array

Costs and Outputs of Measures and Scales

Measure Name	Measure Description	Scale Number	Scale (Acres)	Costs ($1,000)	Wetland (Acres)	C-W Riparian (Acres)	Mesquite (Acres)	Open Water (Acres)
F0	Flow Regulation Wetlands	0	0	0	0			
F1	Flow Regulation Wetlands	1	10	661	10			
F2	Flow Regulation Wetlands	2	15	783	15			
F3	Flow Regulation Wetlands	3	20	849	20			
F4	Flow Regulation Wetlands	4	25	892	25			
O0	Overbank Wetlands	0	0	0	0			
O1	Overbank Wetlands	1	20	415	20			
O2	Overbank Wetlands	2	40	620	40			
O3	Overbank Wetlands	3	60	815	60			
O4	Overbank Wetlands	4	80	1,010	80			
O5	Overbank Wetlands	5	100	1,195	100			
R0	Riparian Corridors	0	0	0		0		
R1	Riparian Corridors	1	2	144		2		
R2	Riparian Corridors	2	4	251		4		
R3	Riparian Corridors	3	6	370		6		
R4	Riparian Corridors	4	8	489		8		
R5	Riparian Corridors	5	10	560		10		
R6	Riparian Corridors	6	12	664		12		
R7	Riparian Corridors	7	14	751		14		
R8	Riparian Corridors	8	16	855		16		
R9	Riparian Corridors	9	18	998		18		
R10	Riparian Corridors	10	20	1,134		20		
S0	Remove Salt Cedar	0	0	0			0	
S1	Remove Salt Cedar	1	1,000	3,480			1,000	
W0	Open Water	0	0	0				0
W1	Open Water	1	100	2,150				100
W2	Open Water	2	200	3,780				200
W3	Open Water	3	300	5,777				300
W4	Open Water	4	400	7,220				400
I0	In-channel Wetlands	0	0	0	0			
I1	In-channel Wetlands	1	40	1,667	40			
I2	In-channel Wetlands	2	80	3,156	80			
I3	In-channel Wetlands	3	120	4,200	120			
I4	In-channel Wetlands	4	160	5,913	160			
I5	In-channel Wetlands	5	200	6,656	200			

The first example shows an array of different measures of various scale. A scale of zero indicates that there is a choice of not implementing a measure. This is important because of the potential to combine different measures to formulate alternative plans.

Example of Measures Array

Outputs (Acres and Quality Index Values) of Solutions and Scales											
Measure Number	Measure Description	Scale Number	Scale (Ac)	Wetlands		C-W Riparian		Mesquite		Open Water	
				Ac	QI	Ac	QI	Ac	QI	Ac	QI
F0	Flow regulation wetlands	0	0	0	0.8						
F1	Flow regulation wetlands	1	10	10	0.8						
F2	Flow regulation wetlands	2	15	15	0.8						
F3	Flow regulation wetlands	3	20	20	0.8						
F4	Flow regulation wetlands	4	25	25	0.8						
O0	Overbank Wetlands	0	0	0	0.85						
O1	Overbank Wetlands	1	20	20	0.85						
O2	Overbank Wetlands	2	40	40	0.85						
O3	Overbank Wetlands	3	60	60	0.85						
O4	Overbank Wetlands	4	80	80	0.85						
O5	Overbank Wetlands	5	100	100	0.85						
R0	Riparian Corridors	0	0			0	1.00				
R1	Riparian Corridors	1	2			2	1.00				
R2	Riparian Corridors	2	4			4	1.00				
R3	Riparian Corridors	3	6			6	1.00				
R4	Riparian Corridors	4	8			8	1.00				
R5	Riparian Corridors	5	10			10	1.00				
R6	Riparian Corridors	6	12			12	1.00				
R7	Riparian Corridors	7	14			14	1.00				
R8	Riparian Corridors	8	16			16	1.00				
R9	Riparian Corridors	9	18			18	1.00				
R10	Riparian Corridors	10	20			20	1.00				
S0	Remove Salt Cedar	0	0					0	0.50		
S1	Remove Salt Cedar	1	1,000					1000	0.50		
W0	Open Water	0	0							0	0.65
W1	Open Water	1	100							100	0.65
W2	Open Water	2	200							200	0.65
W3	Open Water	3	300							300	0.65
W4	Open Water	4	400							400	0.65
I0	In-Channel Wetlands	0	0	0	0.90						
I1	In-Channel Wetlands	1	40	40	0.90						
I2	In-Channel Wetlands	2	80	80	0.90						
I3	In-Channel Wetlands	3	120	120	0.90						
I4	In-Channel Wetlands	4	160	160	0.90						
I5	In-Channel Wetlands	5	200	200	0.90						

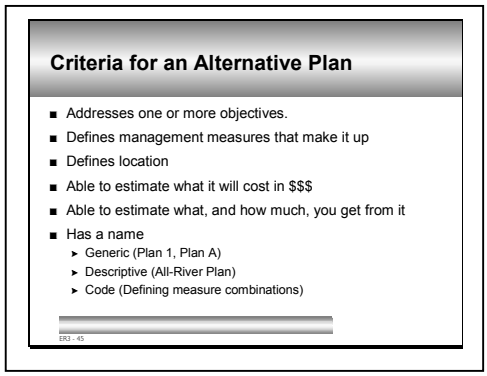
The outputs of the proposed measures are the ecosystem benefits derived from each measure. Some of the measures use treated wastewater to produce wetlands and riparian habitats. Other measures yield open water and wetlands habitats in the river channel; while another involves removal of a low-quality habitat associated with monotypic stands of an exotic species and replaces it with higher-value native species. These wetlands, riparian, and open water areas provide habitat for a variety of aquatic, wetland, terrestrial, and bird species. Rather than attempting to measure ecosystem outputs on a species-by-species basis, the interdisciplinary study team in this case decided to quantify outputs in terms of the acres of each cover type or habitat produced by each solution. The output categories were therefore defined as wetland habitat, cottonwood-willow riparian habitat, honey mesquite habitat, and open water habitat. Costs are estimated in average annual equivalent units.

Example of Measures Array

Composite Outputs (Acres X Quality Index Values)			
Measure Name	Measure Description	Scale Number	Output
F0	Flow Regulation Wetlands	0	0
F1	Flow Regulation Wetlands	1	8
F2	Flow Regulation Wetlands	2	12
F3	Flow Regulation Wetlands	3	16
F4	Flow Regulation Wetlands	4	20
O0	Overbank Wetlands	0	0
O1	Overbank Wetlands	1	17
O2	Overbank Wetlands	2	34
O3	Overbank Wetlands	3	51
O4	Overbank Wetlands	4	68
O5	Overbank Wetlands	5	85
R0	Riparian Corridors	0	0
R1	Riparian Corridors	1	2
R2	Riparian Corridors	2	4
R3	Riparian Corridors	3	6
R4	Riparian Corridors	4	8
R5	Riparian Corridors	5	10
R6	Riparian Corridors	6	12
R7	Riparian Corridors	7	14
R8	Riparian Corridors	8	16
R9	Riparian Corridors	9	18
R10	Riparian Corridors	10	20
S0	Remove Salt Cedar	0	0
S1	Remove Salt Cedar	1	500
W0	Open Water	0	0
W1	Open Water	1	65
W2	Open Water	2	130
W3	Open Water	3	195
W4	Open Water	4	260
I0	In-Channel Wetlands	0	0
I1	In-Channel Wetlands	1	36
I2	In-Channel Wetlands	2	72
I3	In-Channel Wetlands	3	108
I4	In-Channel Wetlands	4	144
I5	In-Channel Wetlands	5	180

The next example shows a slightly different analysis with respect to outputs (costs are the same as before and not included in this example). The study team on this assignment further determined that these cover types possessed different ecological values and the habitats they would provide would be of varying qualities. The quality of the cover types, therefore, was measured subjectively by the biologists on the study team. Index values of 0.0 to 1.0, similar to Habitat Suitability Index (HSI) values, were assigned to each parcel of cover type to describe its overall quality for a variety of species habitats.

The last example creates a single measure of output from the original four outputs. Multiplying the index values by the acreage of each measure and scale combination derived the composite measure of output for each measure. So, what we are left with here is a convenient array of measures and costs linked to a single output.



Corps planning should take into account "*the interconnectedness of water and land resources (a systems approach)*" and "*the dynamic nature of the economy and the environment*" (ER 1105-2-100). Nowhere are these considerations more evident than in the choice of measures for assembling an ecosystem restoration plan. Once possible measures have been identified, the next phase requires their arrangement into alternative plans capable of achieving the objectives. While creativity is an important element in this process as Yoe and Orth (1996) emphasize, cost-effective alternative arrangements must be cognizant of the interdependencies of natural and artificial processes and the combinations most likely to conform to these technical constraints. Nature often appears "creative" in the combination of chance events and our ignorance of natural process. Allowances need to be made for the uncertainty in this "creative process."

Keeping complete and clear records of the analysis is essential for several reasons. They show the logic of each plan—how measures are connected to outputs that connect to the justifying outcome. They track what has been done so unnecessary reiteration is avoided. They provide information to the inevitable turnover of team members and other participants in the planning process. They can be a source of "lessons-learned" information. Last, it's required.

So, what should these records ultimately contain? These criteria summarize the major elements. The plans should demonstrate evidence that they meet planning objectives—that is, that they are technically viable solutions to the planning problem. The evidence should be revealed by thorough discussion of the measures that make up each plan, such as where they are located, how they are scaled, how they combine and depend on each other. The cost of the plan will represent the sum of the cost of the individual measures that make up the plan. Similarly, plan outputs will stem from the summation of outputs obtained from the measures that make up the plan. Finally, naming alternatives in some way may help track and organize later phases of the planning process.

This example shows an array of alternative plans based on the measures that were defined in the previous example. Again, this array identifies any particular plan along with outputs and costs. In this example we use a plan code that has imbedded in it how we combined measures. For example, the first plan shown here is a combination of Flow Regulation Wetlands of scale 1 (10 acres) and Riparian Corridors of scale 4 (8 acres), giving 16 units of composite output for $1,150,000. The last row shows a plan that consists of 10 acres of Flow Regulation Wetlands, 20 acres of Overbank Wetlands, and 2 acres of Riparian Corridors, giving 58 units of composite output at a cost of $1,342,000. A zero in the plan code column indicates that a particular measure is considered (scale 0). The zero (scale 0) next to the letter in a plan code means that the measure is not implemented in that particular combination, it is the equivalent of a "no action" for that measure.

Example Array of Alternative Plans

Possible Combinations of Measures: 19,800		
Actual Combinations: 16,500		
Plan Code	Cost ($1000)	Output
F1 O0 R4 S0 W0 I0	1150	16
F2 O0 R3 S0 W0 I0	1153	24
F2 O1 R0 S0 W0 I0	1198	58
F3 O0 R3 S0 W0 I0	1219	32
F1 O1 R1 S0 W0 I0	1220	50
F1 O0 R5 S0 W0 I0	1221	16
F4 O0 R3 S0 W0 I0	1262	40
F3 O1 R0 S0 W0 I0	1264	66
F2 O0 R4 S0 W0 I0	1272	24
F1 O2 R0 S0 W0 I0	1281	84
F4 O1 R0 S0 W0 I0	1307	74
F1 O0 R6 S0 W0 I0	1325	16
F1 O1 R2 S0 W0 I0	1327	50
F3 O0 R4 S0 W0 I0	1338	32
F2 O1 R1 S0 W0 I0	1342	58
... .	...	...
... .	...	...
...	...	...

At the top you will note that there were nearly 20,000 possible combinations of measures. In this example there were no constraints on combinability per se, but the development of Overbank Wetlands depended on the development of Flow Regulation Wetlands. Thus, because of this dependency relationship, there are 16,500 possible plans. Although not evident in the table, outputs were assumed to be additive, but there were significant cost savings associated with combining In-Channel and Open-Water Wetland measures.

So, what alternative plan among these 16,500 is the best? This is where formulation ends and evaluation begins.

Review Questions

1. Without reviewing your notes, prepare a flow diagram that summarizes the principal elements of formulating ecosystem restoration plans that meet planning objectives.

2. Define and describe the difference between the concepts of ecosystem values and ecosystem services. Provide and example of an ecosystem value and an ecosystem service.

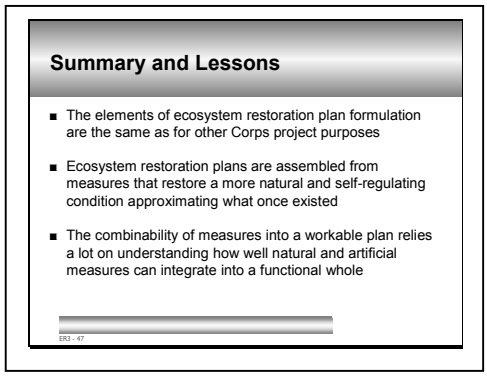
3. List the four criteria that define a management measure.

4. Define and differentiate among structural, non-structural, and active management restoration measures. Provide an example of each type of measure.

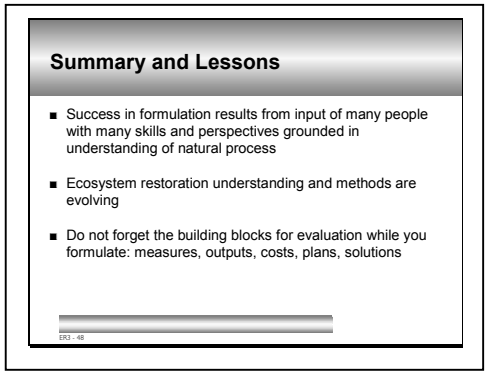
5. Name at least three metrics for measuring environmental outputs. Assume that the planning objective is to restore aquatic and related habitat in a degraded wetland.

6. Name the 6 criteria that define an alternative plan.

Section Summary and a Look Forward



There is a lot to learn and digest when it comes to formulating ecosystem restoration plans. Thankfully, the concepts are the same as for the Corps' more traditional project purposes. Restoration plans are different in that they are intended to restore natural and self-regulating conditions—in essence they are intended to increase hydrologic variability, whereas other Corps purposes are meant to decrease hydrologic variability.



The development of plans relies on understanding how natural and man-made measures can integrate to meet the restoration objective. To do this successfully will require multidisciplinary ideas and hands-on work of many people with the right skills in the natural sciences. We are still learning just how complex nature is and we will continue to learn more and develop useful models over time.

Finally, you need to keep your eye on where you want to end up while you are formulating. You want to end up ultimately in selecting the best plan. To do so, you're going to need thorough descriptions of what you can do, what it will produce along the planning objective, and how much it will cost. If done right, these elements will allow you to develop alternative plans from measures and to identify solutions from the alternative plans.
[Slide ER3-48: Look Forward]

What we intend to cover next naturally builds off of what we have discussed thus far. The next section of the workshop will demonstrate how to evaluate and select among alternative plans. Specifically, we will discuss the role and elements of incremental analysis and cost-effectiveness evaluation and how these can be used to identify the NER Plan.

Following that, we will wrap up with a class exercise focused on formulation, in which we will introduce the IWR-PLAN software that will likely be integral in your future efforts to formulate and evaluate restoration plans.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Water Resources Policies and Authorities - Ecosystem Restoration – Supporting Policy Information, September 1999, EP 1165-2-502, CECW-A.

Water Resources Policies and Authorities – Civil Works Ecosystem Restoration Policy, September 1999, ER 1165-2-501, CECW-A.

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983, U.S. Water Resources Council.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

EC 1105-2-210 Appendix C

Cole, R. *Planning Manual Series: Step Three – Plan Formulation*. (forthcoming 2002). Planning and Management Consultants, Ltd.

Selected Notes to the Instructor

Student Learning Objectives:

1. The student should understand step 3 of the planning process (Plan Formulation)
2. The student should understand the policy constraints placed on ecosystem restoration measures
3. The student should understand basic formulation concepts and strategies used to combine planning measures into alternative plans
4. The student should understand how to prepare the building blocks for evaluating alternative plans

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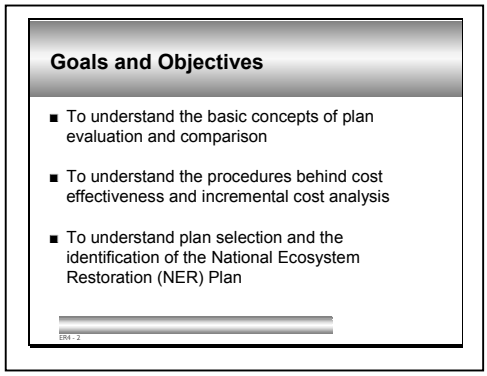
Instructor Notes and Exercises:

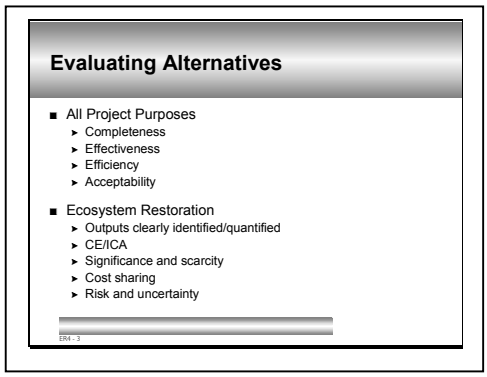
This module will describe the plan formulation process (step 3 of the planning process). Impacts of policy constraints regarding ecosystem restoration measures will be emphasized.

Module ER4: Reformulation – Optimization, Incremental Analysis and Selection of the NER Plan

Student Learning Objectives



The goal of this section is to introduce and familiarize you with the concepts of alternative plan evaluation, comparison and selection, including the identification of the National Ecosystem Restoration (NER) Plan within the context of ecosystem restoration. First, we will discuss plan evaluation and comparison, introducing the concepts of cost effectiveness and incremental cost analyses (CE/ICA) as tools to aid the decision making process when plan benefits can't be easily quantified in monetary terms. Next we will discuss alternative plan selection in terms of identification of the NER Plan and introduce some guidelines for decision making with regards to final plan selection.



The essential purpose of plan evaluation is to determine whether or not an alternative plan you have is worthy of further consideration. It is a qualifying step. Each plan should be held up to a situation-specific set of criteria and you decide whether it deserves further consideration or not. The common qualifying criteria for plan evaluation are completeness, effectiveness, efficiency and acceptability.

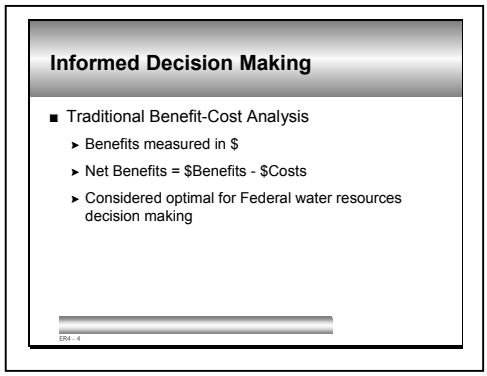
- *Completeness* - Does the plan include all the necessary actions to produce the desired results?
- *Effectiveness* – Does the plan meet planning objectives to some degree? How does it stack up against constraints?
- *Efficiency* – Does the plan minimize costs? Is it cost effective? Does it provide net benefits?
- *Acceptability* – Is the plan acceptable and compatible with laws and policies or with the local sponsor?

With regard to ecosystem recreation projects, ER1105-2-100 lists additional specific criteria:

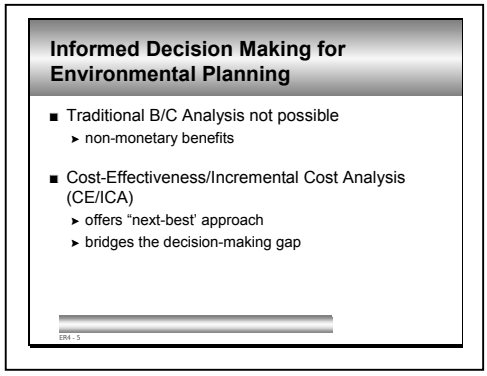
- Outputs must be clearly identified and quantified in appropriate units. Examples of possible metrics include habitat units, stream miles restored, increases in target species and diversity indices.
- Cost effectiveness. – incremental cost analyses must be performed at an appropriate level of detail to identify the most cost effective plan within identified constraints.
- Significance and scarcity of outputs should be determined.
- Cost sharing requirements need to be met.
- Risk and uncertainties associated with achieving projected outputs must be considered.

Throughout the planning process, alternatives should be continually qualified for further consideration. If plans fail to meet the minimum qualification standards, they should be dropped from further consideration, or reformulated to lessen the effect being produced. During this portion of the workshop we will be focused primarily on the efficiency criterion. This should in no way diminish the importance of the other criteria as an integral part of the planning process.

The ability to use benefit-cost analysis is generally considered the "best case scenario" for Federal water resources decision-making. In benefit-cost analysis, the discounted monetary cost of an alternative plan is subtracted from the discounted monetary value of the benefits to be provided by that plan to compute net discounted benefits in dollar terms. When there is a range of alternative plans, the plan that provides the highest present value of net benefits is considered optimal, and is the National Economic Development (NED) Plan.

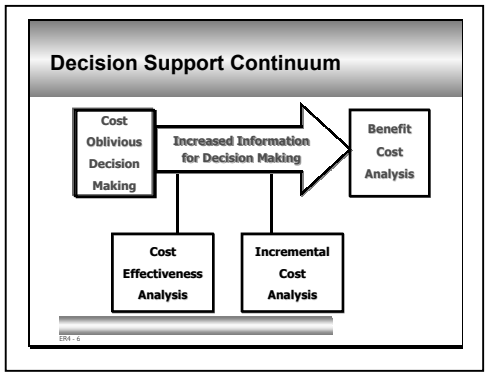


Unlike, planning for traditional economic development projects, there is no universally accepted method for quantifying environmental benefits in monetary terms. Without a monetary measure of project benefits, it is not possible to conduct a traditional benefit-cost analysis for the evaluation of ecosystem restoration plans.



Traditional benefit cost analysis is not enough, or even useful, in answering many of these kinds of question because, although costs of environmental investments can still be measured in dollars, there is also no universally-acceptable method to measure environmental benefits in a single metric - dollars or otherwise. However, other tools, such as cost effectiveness and incremental cost analyses, can be used to give us better information for making such choices.

The figure presented on ER4-6 shows some tools of economic analysis that can be used to provide varying levels of information to support decision-making. This decision-support continuum ranges from cost oblivious decision making (ignore all information related to costs) to benefit-cost analysis (an economic comparison of benefits and costs). Between these two extremes, the economic tools of cost effectiveness analysis and incremental cost analysis can provide information to support decision-making.



For environmental planning, where traditional benefit-cost analysis is not possible because costs and outputs are expressed in different units, cost effectiveness and incremental cost analyses offer plan evaluation approaches that are consistent with the P&G paradigm. *Cost effectiveness analysis* is conducted to ensure that the least cost alternative is identified for each possible level of environmental output; and that for any level of investment, the maximum level of output is identified. Subsequent *incremental cost analysis* of the cost effective alternatives is conducted to reveal changes in costs as output levels increase.

CE/ICA

- Comparison of costs/outputs across differing units of measurement
- Does not identify unique optimal solution
- Can identify the least-cost alternative for producing every attainable level of output

ER4 - 7

In the absence of a common measurement unit for comparing the non-monetary outputs with the monetary costs of environmental plans, cost effectiveness and incremental cost analyses are valuable tools to assist in decision making. The results of the analyses, which can be displayed as graphs of outputs against costs, permit us to progressively compare alternative levels of environmental outputs and ask if the next level is worth it; that is, is the additional environmental output in the next attainable level worth its additional monetary cost?

The example on slide ER4-8 shows an array of alternative plans and their associated costs and outputs. Our plan formulation should have left us with results such as these. This is where plan evaluation and comparison begin.

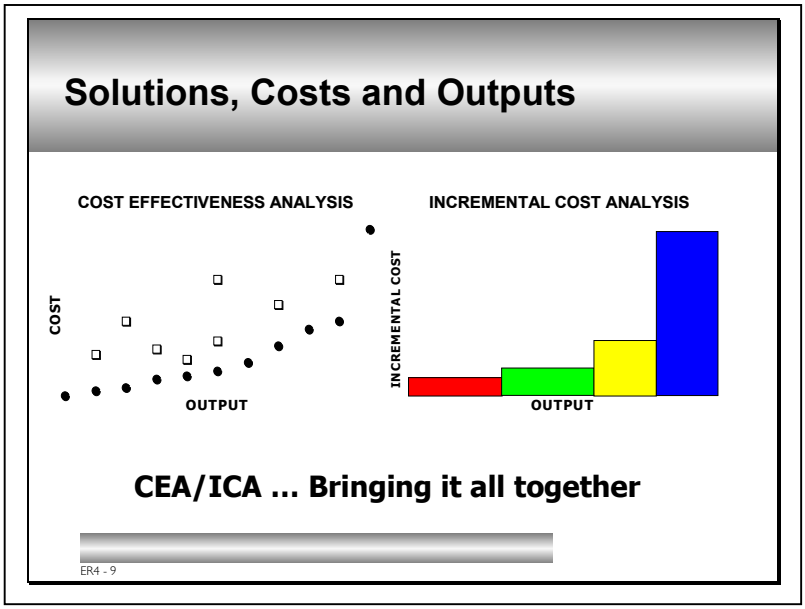
Plan Formulation Results

Example Array of Alternative Plans

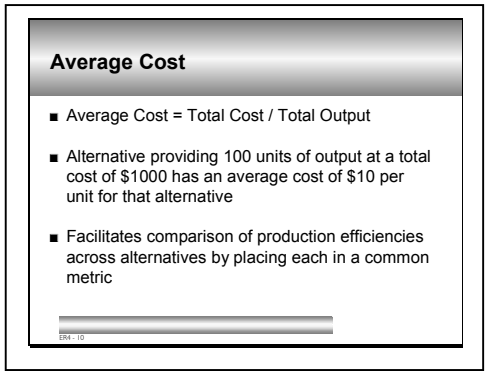
Plan Code	Cost ($1000)	Output
F1 O0 R4 S0 W0 I0	1150	16
F2 O0 R3 S0 W0 I0	1153	24
F2 O1 R0 S0 W0 I0	1198	58
F3 O0 R3 S0 W0 I0	1219	32
F1 O1 R1 S0 W0 I0	1220	50
F1 O0 R5 S0 W0 I0	1221	16
F4 O0 R3 S0 W0 I0	1262	40
F3 O1 R0 S0 W0 I0	1264	66
F2 O0 R4 S0 W0 I0	1272	24
F1 O2 R0 S0 W0 I0	1281	84
F4 O1 R0 S0 W0 I0	1307	74
F1 O0 R6 S0 W0 I0	1325	16
F1 O1 R2 S0 W0 I0	1327	50
F3 O0 R4 S0 W0 I0	1338	32
F2 O1 R1 S0 W0 I0	1342	58
….	…	…
….	…	…

ER4 - 8

So how do we select the "best" alternative from the array displayed on slide ER4-8? Cost effectiveness and incremental cost analysis can help.



Average cost is calculated by dividing total cost by total output. The formula for this computation is shown in the figure below. The average cost for a particular level of output is the *cost per unit of output* for that level. If an alternative plan provides 100 units of output at a total cost of $1000, the average cost is $10 per unit for that alternative. Average costs can facilitate the comparison of production efficiencies across alternatives by placing each alternative plan in a common metric: dollars per unit of output. For example, an alternative plan producing output at $10 per unit would be considered more efficient in production than an alternative plan producing the same type of output at $20 per unit.



$$\text{Average Cost} = \frac{[\text{Total Cost of Solution A}]}{[\text{Total Output of Solution A}]}$$

When we use the term increment or incremental in discussing incremental cost analysis, we are using the term to mean a *difference, or change,* between two alternatives. The types of changes we are interested in are differences in cost and differences in output between alternatives; these differences are referred to as incremental cost and incremental output.

Incremental Cost & Output

- Incremental Cost
  - The difference in total cost between 2 alternatives
  - (Plan B Costs - Plan A Costs)
  - Example: ($175,000 - $100,000) = $75,000
- Incremental Output
  - The difference in output between 2 alternatives expressed in the output's unit of measurement
  - (Plan B Output - Plan A Output)
  - Example: (300 - 20) = 10

ER4 - 11

Incremental Cost is the difference in total cost between two alternatives, expressed in dollars. For example, if a 40-acre pond costs $100,000, and a 50-acre pond costs $175,000, the increment of cost (or change in cost) between the two ponds is $75,000. This incremental cost information simply tells us that the 50-acre pond costs $75,000 more than the 40-acre pond. The figure presented below contains the formula for incremental cost.

Incremental Cost of Plan B = [Total Cost of Plan B] – [Total Cost of Plan A]

Incremental Output is the difference in output between two alternatives, expressed in the output's unit of measurement. Continuing with the pond example, if the 40-acre pond would produce 20 habitat units, and the 50-acre pond would produce 30 habitat units, the increment of output between the two ponds is 10 habitat units. In other words, the 50-acre pond provides 10 more habitat units than the 40-acre pond. The figure presented below contains the formula for incremental output.

Incremental Output of Plan B = [Total Output of Plan B] – [Total Output of Plan A]

Incremental cost analysis is an examination of the changes in both cost and output across alternative plans. We can make this two-dimensional problem more apparent, helping us to make comparisons across alternatives, by combining the concepts of incremental cost and average cost to compute *incremental cost per unit;* one number that reflects both types of change. The figure presented below contains the formula for incremental cost per unit.

Incremental Cost per Unit

- Combination of average cost and incremental cost concepts
- Examining the change in cost and output across alternatives
- (Plan B Costs - Plan A Costs) / (Plan B Acres of Wetlands - Plan A Acres of Wetlands)
- Example: ($175,000 - $100,000) / (30-20) = $7,500

ER4 - 12

It is important to note that the formulas presented above are for calculating the incremental cost, incremental output, and incremental cost per unit, respectively, of a*lternative plan B*. While saying these incremental values correspond to one alternative simplifies the discussion, the incremental values in these formulas actually apply to analyses of *the decision to implement alternative plan B over alternative plan A*.

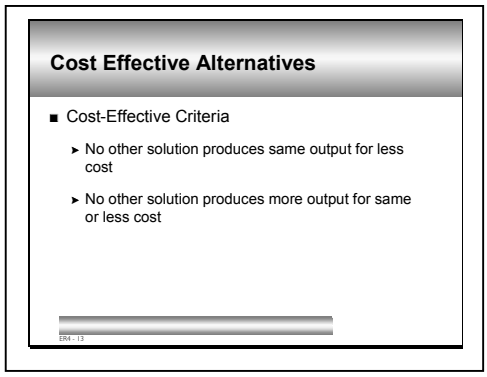
$$Incremental\ Cost\ per\ Unit\ of\ Plan\ B = \frac{[Incremental\ Cost\ of\ Plan\ B]}{[Incremental\ Output\ of\ Plan\ B]}$$

Examining the changes in incremental cost per unit across alternatives is, in other words, examining how the cost per unit (or average cost) of incremental output changes as the level of output changes. Returning again to the pond example, the incremental cost per unit of the 50-acre ponds is $7,500 per habitat unit, based on the following calculation:

$$\frac{(\$175{,}000_{\text{cost of 50 acre pond}} - \$100{,}000_{\text{cost of 40 acre pond}}) = \$75{,}000}{(30\ \text{HU}_{\text{output of 50 acre pond}} - 20\ \text{HU}_{\text{output of 40 acre pond}}) = 10\ \text{HU}} = \$7{,}500/\text{HU}$$

This tells us that the 10 extra habitat units that the 50-acre pond can provide (over the 20 units provided by the 40-acre pond) cost $7,500 each. Using the average cost equation from slide ER4-10, we find that the 20 habitat units provided by the 40-acre pond cost $5,000 each. This information tells us that we can get the first 20 habitat units for $5,000 each; if we want more we can get 10 additional units, but those will cost $7,500 each. Now we have our cost and output data in a format that facilitates answering the "is it worth it?" question. Specifically, are 20 habitat units worth $5,000 each?; if so, are 10 more worth $7,500 each?

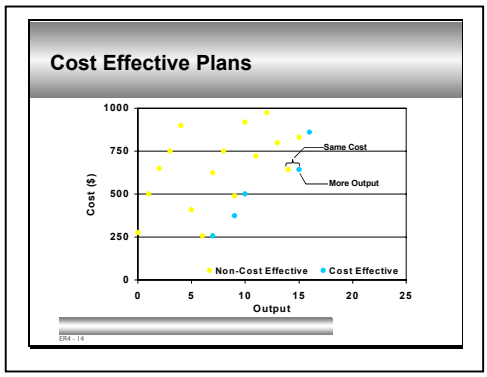
Cost effective alternatives are defined as plans that are both the most efficient as well as the most effective in production. Arriving at the cost effective set of alternatives is a screening process which eliminates those plans which are inefficient and ineffective in production.



Plans that are *inefficient in production* are defined as those where the same output level can be provided at a lesser cost by another plan. When two or more plans provide the same level of output, aside from any other considerations, the more costly plans are screened out and labeled as part of the non-cost effective set.

Plans that are *ineffective in production* are defined as those where more output can be produced at a lesser or equal cost. Following the "efficiency screening" described above, the plans producing less output at an equal or greater cost than subsequently ranked plans are screened out and labeled as the remaining part of the non-cost effective set.

The graph on slide ER4-14 depicts a graph of alternative plans, differentiating the cost effective and non-cost effective set.



The table on slide ER4-15 displays an array of alternative plans and their associated costs and outputs. Once the screening process is complete, alternatives 2, 4, and 5 would be eliminated as non-cost effective. Alternatives 1 and 2 produce less output than alternatives 3 at a higher cost. Likewise, alternatives 4 and 5 produce the same output as alternative 3 but at a higher cost. From this array of 5 alternatives, only alternative 3 would be labeled cost effective.

Identify Cost Effective Plans

PLAN	COST	OUTPUT
F3O5R9S1W4I5	20398	1062
F3O5R10S1W4I	20534	1062
F4O5R1S1W0I5	12367	1070
F4O5R2S1W0I5	12474	1070
F4O5R3S1W0I5	12593	1070

ER4 - 15

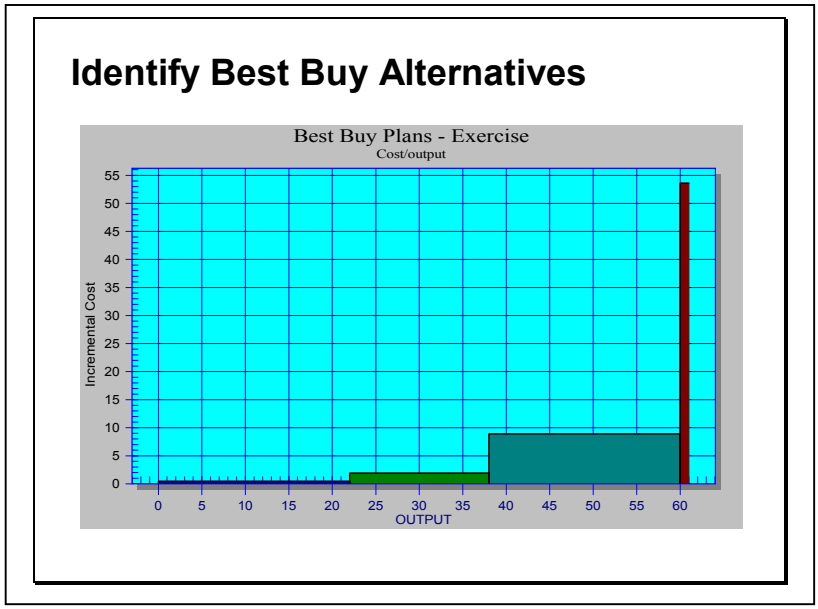
"Best buy" alternatives are a subset of the cost effective set. These plans have the lowest incremental cost per unit, meaning they provide output at the lowest per unit cost and are accordingly the most efficient in production. The screening of the cost effective set to produce a subset of "best buy" plans is not performed in order to eliminate plans from being selected, but rather to identify those plans where there is a marked increase in production costs. By identifying where significant increases in production costs occur as we increase levels of output, we provide information to assist in determining desirable project scale.

Best Buy Alternatives

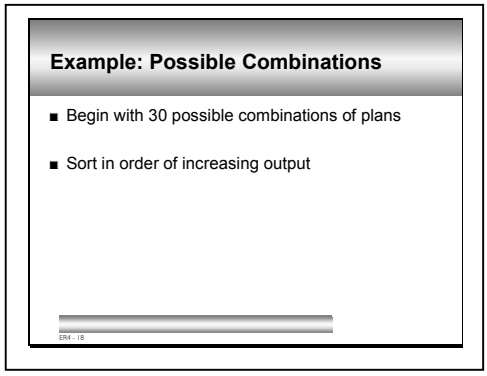
- Subset of cost effective solutions
- Solutions most efficient in production
- Greatest increases in output for least increases in cost
- Lowest incremental cost per unit of output
- Not an elimination but rather an identification routine

ER4 - 16

The graph on slide ER4-17 depicts a box plot graph of best buy showing changes in incremental cost per unit of output as you move to successively larger best buy plans.



The example problem includes 30 possible combinations of plans (A to DD) with the plans sorted in order of increasing output.



For each of the plans, the output is signified by wetlands in acres and the cost in $1,000. An average cost per acre is calculated. The plans are sorted in order of increasing output (wetland acres). In this example the outputs range from 0 to 125 wetland acres.

Example: Possible Combinations

Plan	Wetlands (Acres)	Costs (1000)	Average Cost (1000/Acres)	Plan	Wetlands (Acres)	Costs (1000)	Average Cost (1000/Acres)
A	0	$ –	$ –	P	65	$ 1,512	$ 23.2615
B	10	$ 661	$ 66.1000	Q	70	$ 1,476	$ 21.0857
C	15	$ 783	$ 52.2000	R	75	$ 1,598	$ 21.3067
D	20	$ 415	$ 20.7500	S	80	$ 1,010	$ 12.6250
E	20	$ 849	$ 42.4500	T	80	$ 1,664	$ 20.8000
F	25	$ 892	$ 35.6800	U	85	$ 1,707	$ 20.0824
G	30	$ 1,076	$ 35.8667	V	90	$ 1,671	$ 18.5667
H	35	$ 1,198	$ 34.2286	W	95	$ 1,793	$ 18.8737
I	40	$ 620	$ 15.5000	X	100	$ 1,195	$ 11.9500
J	40	$ 1,264	$ 31.6000	Y	100	$ 1,859	$ 18.5900
K	45	$ 1,307	$ 29.0444	Z	105	$ 1,902	$ 18.1143
L	50	$ 1,281	$ 25.6200	AA	110	$ 1,856	$ 16.8727
M	55	$ 1,403	$ 25.5091	BB	115	$ 1,978	$ 17.2000
N	60	$ 815	$ 13.5833	CC	120	$ 2,044	$ 17.0333
O	60	$ 1,469	$ 24.4833	DD	125	$ 2,087	$ 16.6960

ER4 - 19

Next the cost-effective plans are selected based on the following criteria:

- Select the least costly plan, wherever two or more plans provide the same level of output
- Select plans that produce more output at lower costs than subsequently ranked plans

Example: Cost Effective

- Select the least costly plan wherever two or more plans provide the same output level,
- Select plans that produce more output at lower costs than subsequently ranked plans

ER4 - 20

From the original 30 possible combinations of plans, 20 plans are eliminated and 10 are retained. Of the 10 retained plans, five plans (plans D, I, N, S and X) were retained because the meet the 'wherever two or more plans provide the same output level, the least costly plan is selected' criteria. For example, from the original 30 possible combinations, two plans (D and E) both had outputs of 20 acres. Plan D costs was $415 and plan E costs was $849. Plan D was selected as the least cost plan and plan E was eliminated.

Example: Cost Effective

Plan	Wetlands (Acres)	Costs (1000) ($)	Average Cost (1000/Acres) ($)	Incremental Cost Per Output ($)
A	**0**	**0**	**0**	**0**
D	20	415.00	20.7500	20.75
I	40	620.00	15.5000	15.50
N	60	815.00	13.5833	13.58
S	80	1,010.00	12.6250	12.63
X	**100**	**1,195.00**	**11.9500**	**11.95**
AA	110	1,856.00	16.8727	16.87
BB	115	1,978.00	17.2000	17.20
CC	120	2,044.00	17.0333	17.03
DD	**125**	**2,087.00**	**16.6960**	**16.70**

ER4 - 21

The other 'retained' plans (AA, BB, CC and DD) were selected through the filtering process of pair-wise comparisons of outputs and costs of plans that passed through the efficiency screening.

The incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective output level of the remaining plans (plans A, D, I, N, S, X, AA, BB, CC and DD) are calculated. All plans are compared to the 'no action' plan (in our example it is plan A where output and cost are zero). The incremental costs between each plan and plan A is calculated. For example, the incremental cost per unit output between plan D and plan A is ($415.00 - $0) / (20 – 0) = $20.75. The plans are sorted in order of increasing outputs.

Next the best buy plans are identified by comparing the incremental cost per output unit between each plan and the 'no action' plan (plan A) and identifying the plan with the lowest cost per output unit. In our example, the plan with the lowest cost compared to zero is plan X. That means plan X is the "first best buy plan." Then continue to identify the next plan with the next lowest cost per output unit. On the example, plan DD is the next lowest cost per output unit. The best buy plans from our example are plans A, X and DD.

Example: Best Buys

- Compute the incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective output level

ER4 - 22

In this case, you calculate the change in cost divided by the change in output as you move from plan X to all subsequent plans. Using plan X as the starting point for incremental calculations, the plan with the lowest incremental cost per unit of output is the "second best buy plan," in this case, plan DD.

The incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective output level of the selected three plans (plans A, X and DD) are calculated.

Example: Cost Effective

Plan	Wetlands (Acres)	Costs (1000) ($)	Incremental Output (Acres)	Incremental Cost (1000) ($)	Incremental Cost Per Output ($)
X	**100**	**1,195.00**	**0**	**0**	**0**
AA	110	1,856.00	10	661.00	66.10
BB	115	1,978.00	15	783.00	52.20
CC	120	2,044.00	20	849.00	42.45
DD	**125**	**2,087.00**	**25**	**892.00**	**35.68**

ER4 - 23

The incremental cost between plans A and X is $1,195 where $1,195 - $0 = $1,195. The incremental output between the same two plans is 100 where 100 – 0 = 100. Finally the incremental cost per unit between A and X is $11.95. The plan X cost is subtracted from the plan A cost and the plan X outputs subtracted from the plan A outputs. The difference of cost and difference of outputs are divided to calculate the incremental cost per unit.

Example: Best Buys

Plan	Wetlands (Acres)	Costs (1000)	Average Cost (1000/Acres)	Inc. Cost (1000)	Inc. Output (Acres)	Incremental Cost Per Output
A	0	$ –	$ –	$ —	0	$ –
X	100	$ 1,195.00	$ 11.95	$ 1,195.00	100	$ 11.95
DD	125	$ 2,087.00	$ 16.70	$ 892.00	25	$ 35.68

ER4 - 24

Plan selection in early iterations of the planning process is basically a screening process. The final iteration of plan selection in the planning process completes the planning process. You must now purposefully choose the single best alternative future path from among all those that have been considered. Neither cost effectiveness analysis nor incremental cost analysis include a plan selection rule which will indicate a single, optimal planning solution. In the absence, of such a decision making rule, neither analysis will tell you what choice to make. However, the information developed by both analyses will help you make better informed decisions; and, once a decision is made, they will help you to better understand it's consequences in relation to your other choices.

Plan Selection

- Choices
  - Do nothing (default choice)
  - National Ecosystem Restoration (NER) Plan
  - Select a "locally preferred" plan
- Planner's perspective
  - Perform good planning
  - Give good advice
  - Ultimately, decision makers select the plan

ER4 - 25

The first and default choice is always to do nothing. Planners have the burden of demonstrating that any plan that is recommended is better than doing nothing. The planning process is built on the default assumption that we should do nothing to address the problems and opportunities. The agency should become involved in a project only if it is better for society than doing nothing. Hence, the planning process must convincingly demonstrate that involvement in some project is preferred over no action by the agency.

The second choice should be to select the National Ecosystem Restoration (NER) Plan from the array of alternatives. The NER Plan is used in lieu of the NED Plan when selecting plans for single purpose ecosystem restoration projects. Then NER plan, as defined in ER1105-2-100, is the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

The last choice would be to select a "locally preferred" planning alternative. A "locally preferred" plan may deviate from the NER Plan if requested by a non-Federal sponsor but is subject to approval from the office of the Assistant Secretary of the Army for Civil Works. In cases where the "locally preferred" plan is selected and does not meet the criteria for the NER Plan, some additional factors come into play such as having a sufficient number of alternatives analyzed and the sponsor paying any difference in cost. The selection of a plan above the cost effective frontier may be appropriate in some cases. The models used to estimate the effects of environmental restoration alternatives may not be capable of capturing the full range of effects impacting the decision process. If you select a plan that the analyses show is not cost effective or incrementally justified, then the reasons for such a selection should be clearly explained tin the supporting documentation as well as the potential cost sharing implications.

This slide contains an excerpt from ER1105-2-100 where the NER Plan is defined.

ER1105-2-100 (April 2000)

- Recommend the NER Plan
- "… justified alternative & scale having the maximum excess of monetary & non-monetary beneficial effects over monetary & non-monetary costs."
- "...occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated, where the extra environmental value is just worth the extra costs." (App. E-28.e(1))

ER4 - 26

This slide contains an excerpt from ER1105-2-100 where the NER Plan is defined.

ER1105-2-100 (cont.)
(April 2000)

- "Selecting the NER plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness." (Appendix E, E-41)

ER4 - 27

This slide contains an excerpt from ER1105-2-100 citing additional considerations when selecting the NER Plan.

NER Plan – Additional Considerations

- Partnership context
  - higher priority to those projects planned in cooperation with other Federal resource agencies & regional & national interagency programs
- Reasonableness of costs
  - decision-maker ascertains that the benefits are really worth the costs
- Rarely will the NER plan not be among the best buy plans (ER1105-2-100 Appendix E, E-41)

ER4 - 28

While there is no parallel to the traditional NED Rule for selecting the NER Plan, there are general decision making guidelines related to outputs, costs and the displays provided by the application of cost effectiveness and incremental cost analyses. These guidelines consist of:

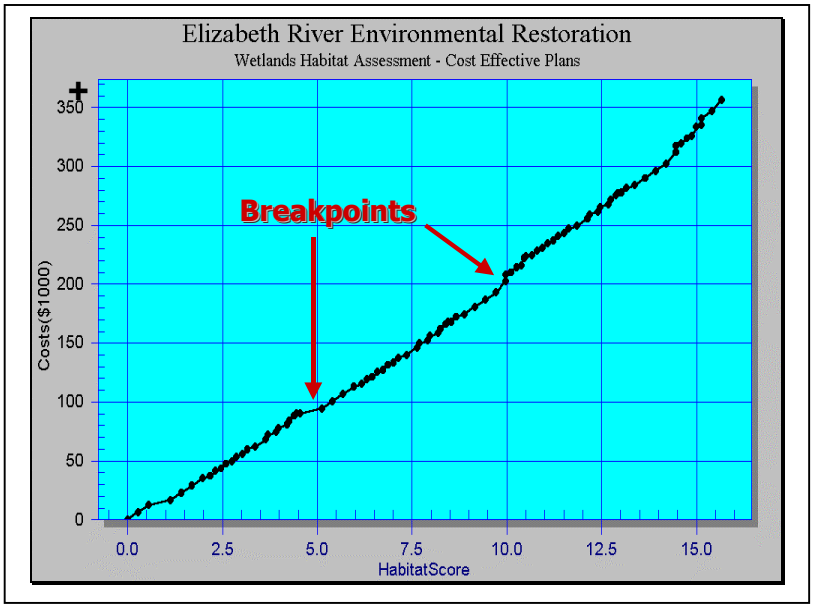
- Breakpoints
- Output Targets
- Output Thresholds
- Cost Limits
- Unintended Effects

Decision Making Guidelines

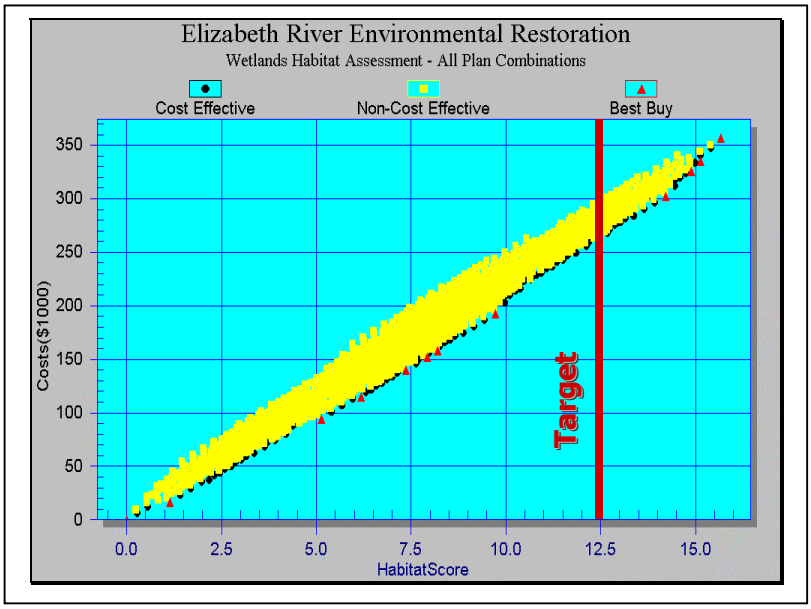
- Identify break points
- Identify and consider any output targets
- Identify and consider any output thresholds
- Identify cost limits
- Consider and document unintended effects of plans
  - i.e., impacts to species not previously considered

ER4 - 29

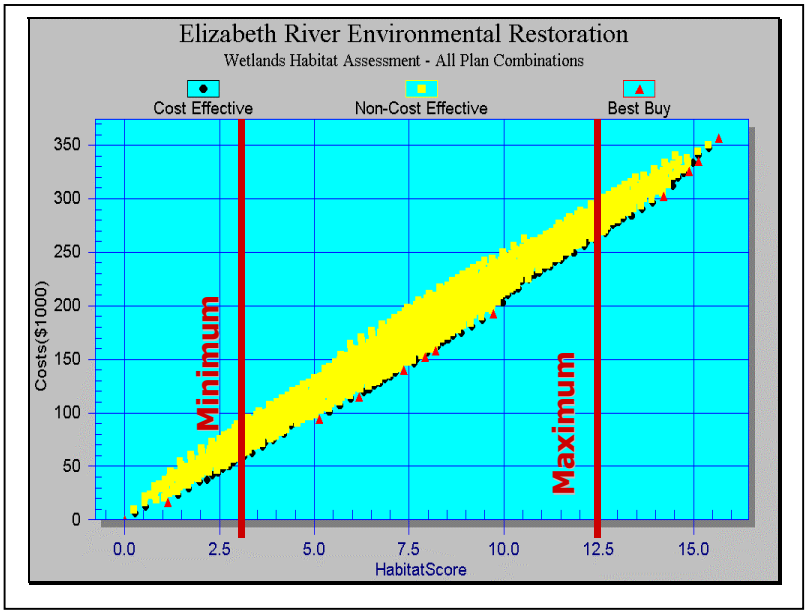
Abrupt changes in an incremental cost curve identify potential decision points for focusing the decision making process. These abrupt anomalies are commonly referred to as *breakpoints* in the curve. These points will provide you with reasons to question the causes of the changes, and whether any additional incremental cost increases are worth the investment. For example, is a large increase in output or cost due to an increase in the size of the planning alternative? Such situations may provide persuasive reasons for accepting large increases in incremental costs but a minimum provide a good starting point for further investigation.



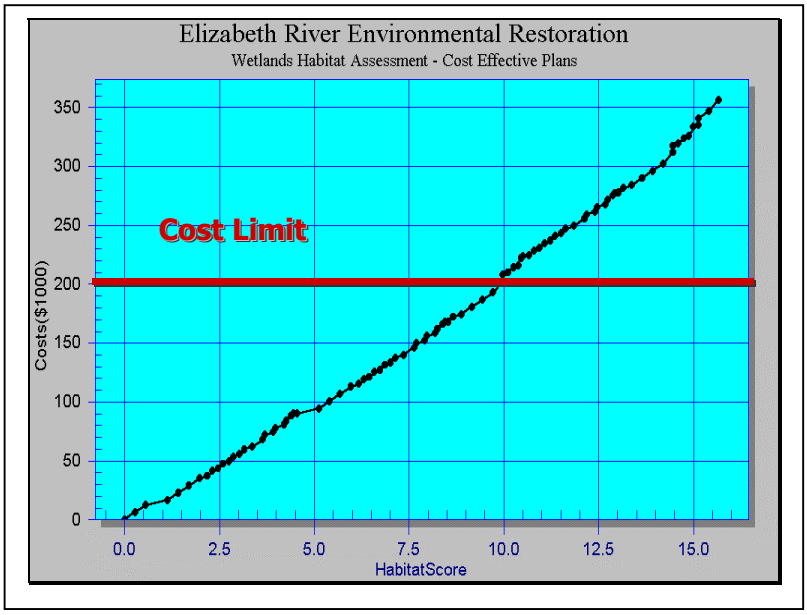
If your study has established a specific resource output target to be met, then a decision rule could be developed to meet the entire target or some portion thereof. A target should be considered a goal to strive for; in most cases it is not an absolute that must be achieved because it may be unrealistic and may establish expectations that cannot be met. A display such as the one depicted on this slide is useful in providing a focal point to begin determinations as to the justifications of incremental increases in costs leading up to that target. If getting to the output target is considered justified, then you may consider alternative plans beyond the target until a point is reached when it is no longer "worth it" to produce any additional output.



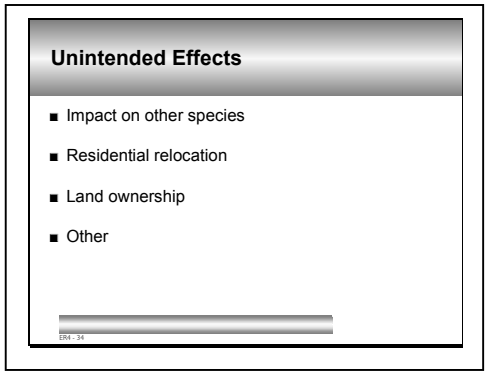
In some cases, it may be necessary to first produce a minimum base amount of output, where any lesser amount produced would be considered unsuccessful. For example, a minimum amount of habitat may be required to support identified key species, and any lesser amount than that threshold would not be adequate to meet planning objectives. In such a case, a minimum level of output should be defined, and only plans that meet or exceed that minimum should be considered. Similarly, there may also exist a maximum threshold where production beyond that level of output would no longer contribute to the achievement of planning objectives – a point of diminishing returns has been reached. In either case, thresholds can be utilized to bound the range of acceptable alternative plans.



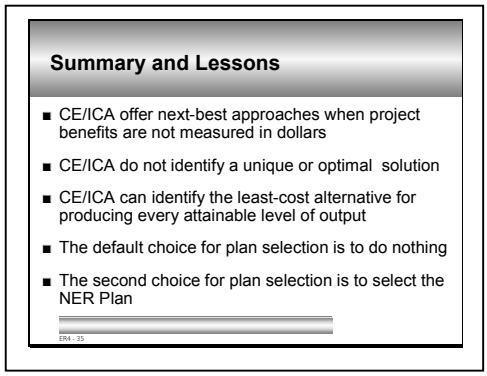
When implementation funds are a constraint (which is generally the case), the information gathered from cost effectiveness and incremental cost analyses can help you judge the "best investment" for the funds available. For example, if only $200,000 is available for a restoration effort, then by examining the graph depicted on this slide, it is easy to eliminate all alternative plans above the designated cost limit and focus on those alternatives below the $200,000 funding level.



Any unintended effects (previously not considered) arising from implementation of an alternative plan should be well documented and will provide further insight into final plan selection. Impacts to species, other than ones specifically targeted by your alternatives, are a good example of these types of effects. Effects such as relocation of residential housing or ownership of land where an alternative plan will be implemented are just a few of the impacts that may help guide your recommendation for final plan selection. The Corps is currently working on procedures to deal with the issues related to multiple effects.



When project benefits are not measured in dollars, cost effectiveness and incremental cost analyses offer next-best approaches. While the cost effectiveness and incremental cost analyses of alternative plans may not identify a unique or optimal solution, they can lead to more-informed choices from among alternatives by elevating the decision making process above cost oblivious decision making.



Although cost effectiveness and incremental cost analyses will not usually lead us to a single planning solution, they will, at the very least, help us make *more informed* decisions. And, with some care and thought in interpreting and communicating the results, they may help us make *better informed* decisions. In the long term, we hope that this will bring about *better decisions* about today's actions that will affect the environment of future generations.

The default choice for plan selection is always to do nothing. The burden of doing more than that rests solely on the shoulders of the planners. The planning process then must convincingly demonstrate that involvement in some project is preferred over simply doing nothing at all. If a selection of a plan is to be made, then the plan selected should be the NER Plan.

Review Questions

1. Does CE/ICA identify a unique optimal solution to a planning problem?
2. When selecting a planning alternative, what is always the default choice?
3. What is the NER plan?

Section Summary and a Look Forward

What we intend to cover next naturally builds off what we have discussed so far. In the next section of the workshop, you will be presented with a class exercise focused on plan formulation where you will have an opportunity to practice what you've learned so far. Along the way, you'll get an introduction to the IWR-PLAN software that will likely be integral in your future efforts to formulate and evaluate restoration plans.

References and Suggestions for Further Reading

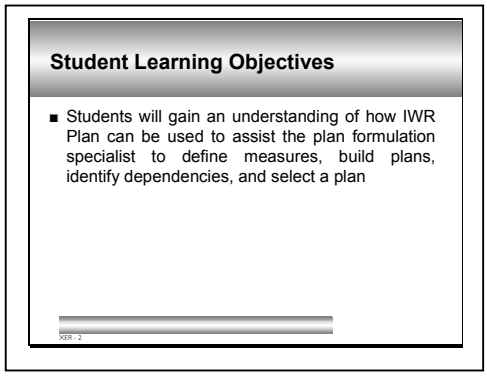
Planning Guidance Notebook, 22 April 2000, ER 1105-2-100, CECW-P.

Yoe, Charles and Kenneth Orth. Planning Manual Chapter 8. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Robinson, R., W. Hansen, and K. Orth. *Evaluation of Environmental Investments Procedures Manual. Interim: Cost Effectiveness and Incremental Cost Analyses*, IWR Report 95-R-1, May 1995.

Module XER: Incremental Analysis Exercise with IWR-PLAN

This module will consist of a laboratory exercise that will demonstrate through an easy example, the formulation and evaluation procedures that have been automated in a software program called IWR-PLAN. As we proceed with these exercises it is very likely that students will understand the need for automated assistance in the formulation and evaluation steps. At the end of the class, participants will take a look at some features and displays that are produced by IWR-PLAN, and will be given information on how to obtain a copy of the software as well as training.



This module is a hands-on exercise applying the information presented in modules ER2, ER3 and ER4. Four student exercises will be presented and completed. The exercise hand-outs are provided in Appendix D.

Session 1: Identification of Possible Management Measures

Background Information

Bussey Lake is a 213-acre backwater located on the Upper Mississippi River, lower Pool 10, near Guttenberg, Iowa (see map above). The project was selected for habitat restoration under the Upper Mississippi River System Environmental Management Program. Sedimentation had made the lake considerably shallower over a period of years and an important recreational fishery was threatened by the shallow water depths, low levels of dissolved oxygen, and an over-abundance of aquatic vegetation. Bluegill and largemouth bass were both considered as indicator species. Corps managers developed four basic management measures to improve the habitat: aeration, substrate improvement, aquatic plant harvesting, and dredging. Five different scales

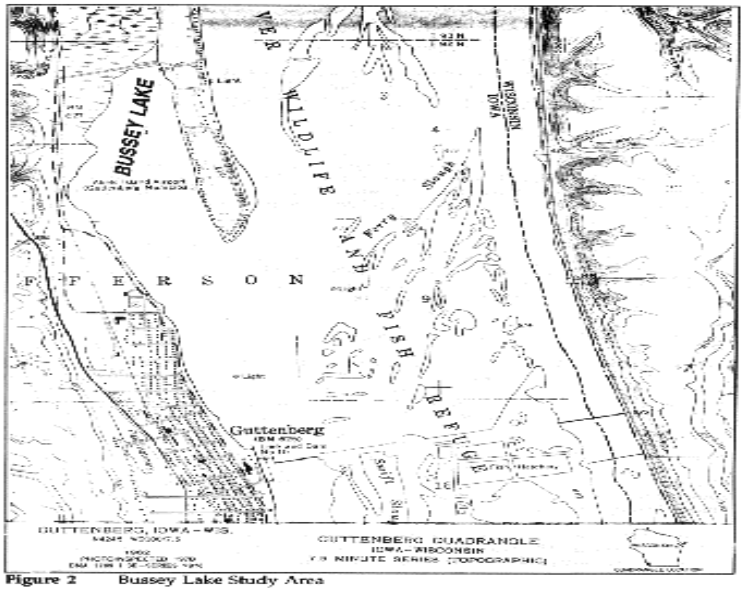


Figure 2 Bussey Lake Study Area

were analyzed for plant harvesting and seven scales were evaluated for dredging. Average annual equivalent costs were calculated for each management measure and scale using a 50-year project life. Costs included initial and operation and maintenance costs.

Session 1 Exercise:

The objective of this exercise is to improve the habitat for bluegill in the lake. The challenge is to identify specific management measures that can be taken in order to meet this objective. Having read the brief background information, it is evident that there are a number of possible management measures that can be taken to resolve the problem. Recall the procedure you learned in the previous sections (especially the plan formulation steps) and the information provided in the "G" modules.

Questions

1. From reading the background information, create a list of individual management measures. For the time being, do not consider combining individual measures to create plans.

2. How many management measures have you listed?

3. Can you think of other structural or nonstructural measures that can be used to resolve the sedimentation problem? If so please list them.

4. What other information would you need to fully define your management measures?

5. What would you pick as your output for the management measures in this case?

6. How would you measure your output?

Session 2: Adding Dependency and Combinability Relationships

Now let us introduce the dependency and combinability relationships between management measures. The process involves analysis of the management measures to identify those that can be implemented together and those that can not, as well as those measures which may only be implemented after the implementation of specific other measures. It is important to note here that the scales of any management measure are mutually exclusive.

Table A

Scale	Management Measure	Cost ($1000)	Outputs (HU)
A0	No Action	0	0
A1	Aeration	9.7	22
D0	No Action	0	0
D1	Dredging (140,000 cu. Yds.)	101.6	24
D2	Dredging (220,000 cu. Yds.)	176.2	33
D3	Dredging (270,000 cu. Yds.)	205.2	44
H0	No Action	0	0
H1	Aquatic Plant Harvesting (63 Acres)	28.6	11
H2	Aquatic Plant Harvesting (106 Acres)	30.8	16
S0	No Action	0	0
S1	Improve Substrate	53.6	1

XER - 4

<u>Management Measures Relationships</u>

For the management measures relationships in this example, we make the following assumptions:

Aeration is NOT COMBINABLE with dredging

Substrate improvement is DEPENDENT UPON dredging AND

Substrate improvement is DEPENDENT UPON harvesting of aquatic plant vegetation

Session 2 Exercise:

Questions

1. Using the information provided in Table A (slide XER-4), and the management measure relationships assumptions given above, identify all possible plans (i.e., combinations of the management measures). Assume costs and outputs are additive, and calculate these for each combination.

2. How many combinations are possible?

Comment:

This exercise will demonstrate how complicated it can be to come up with all the possible combinations. Given the number of management measures and their associated scales, the potential exist for the number of possible combinations to quickly grow to an unmanageable number that are hard to track. IWR-PLAN has a procedure that creates these combinations for you that are later screened to select cost effective plans for incremental cost analysis.

Session 3: Costs and Outputs in CE/ICA

The following section will now be concerned with plan evaluation, specifically, the application of cost effectiveness and incremental cost analysis. The important variables that must be considered in any cost effectiveness and incremental cost analyses (CE/ICA) are the costs and outputs of the proposed solutions (management measures). The outputs of the proposed management measures in this particular example are the average annual habitat units as presented in Table B (slide XER-5).

Table B

Combinations				Cost ($1000)	Output (HU)
A0	D0	H0	S0	0	0
A0	D0	H1	S0	28.6	11
A0	D0	H2	S0	30.8	16
A1	D0	H0	S0	9.7	22
A0	D1	H0	S0	101.6	24
A1	D0	H1	S0	38.3	33
A0	D2	H0	S0	176.2	33
A0	D1	H1	S0	130.2	35
A0	D1	H1	S1	183.8	36
A1	D0	H2	S0	40.5	38
A0	D1	H2	S0	132.4	40
A0	D1	H2	S1	186	41
A0	D3	H0	S0	205.2	44
A0	D2	H1	S0	204.8	44
A0	D2	H1	S1	258.4	45
A0	D2	H2	S0	207	49
A0	D2	H2	S1	260.6	50
A0	D3	H1	S0	233.8	55
A0	D3	H1	S1	287.4	56
A0	D3	H2	S0	236	60
A0	D3	H2	S1	289.6	61

Session 3 Exercise:

In this exercise, the objective is to first identify management measures that are inefficient in production and second, to identify those management measures that are ineffective in production. The management measures that are "inefficient in production" are defined as those whose output can be provided at a lesser cost by another measure. In order to identify such measures, we can sort through the measures by their output level.

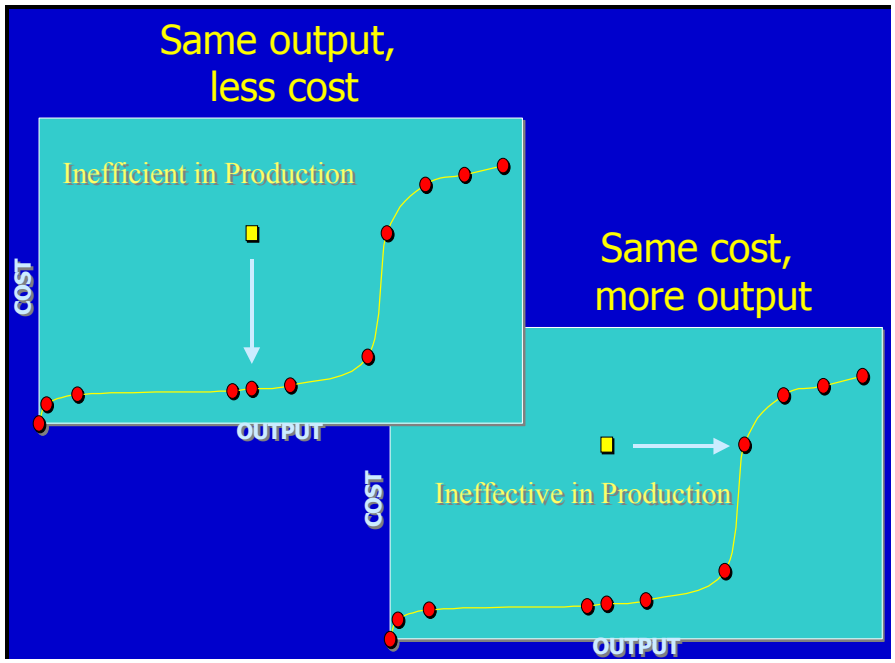


Figure 3.1: Illustration of cost efficient and cost effective plans

Wherever there are two or more measures providing the same level of output, holding everything else constant, then the more costly measures should be eliminated. This identifies the least-cost measure for every level of output under consideration. The management measures that are "ineffective in production" are defined as those where greater output can be produced at a lesser or equal cost. If there exists a plan that produces greater output at a lesser cost, then the plans that produces less output at an equal or greater cost should be eliminated. Figure 3.1, illustrates these concepts of "efficiency" and "effectiveness."

Table B (slide XER-5) contains twenty-one possible combinations of the management measures, their associated costs and outputs. Use this table to answer the following questions.

Questions:

1. Identify those combinations of management measures that are economically inefficient in production (inefficient measures are those whose output can be provided at a lesser cost by another measure).

2. Identify those combinations of management measures that are ineffective in production (ineffective measures are those where greater output can be produced at a lesser or equal cost).

3. Now list the management measures that are cost effective. How many measures are cost effective?

Comment

The above procedures are made simpler by the use of the IWR-PLAN software. In the last exercise, twenty-one possible combinations were presented to the class for the analysis of sifting through and identifying the inefficient and ineffective combinations of measures as shown in Table C.1 (slide XER6). However, in the event that there are hundreds or even thousands of possible combinations, then the process could become extremely difficult to manage by hand. The ease of performing such analysis using computer software such as IWR-PLAN can be appreciated. This software has the capability of plotting the relationships of costs versus output on a graph. Additionally, efficient and effective measures can be displayed on a graph.

Table C.1

Combinations				Cost ($1000)	Output (HU)	Evaluation
A0	D0	H0	S0	0	0	
A0	D0	H1	S0	28.6	11	Non-cost effective
A0	D0	H2	S0	30.8	16	Non-cost effective
A1	D0	H0	S0	9.7	22	
A0	D1	H0	S0	101.6	24	Non-cost effective
A1	D0	H1	S0	38.3	33	
A0	D2	H0	S0	176.2	33	Non-cost efficient
A0	D1	H1	S0	130.2	35	Non-cost effective
A0	D1	H1	S1	183.8	36	Non-cost effective
A1	D0	H2	S0	40.5	38	
A0	D1	H2	S0	132.4	40	
A0	D1	H2	S1	186	41	
A0	D3	H0	S0	205.2	44	Non-cost efficient
A0	D2	H1	S0	204.8	44	
A0	D2	H1	S1	258.4	45	Non-cost effective
A0	D2	H2	S0	207	49	
A0	D2	H2	S1	260.6	50	Non-cost effective
A0	D3	H1	S0	233.8	55	
A0	D3	H1	S1	287.4	56	Non-cost effective
A0	D3	H2	S0	236	60	
A0	D3	H2	S1	289.6	61	

Table C.2

Combinations				Output (HUs)	Cost ($1000)
A0	D0	H0	S0	0	0
A1	D0	H0	S0	22	9.7
A1	D0	H1	S0	33	38.3
A1	D0	H2	S0	38	40.5
A0	D1	H2	S0	40	132.4
A0	D1	H2	S1	41	186
A0	D2	H1	S0	44	204.8
A0	D2	H2	S0	49	207
A0	D3	H1	S0	55	233.8
A0	D3	H2	S0	60	236
A0	D3	H2	S1	61	289.6

XER - 7

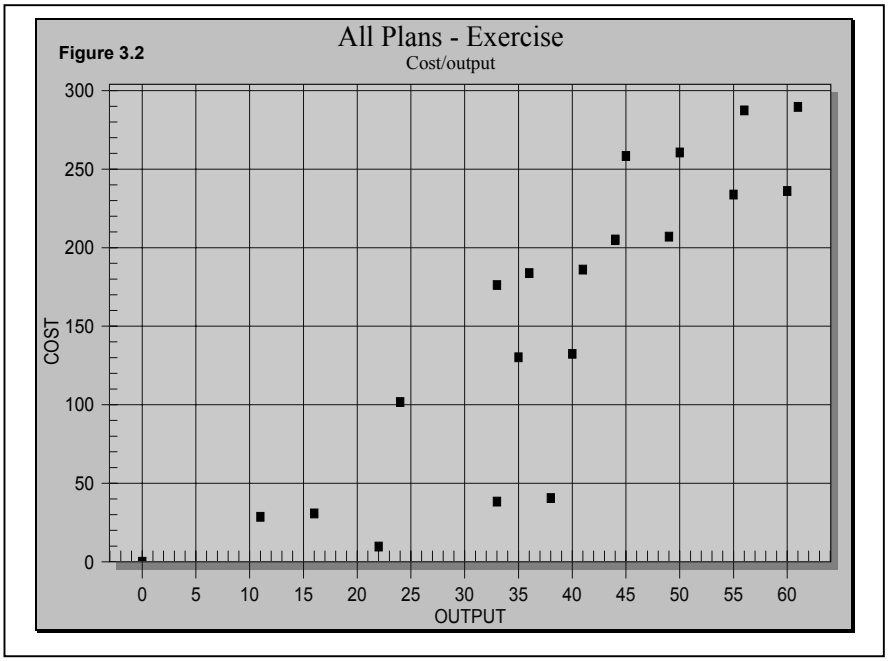


Figure 3.2
All Plans - Exercise
Cost/output
COST
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60
OUTPUT

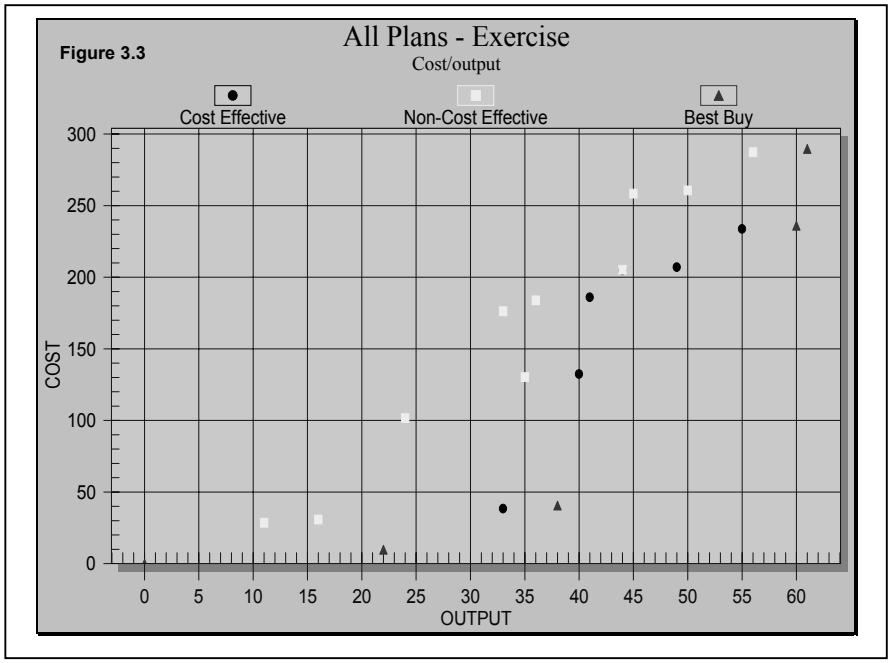


Figure 3.3
All Plans - Exercise
Cost/output
Cost Effective
Non-Cost Effective
Best Buy
COST
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60
OUTPUT

Session 4: Incremental Cost Analysis

Once the previous screening and cost effectiveness procedures are performed, it is now time to perform an incremental cost analysis. At this juncture, one needs to compute the incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective level of output. This analysis provides information to assist in determining whether the additional output provided by each successive plan is worth the additional cost that must be incurred to implement it. Recall the procedures for calculating incremental cost and incremental output that were covered in ER4.

Comment:

The information contained in Table D (in Student hand-out) can be used to conduct an incremental cost analysis. Comparisons of the incremental cost and incremental output of plans can be accomplished by looking at the incremental cost per unit of each plan over the baseline condition (no action plan). This process should be repeated for each successive plan over the baseline condition (i.e., recalculating the incremental cost per unit for each remaining plans over the last selected Plan). This process of recalculating incremental cost per unit for each remaining Plan over the last selected plan is reiterated until the last remaining plan is selected. The number of reiterations depends on the number of plans and on the respective cost and output data.

Equations

Incremental cost of Plan Y = [Cost of Plan Y] – [Cost of Plan X]
Incremental Output of Plan Y = [Output of Plan Y] – [Output of Plan X]
Incremental Cost per Unit of Plan Y = [Incremental Cost of Plan Y] / [Incremental Output of Plan X]

Where:

Plan X is considered the baseline to which all other plans are compared.
Plan Y refers to all the other plans

Session 4 exercise:

Steps

1. Calculate the incremental output, incremental cost, and incremental cost per unit of all plans. Here the no-action plan can be taken as the baseline condition, to which each other plan is compared.

2. The first comparison of the incremental cost and incremental output of plans can be accomplished by looking at the incremental cost per unit of each plan over the baseline condition.

3. As an arbitrary, but informed, decision rule, select the plan with the lowest incremental cost per unit and then retain this plan and any other plans that provide a greater output level than this plan. Remove from further consideration plans that have both lower output and higher incremental cost than this plan.

4. Make this Plan your new baseline condition, and repeat the process above for each successive plan (i.e., recalculate the incremental cost per unit for each of the remaining plans over the last selected plan, retaining the next lowest incremental cost plan each time, until there are no more plans to evaluate).

Questions:

1. Table D contains five plans and a no-action plan. Using the cost and output information in this table, take a few minutes and calculate the incremental cost, incremental output, and incremental cost per unit of advancing from the no-action plan (refer to equation 1 above).

2. Repeat question 1 above, but this time, select the plan with the lowest incremental cost per unit as your baseline instead of the no-action plan (don't forget to recalculate your incremental outputs and costs relative to this plan; refer to the equations above).

3. Perform the previous operation for each successive plan until you complete the selection of the last plan.

4. How many best buy plans are selected from this exercise?

Table D: Incremental Cost Analysis

Selecting the first "Best Buy Plan" advancing from the no-action plan

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A0D0H0S0	0	0	NA	NA	NA
A1D0H0S0	**22**	**9.7**	**22**	**9.7**	**0.441**
A1D0H1S0	33	38.3	33	38.3	1.161
A1D0H2S0	38	40.5	38	40.5	1.065
A0D1H2S0	40	132.4	40	132.4	3.310
A0D3H2S0	60	236	60	236	3.930

Table E: Incremental Cost Analysis (Cont.)

Selecting the next "Best Buy Plan" advancing from the first selected plan

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A1D0H0S0	22	9.7	0	0	0
A1D0H1S0	33	38.3	11	28.6	2.600
A1D0H2S0	**38**	**40.5**	**16**	**30.8**	**1.925**
A0D1H2S0	40	132.4	18	122.7	6.817
A0D3H2S0	60	236	38	226.3	5.955

Table F: Incremental Cost Analysis (Cont.)

Selecting the third "Best Buy Plan"

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A1D0H2S0	38	40.5	0	0	0
A0D1H2S0	40	132.4	2	91.9	45.950
A0D3H2S0	**60**	**236**	**22**	**195.5**	**8.886**

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Table G: Incremental Cost Analysis (cont.)

Selected "Best Buy Plans"

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A0D0H0S0	0	0	NA	NA	NA
A1D0H0S0	22	9.7	22	9.7	0.441
A1D0H2S0	38	40.5	16	30.8	1.925
A0D3H2S0	60	236	22	195.5	8.886

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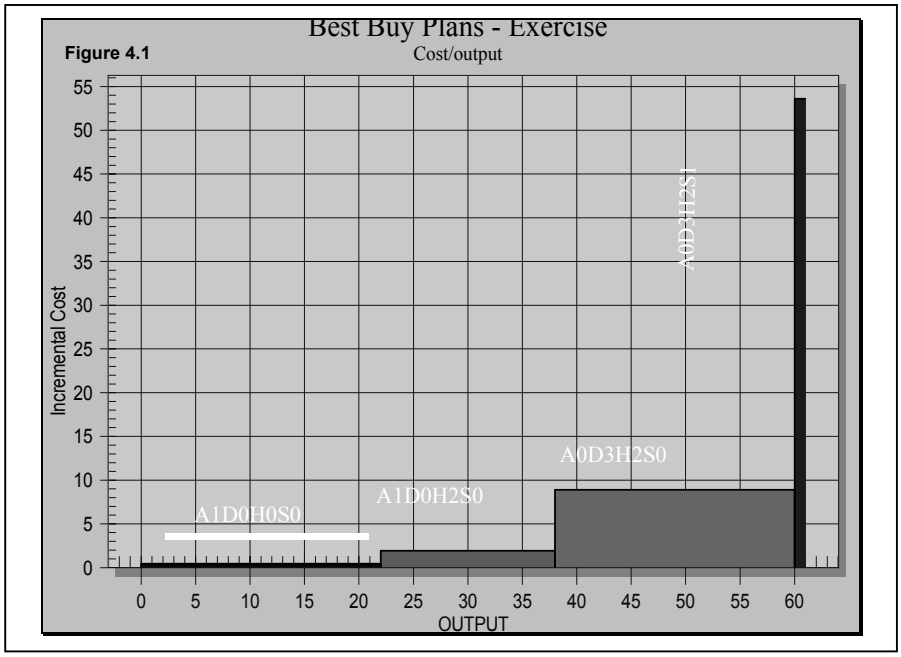
Table H: Incremental Cost Analysis

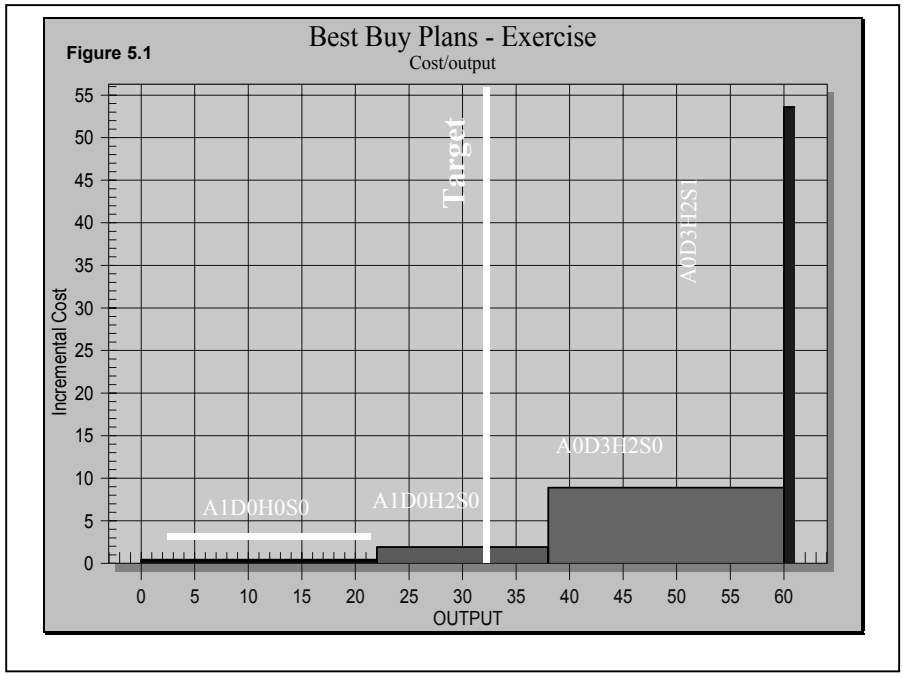
Plan	Output (Habitat units)	Cost (1000)	Incremental Output	Incremental Cost	Incremental Cost Per Unit of Output
A0D0H0S0	0	0	NA	NA	NA
A1D0H0S0	**22**	**9.7**	**22**	**9.7**	**0.4409**
A1D0H1S0	33	38.3	33	38.3	1.1606
A1D0H2S0	38	40.5	38	40.5	1.0658
A0D1H2S0	40	132.4	40	132.4	3.3100
A0D3H1S0	60	236	60	236	3.9333
A1D0H0S0	*22*	*9.7*	0	0	0
A1D0H1S0	33	38.3	11	28.6	2.6000
A1D0H2S0	**38**	**40.5**	**16**	**30.8**	**1.9250**
A0D1H2S0	40	132.4	18	122.7	6.8167
A0D3H1S0	60	236	38	226.3	5.9553
A1D0H2S0	*38*	*40.5*	0	0	0
A0D1H2S0	40	132.4	2	91.9	45.9500
A0D3H1S0	**60**	**236**	**22**	**195.5**	**8.8864**
A0D0H0S0	**0**	**0**	**NA**	**NA**	**NA**
A1D0H0S0	**22**	**9.7**	**22**	**9.7**	**0.4409**
A1D0H2S0	**38**	**40.5**	**16**	**30.8**	**1.9250**
A0D3H1S0	**60**	**236**	**22**	**195.5**	**8.8864**



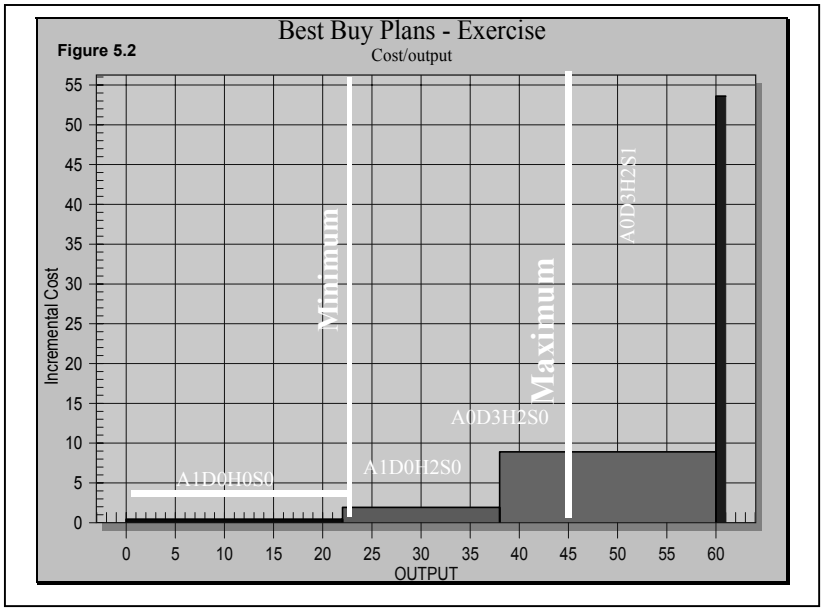
Session 5: Decision making Guidelines

Output Target

A target should be considered a goal to strive for; in most cases it is not an absolute that must be achieved because it may be unrealistic and may establish expectations that cannot be met. If a study has established a specific resource output to be met, then a decision rule could be developed to meet some portion of that target. Under the target in figure 5.1 (slide XER-16), plan A1D0H2S0 would be chosen.

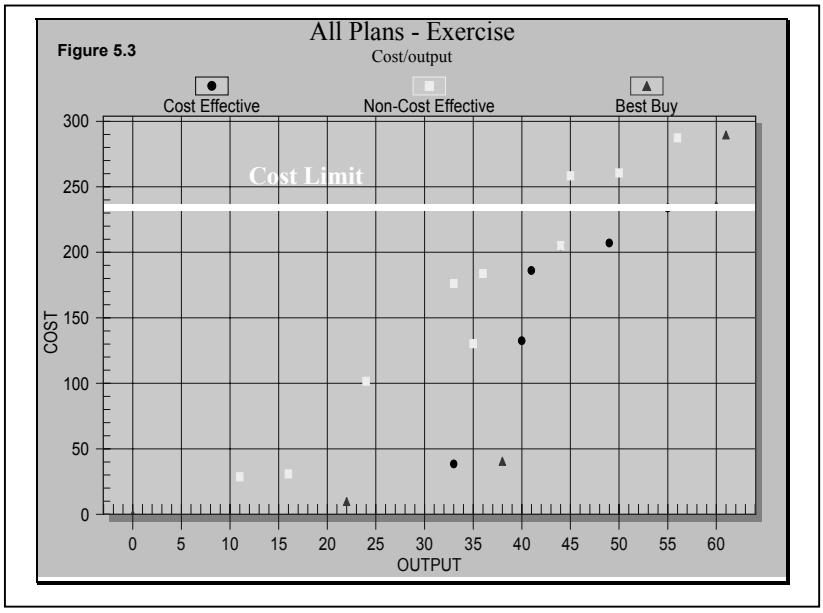


Output Thresholds



In some cases it may be necessary to first produce a minimum base amount of output, where any lesser amount would not be successful. For example, a certain habitat community may require a minimum of say 200 habitat units, and anything less than that threshold would not be adequate. In such cases, a minimum level of habitat units should be considered, and only solutions that would meet or exceed the minimum threshold would be considered. Similarly, there may also exist a "maximum threshold" level of habitat units where production beyond that threshold would no longer contribute to the achievement of planning objectives. If minimum or maximum thresholds exist, they can be utilized to bound the range of acceptable solutions. Using the threshold concept shown in Figure 5.2 (slide XER-17) you would not want plan A1D0H0S0 and plan A0D3H2S0 would provide more output than you need. Again, plan A1D0H2S0 would probably be selected in this case.

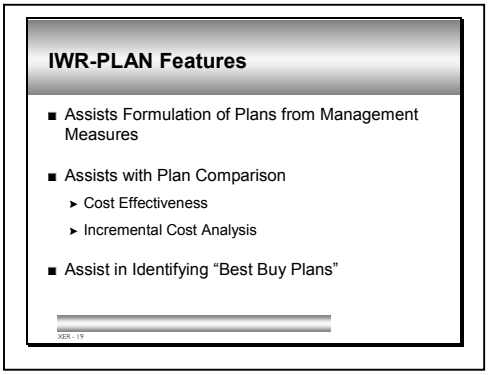
Cost Affordability



If implementation funds are a constraint, then decision-makers can review both the cost effectiveness and incremental cost for information that will help them judge the "best investment" for the funds available. Given the cost limit as shown in Figure 5.3 (slide XER-18), Plan A0D3H2S0 would be selected (this plan has an output of 60 habitat units at the cost of $236,000).

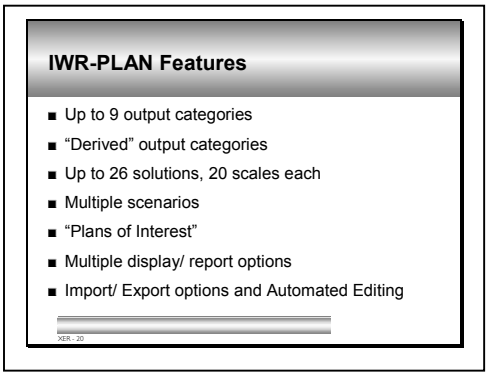
Session 6: IWR-PLAN Overview

Plan Formulation



Once the relationship between different management measures has been identified, the software does all the formulation of plans from different combinations of management measures. Additionally, it screens them to select those that are cost effective. IWR-PLAN then has the internal algorithms to perform incremental cost analysis and identify those that are best buys.

Outputs



Output estimates may be measured in different units such as acres, habitat units, population counts, or any other measure. The software allows up to 9 output categories to be specified. These are the categories upon which the effects of alternative plans can be compared.

Derived Variables

IWR-PLAN has the capability to calculate derived variables. A derived variable is defined as a combination of two or more variables already existing in the database. These variables can be derived as either a cost parameter or an output parameter. For example, a derived variable might be "eco-units", where eco-units are a weighted combination of the variables "aquatic" and "terrestrial" defined as: 1 eco-unit = 0.5(aquatic) + 0.5(terrestrial).

Multiple Scenarios

A scenario is a set of parameters that define the rules for building combinations of solutions and then conducting the cost analyses on the resultant combination. The user can specify the parameters that make up a scenario. The scenario parameters are the required cost and output variables. For example, one might be interested in comparing between different scenarios such as those measuring fish habitats versus bird habitats in a study area, or riverine habitats versus fauna (where fauna is defined as different proportions of fish and bird habitats). The software allows one to view each scenario individually as well as comparing between them.

Plans of Interest

The plans of interest allow the identification of specific combinations of solutions to be carried forward through the analysis. Plans of interest such as local sponsor's plan or another agency's plan can be included in reports and graphs of all plans and cost effective plans even if they do not pass constraints or meet cost effectiveness criteria. For example, concerns about endangered species, support by a local sponsor or other interest group, cost sharing arrangements, and other factors may lead to the continuing and consideration and selection of solutions that may not be the most cost effective, or that may incur substantial incremental costs.

Import/Export and Automated Editing Options

Data can be imported or exported into IWR-PLAN via Excel spreadsheet files. By importing or exporting data, a user avoids having to re-type the same information within the data file. Meanwhile automated editing allows the user to set certain conditions on parameters in advance, such that the program will execute when encountered.

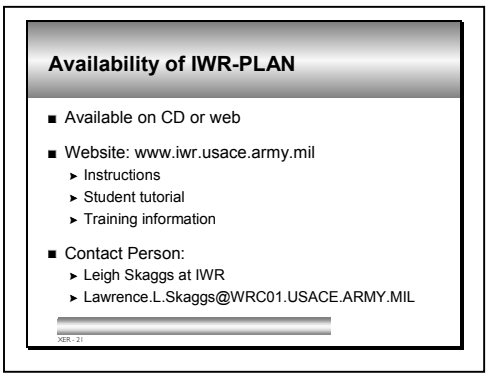
Display capabilities

The software has a feature that allows the user to display the Best Buy box graph either by itself or with a choice of two tables drawn below it. This purpose of this feature is to provide a graphic that may help to make more explicit some of the unintended/ intended effects of Best Buy plans to assist in plan comparison and selection.

IWR-PLAN

The software is available on CD or at IWR-PLAN Homepage www.pmcl.com/iwrplan/.

Instructions, student tutorials, and training information can be accessed at www.iwr.usace.army.mil and should there be a need, the contact person at IWR is Leigh Skaggs whose email address is: Lawrence.L.Skaggs@WRC01.USACE.ARMY.MIL.



Visit the IWR-PLAN Homepage
www.pmcl.com/iwrplan/

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Selected Notes to the Instructor

Student Learning Objectives

1. Students will gain an understanding of how IWR Plan can be used to assist the plan formulation specialist to define measures, build plans, identify dependencies, and select a plan.

Instructor Notes and Exercises

This module is scheduled for 2 hours separated into six sessions. Sessions 1, 2, 3 and 4 contain group exercises. Sessions 5 and 6 are general discussions facilitated by the instructor. These exercises should be done in groups with between 3 to 5 participants per group depending on the class size. The workshop student hand-out material will include the session discussion and session exercises. The instructor will be responsible for distributing the appropriate tables to the students during the exercises. The tables are provided in Appendix D. Instructions are provided in the following instructor notes indicating the appropriate time to distribute and discuss the tables for each session and exercise.

Session 1
The class should be instructed to read the background information and then perform the exercise that follows. Have the class break out into groups of 3 to 5, depending on class size.

1. Team time: 10 minutes

2. Discussion time: 5 minutes

Session 1 Exercise
Once the above exercise is completed, Table A, should be handed out. This table has the management measures that the class should have been able to identify from the background information. Additionally, the associated costs (measured in $1000) and outputs (measured in Habitat Units) are also presented here for further analysis. Mention here that for one to do this kind of analysis, one needs to identify the cost and output associated with each management measure (i.e., management measures when implemented incur costs and produce output which in this case are measured in habitat units).

Session 2
Have the class break out again into groups of 3 to 5, depending on class size for the next exercise.

1. Team time: 15 minutes

2. Discussion time: 10 minutes

Session 2 Exercise
Once the class has completed their attempt to assemble possible solutions, the instructor should reconvene them. Handout the possible solutions generated by the software (Table B – slide XER-5) and hold a class discussion, answer questions, and make specific comments about this exercise. Mention the fact that the table shows an easy example with just a few measures. Pay particular attention to the different management measures that are included within each plan, in this example, the letters (A,D,H,and S)

identify each management measure. Wherever a letter is followed by a 0, indicates that there is no implementation of that management measure within the respective plan. Thus, the no-action plan is signified by (A0D0H0S0). For management measure D (dredging), which has four different scale options, (including no-action), each scale is signified by a suffix (0,1,2,and 3).

Session 3
The class should be instructed to use Table B (slide XER-5) to perform this next exercise and have the class break out into groups of 3 to 5, depending on class size.

1. Team time: 15 minutes

2. Discussion time: 10 minutes

Session 3 Exercise
Once they complete the exercise, the groups should come together and the instructor should hand out Table C.1 (slide XER-6) first, this identifies "inefficient" and 'ineffective" measures. Then hand out Table C.2 (slide XER-7) that contains eleven combinations of management measures that are cost effective extracted from Table C.1. Discuss these results and make comments.

Show the graph of Figure 3.2 (slide XER-8) that illustrates cost and output of all plans and Figure 3.3 (slide XER-9) that illustrates all plans differentiated. Those marked as "best buy" will be the topic of the next exercise.

Session 4
Hand out Table D (from Appendix D), this table contains a subset of the eleven combinations of management measures that are cost effective extracted from Table B. This table should be used in performing the next exercise. The instructor should at this time also explain to the participants the procedures of calculating incremental costs and incremental outputs.

1. Team time: 25 minutes

2. Discussion time: 15 minutes

Session 4 Exercise
The teams should get back together and as a group attempt to answer these questions to determine the "best buys". This is a tedious exercise that is prone for errors. Give the class about twenty-five minutes to try this exercise.

Discuss the results displayed in Tables D through H (slides XER-10 to 14) and briefly run through the steps of selecting the best buy plans. Then show figure 4.1(slide XER-15) which displays the best buy plans from IWR-PLAN. This is also a good place to emphasize the efficiency of using IWR-PLAN.

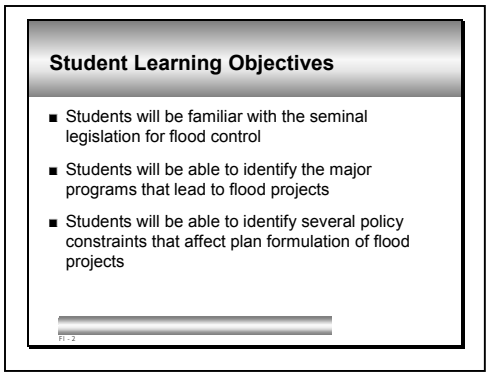
Session 5
This session is designed for the instructor to make special comments concerning the decision making process. No specific group exercises are necessary. Specifically, important considerations such as output targets, cost limits and the best buys need to be explained in detail. Show IWR-PLAN results for CE and ICA and than ask additional questions to the class about what plan or plans would be selected under various criteria. Some of the commonly used criteria are output targets, output thresholds, and budget constraints. Use Figures 5.1, 5.2 and 5.3 (slides XER-16 to 18) to illustrate the following decision making guidelines.

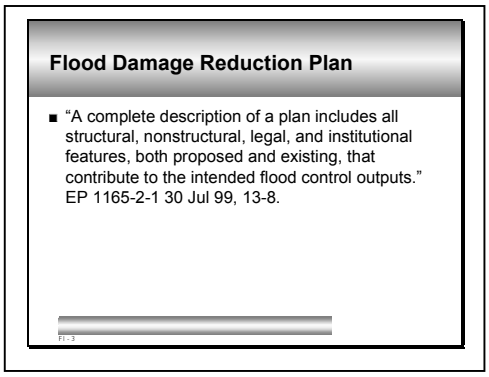
Session 6

If time permits the instructor should take a few minutes to review the corresponding slides and explain the information listed below in more detail, which pertains to features of IWR-PLAN. You may invite the class to stay at the end of the session to view the software on a computer or have copies available to hand out on CD.

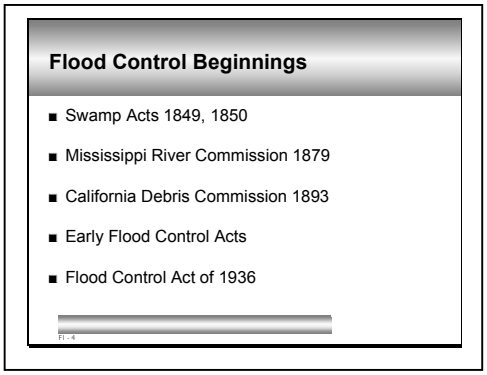
Chapter 5 – Flood Damage Reduction

Module F1: Authorities and Policies





In the Beginning



Flood control remained a purely local concern much longer than navigation did. In 1849 and 1850 Congress passed the Swamp Lands Acts giving Federal lands subject to flooding in Mississippi, Arkansas, Louisiana, and Missouri to those states with the requirement that proceeds from the subsequent sale of those lands be used to provide flood protection.

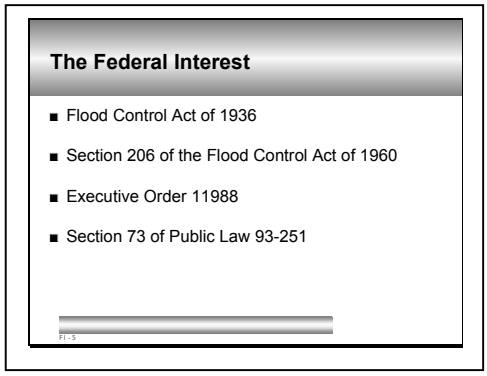
The flood problems of the Mississippi were surveyed during the 1870s and extensive levee construction was proposed. The states could not afford to implement the recommendations and the Federal government would have done it but post Civil War sectionalism waylaid those plans. A disastrous flood in 1874 eventually resulted in the 1879 formation of the Mississippi River Commission. In 1890 the Commission was allowed to use funds for levees. Until then only channel improvements for navigation and incidental flood control were allowed.

The California Debris Commission created in 1893 was established to address flooding on the Sacramento and San Joaquin Rivers. Flood Control Acts following major floods began to appear in the first quarter of the century but there was no National program. In 1928 the flood of record, to that point in time, occurred on the Mississippi and led to an ambitious plan to control floods there. Because of the extremely high costs the Federal government would take on the responsibility. Reservoirs for flood control were first recognized as valuable in this act.

The 1936 Flood Control Act inaugurated a National flood control program and gave jurisdiction over it to the Corps. This same act instituted the requirement for a benefit cost analysis for water resource projects.

Notice how formulation options evolve through this history. At first only channel improvements were permitted. Then levees were allowed. Eventually reservoirs were acceptable. Today virtually any kind of measure is possible, but it was not always so.

The Flood Control Act of 1936 provides the principle authority for the Corps' flood control program. This enabled the Corps to study, plan, construct and operate flood control projects.



Section 206 of the Flood Control Act of 1960, as amended, authorizes the Corps to provide flood hazard and wise use of the floodplain information, technical planning assistance, and guidance upon request to Federal and non-Federal entities.

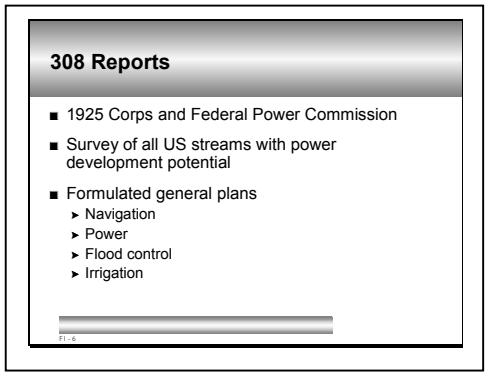
Executive Order 11988, issued in 1977, requires the Corps to provide leadership and take action to: 1) avoid development in the 100-year flood plain unless it is the only practical alternative; 2) reduce the hazards and risk associated with floods; 3) minimize the impacts of floods on human safety, health and welfare; and 4) restore and preserve the natural and beneficial values of the base flood plain.

Section 73 of Public Law 93-251 endorses the Corps' use of nonstructural measures to reduce flood damages.

Section 403 of the WRDA of 1986 expands the definition of flood control to include flood prevention improvements for protection from groundwater induced damages.

Did You Know?

In 1924, Congress directed the Corps and the Federal Power Commission to prepare a list and estimate the cost of making examinations and surveys of navigable streams with power development potential. The Colorado River was excluded from this directive. This was done with a view to formulate "general plans for the most effective improvement of such streams for the purposes of navigation and the prosecution of such navigation improvement in combination with development for power, flood control and irrigation."



Two years later the reports were submitted to Congress and printed in House Document 308. The Corps was authorized to prosecute these surveys, which became known as "308 reports."

There are a few interesting things to note here. Plan formulation is not a new process. Congress directed multi-purpose planning for entire waterways. General plans were formulated for many waterways. There is a good likelihood one or more streams in your district may have a flood control plan over 75 years old already formulated for it! Perhaps most amazing, the plans started in 1925 were completed by 1927. The

Corps was assigned the responsibility for conducting these plans. Many of the comprehensive review studies undertaken by districts in recent decades are essentially reviews of this 1920's work.

Nonstructural flood control has received increased emphasis in recent years, most notably in cost sharing provisions. A nonstructural plan can cost locals a maximum of 35 percent while structural measures could cost as much as 50 percent to the non-Federal partner. Few planners realize the interest in nonstructural is not new. Authorities began as early as 1938 as the figure shows. Section 73 of the Water Resources Development Act of 1974 requires consideration of nonstructural alternatives in flood damage reduction studies. They can be considered independently or in combination with structural measures. The Principles and Standards (P&S) of 1973 required consideration of nonstructural measures. By 1979 the P&S had been revised to require the development of a primarily non-structural plan.

It is useful to realize that nonstructural plans have been part of flood control plan formulation for many decades. The emphasis is not new. Knowledge of historical policy can help you avoid "reinventing the wheel."

History of Nonstructural

- FCA 1938—land acquisition approved
- H.D. 465 (1966)—alternative methods encouraged
- EO 11296 (1966)—flood losses on Federal lands must be considered
- National Flood Insurance act (1968)

F1 - 7

History of Nonstructural

- EC 1120-2-40 (1968)—treatment of nonstructural alternatives
- EC 1120-2-49 (1969)—progress in treatment of nonstructural alternatives
- ER 1120-2-117 (1970)—alternatives in flood related planning
- 1973 Flood Disaster protection act requires NFIP participation

F1 - 8

History of Nonstructural

- P&S (1973)—planning process to include nonstructural
- Sec. 73 WRDA 1974—required consideration of nonstructural measures for flood control
- ER 1105-2-351 (1975)—NED benefit procedures include nonstructural

F1 - 9

History of Nonstructural

- ER 1105-2-200 (1975)—no multi-objective bias toward structural or nonstructural
- EO 11988 (1977)—agency role in flood plain management
- President's Policy 6/6/78—greater utilization of nonstructural
- ER 1105-2-353 (1979)--benefits and costs of evacuation and relocation

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History of Nonstructural

- ER 1165-2-26 (1979)—implementation of EO 11988
- Water Resource Council's Unified National Programs for Flood Plain Management (1979)
- Policy Guidance Nonstructural Measures (10/15/79)

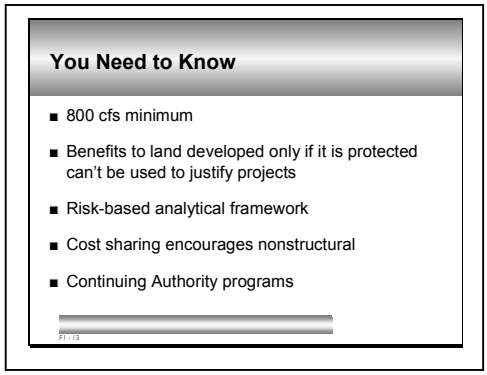
F1 - 11

History of Nonstructural

- Revisions to P&S (1979)—nonstructural plan required
- Policy in land acquisition for nonstructural (4/12/82)
- Principles and Guidelines (1983)

F1 - 12

You Should Know



There are some things that are nice to know. Understanding some of the history of water resources can be a rich source of information, much of it still quite useful. There are, of course, some things you have to know to formulate flood control plans today.

Current policies affect plan formulation in a number of ways. First, an urban stream must have an average annual flow of at least 800 cfs for the 10 percent flood to be eligible for the Corps' flood control authorities. Drainage areas which lie entirely within the urban area and which are less than 1.5 square miles in area, are assumed to lack sufficient discharge to meet the above hydrologic criterion. This rule was intended to prevent the Corps from becoming involved in urban drainage flood problems. Plans cannot be formulated for streams smaller than this under current Corps policy.

EP 1165-2-1 30 July 1999 in Section 13-14.d.(2) describes what NED plan benefits can include. Missing from this description are benefits to land that would develop only with flood protection. Plans that rely on benefits to future development of the floodplain land attributable to flood protection do not address the priority output of flood damage reduction. Consequently they are not likely to be implemented and generally should not be formulated.

The Corps cannot participate in structural flood damage reduction for a single private property. Nor can it participate in single property nonstructural flood damage reduction measures, unless single property protection is part of a larger plan for structural or nonstructural measures benefiting multiple owners collectively.

Flood damage reduction studies are conducted using a risk-based analytical framework. Project performance is analyzed and described in terms of its expected performance, no longer in terms of its level of protection. For formulation purposes there is no minimum level of performance or protection or size required for Corps flood damage reduction projects. The analysis of any proposed flood damage reduction project must estimate residual expected annual damages to the protected community with the project in place. Departures from the NED plan may be considered to manage NED plan residual risks considered unacceptable.

Flood control cost sharing is currently described in Policy Guidance Letter (PGL) no. 51 18 July 1997 and in EP 1165-2-1, 30 July 1999 in Section 13-10. The "price" of nonstructural and structural plans to non-Federal interests can be significantly different. If partners, like the rest of us, prefer cheaper to more costly this could represent a bias toward nonstructural plans. Obviously, price is important but it is not the only important issue. Nonetheless, the difference in cost sharing suggests that, when possible, it might be wise to formulate plans that are primarily structural and primarily nonstructural to offer partners that option, all other things equal.

Cost sharing provisions are somewhat complex but they are summarized in the PGL as follows. Structural projects will cost non-Federal partners a minimum of 35 percent and a maximum of 50 percent. The difference depends principally on the costs of lands easements and rights of way (LERRD). Nonstructural plans, on the other hand, will cost partners 35 percent.

A somewhat hidden local incentive for a nonstructural plan is spurred by the requirement that non-Federal interest must pay the costs of operating, maintaining, repairing, replacing and rehabilitating (OMRR&R)

the project after it is completed. Nonstructural flood control plans usually have lower OMRR&R costs than structural plans do.

It is important to note that an awareness of this potential preference should not artificially affect plan formulation. The best formulation strategy is to formulate plans that meet planning objectives and avoid planning constraints. When possible and reasonable, these plans should include nonstructural elements.

In addition to the National flood protection plan created in 1936 the Corps has several continuing authority programs that support flood damage reduction projects. Section 208 of the Flood Control Act of 1954, as amended, authorized the Chief of Engineers to implement snagging and clearing projects for flood damage reduction. Section 205 of the Flood Control Act of 1948, as amended, provides for smaller scale flood damage reduction projects. More recently, Section 212 of the Water Resources Development Act of 1999 provides programmatic authority for the Secretary of the Army to implement projects that reduce flood hazards and restore the natural function and values of rivers within certain specified limits. The program emphasizes the use of nonstructural approaches to flood damage reduction. Projects must significantly reduce potential flood damages, improve the quality of the environment and be justified considering all costs and beneficial outputs.

Review Questions

1. When did the Corps of Engineers first become involved in flooding issues?
2. How did the National flood control program begin?
3. Is multipurpose watershed planning a new idea?
4. How has the Corps' policy on nonstructural flood damage reduction measures evolved over time?
5. Is there any limit on the size of a stream the Corps can consider for a flood damage reduction project?
6. What authority does the Corps have to become involved in flood damage reduction other than the National program?

Section Summary and a Look Forward

The Corps' flood damage reduction program began as a National flood control program in 1936. Before that, flooding was primarily a local responsibility with some Federal help here and there. Since then the program has been expanded through continuing authority programs. Multipurpose watershed planning has been practiced throughout much of the last century, it is nothing new. Neither is the consideration of nonstructural flood damage reduction measures. There is much to be gained by considering the Corps' history in flood damage reduction. There are many engineering regulations, reports and other documents rich with valuable experience and insights available to the interested planner.

The next section provides some ideas about how to define a flood problem richly. Several kinds of flood problems and resulting flood damages are considered. The important notion of an exceedance frequency is defined and illustrated.

References and Suggestions for Further Reading

Corps Policy and Guidance

The best source of Corps Guidance on the topics of this chapter is the Planning Guidance Notebook, ER 1105-2-100. Current Corps guidance on flood control issues can be found by searching on "Flood Control" and related terms at: http://www.usace.army.mil/search.html#Search. The EP 1165-2-1 30 July 1999 Flood Control Chapter is available for download at: http://www.usace.army.mil/inet/functions/cw/cecwa/floodc.htm. The Flood Plain Management, Executive Order 11988 is addressed in ER 1165-2-26. The PGL no. 51 on Cost Sharing can be found at: http://www.usace.army.mil/inet/functions/cw/cecwa/branches/guidance/pgls/pdf/pgl51.pdf.

For an excellent history of water resources in the US read Beatrice Holmes. The two best sources are:

Holmes, B.H., *A History of Federal Water Resources Programs, 1800-1960.* No further information available.

Holmes, B.H., *History of Federal Water Resources Programs and Policies, 1961-70.* U.S. Department of Agriculture, Economics, statistics and Cooperative Service, Miscellaneous Publication No. 1379. 1979.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will be familiar with the seminal legislation for flood control.
2. Students will be able to identify the major programs that lead to flood projects.
3. Students will be able to identify several policy constraints that affect plan formulation of flood projects.

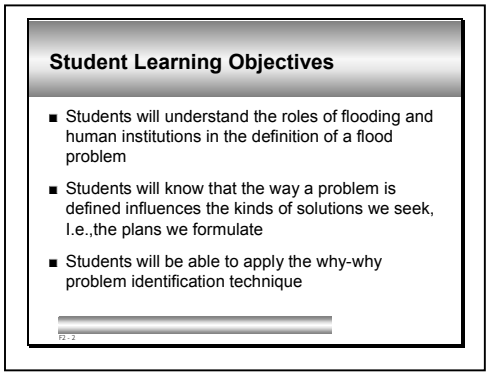
Instructor Notes and Exercises:

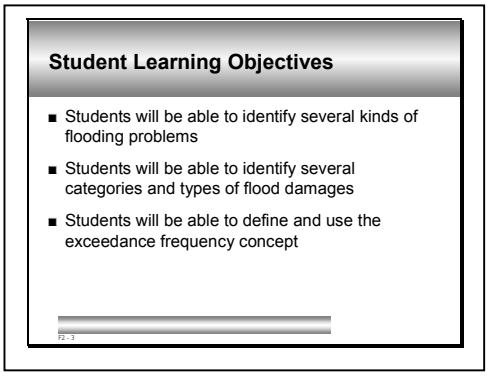
There is a lot of history here. You can skip or emphasize it to suit the needs of the class. It is however useful to know that a great deal of thought and writing has been put into many of the formulation issues planners face today. Studying the past can be a fruitful endeavor in meeting the challenges of the present and future.

The slides on nonstructural should be reviewed very quickly. The history includes only policies prior to the P&G. A few abbreviations for these slides are FCA-Flood Control Act, H.D.-House Document, and EO-Executive Order. The point to take away from this "did you know" section is that planning is not new and some new looking initiatives have been done before. Formulated plans often have a long shelf life. In fact the plans considered and projects for flood control implemented in many areas originated in the 1920s. In addition, neither watershed planning, multiobjective planning nor nonstructural planning are new. You might also want to point out that the Corps developed general plans for most of the nation's major waterways in two years!

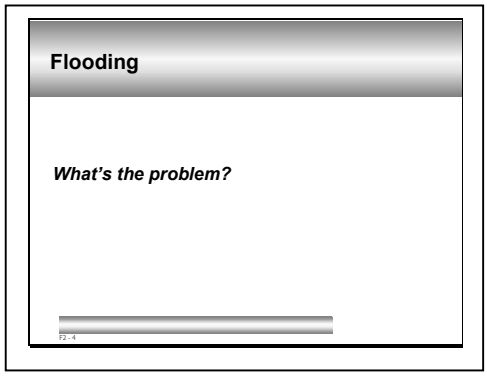
Slide F1-5
Exercise F1.1 What Do You Know
Spend a few moments finding out what the class knows about the Corps' flood control program. Ask how long the Corps has been involved in flood control. Ask when the national flood control program began. See if students are aware of the authorities the Corps uses to get involved in flood control projects. Make sure people are aware of the evolution in our use of the language. We used to say flood control, then we said flood damage reduction and now we like to say comprehensive floodplain management. You will hear all three terms here, the nuance is important and different but the terms mean essentially the same thing. Flood control is used at times because of its historical context and at times precisely because of that nuance of difference in meaning.

Module F2: Problem Identification, Inventory and Forecast for Formulation





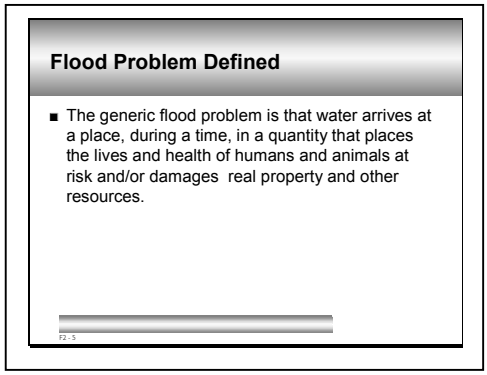
What's the Problem?



Each flood prone area quite naturally has a unique problem. The problems and opportunities of an individual project area need to be carefully identified. Here we seek some understanding of flood problems that will be useful in helping us think about formulating plans for flood-related problems. So we begin with the title of this section and ask, "What's the problem?"

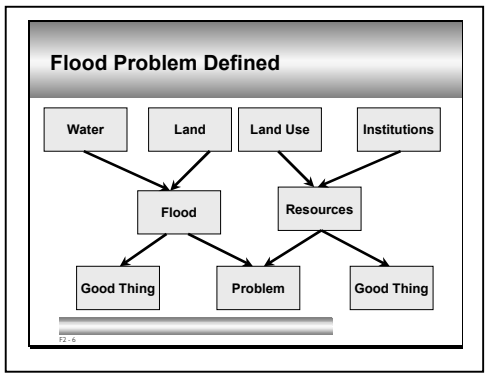
If you like many people feel the problem with flooding is obvious, you're on the right path but you may have a ways to go. The reason our definition of the problem is important for formulation is quite simple. The way we define the problems determines the types of solutions we seek. Thus, problem definition is fundamental to formulation. Before defining the flood problem let's illustrate this point with a simple exercise.

Flood Problem Defined



Flooding alone is not the problem. In fact, we hear more and more that the natural variability in a waterway's flow, which includes periods of flooding, is important to an ecosystem. The generic flood problem is that water arrives at a place, during a time, in a quantity that places human and animal life and health at risk and/or damages personal and real property and other resources.

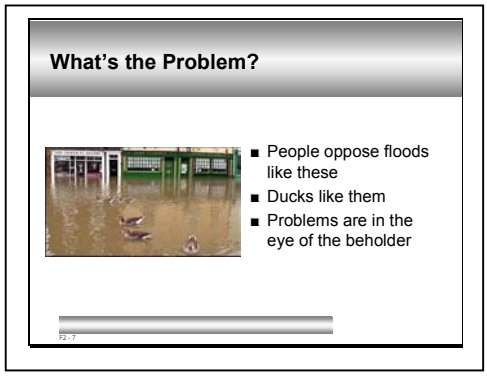
In that broad generic sense we can think of the problem as shown in the figure. It is the confluence of a flood and valuable resources at risk that transform the perception of a natural event into a hazard to life, health, and property. The figure provides a simplified view that is not intended to capture the detail or true richness of this problem so much as it gives us a way to think about the problem.



In a greatly oversimplified sense, floods occur because of water and land systems. For convenience we can think of this as hydrology and hydraulics (H&H). A flood can be a good thing or a bad thing. What makes it a bad thing is when it conflicts with the existing and future use of resources.

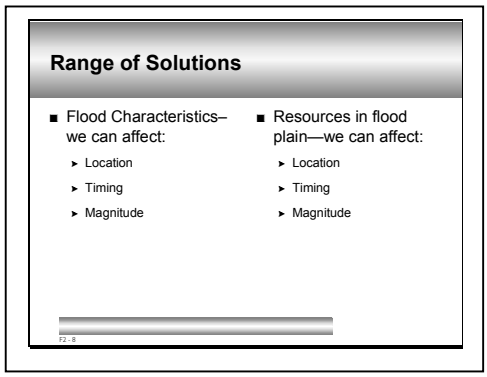
These resources in the floodplains are also the result of some rather complex economic and social systems. They are summarized in the figure by land use patterns and human institutions. We might also see environmental resources that may have pre-existed the human uses of the flood plain.

The use of these resources can be a good thing or a bad thing for reasons far beyond the scope of this course, but we are generally agreed that it is a bad thing when floods and resources simultaneously try to occupy the same land at the same time. So the problem then is risk to life and health and damage to property that is caused by flood events.

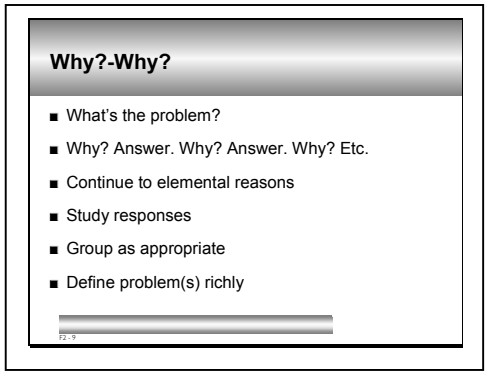


If we see a problem as being partly defined by flooding and partly defined by resource use we have access to a much broader array of solutions than if we define it more narrowly, as has been done in our past.

Identification of specific problem and opportunity statements for a flood study will delve into the specific and unique nature of that area's problem. Some of that may involve the natural systems that produce the floods and some of that may involve the human systems that produce the resources in the flood plain. It is essential that planners seek a broad range of stakeholder views on problem definition to ensure that problems are defined comprehensively.

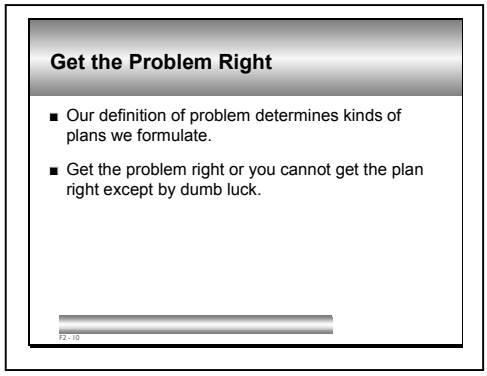


There are a variety of techniques available for identifying specific problems. One handy one goes by many names but we'll call it the "Why-Why Approach."

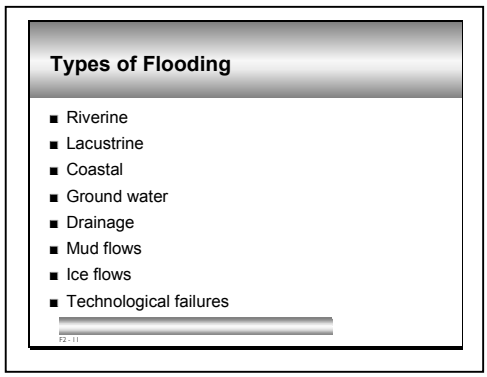


Using this or other techniques we proceed from the general to the specific in problem identification. Problem identification is fundamental to plan formulation. It more than anything, even more than planning objectives, influences our formulation. Although we formulate to achieve objectives and avoid constraints we base our objectives on our problems and opportunities. If they are not defined richly enough neither will our objectives be.

Objectives may be as simple as reducing flood damages in Old Frederick due to Augusta Creek flooding. Plans formulated to achieve this objective will benefit immensely from the richly defined statement of problems and opportunities.



Kinds of Floods



It can help to develop an understanding of the kinds of floods that occur. Let us begin by being clear about the Corps' flood damage reduction program. We are interested in urban riverine flooding on creeks with a mean annual flow of 800 cubic feet per second (cfs) or more. That does not mean you will not encounter any other kinds of flooding.

Coastal flooding caused by storms and hurricanes are a significant problem that we do not specifically consider here. Lacustrine (i.e. lake) flooding is a concern in districts that border the Great Lakes and other large lakes. These floods can be similar to coastal flooding in some cases. In other cases lakes result in a weir-like flow of water as rising lake levels creep over their banks and spread slowly and gradually over the land. These floods are sometimes characterized by large land areas covered by relatively shallow depths of water for long periods of time.

Riverine flooding is, of course, the best-known variety. This generally occurs as a result of rainfall, snowmelt and run-off. We'll say more about this later. Groundwater flooding is associated with standing water that results from a high water table. Drainage characterizes a type of flood that can occur locally

and naturally because of the topography of the land with inadequate run-off opportunities. Urban drainage can result in floods if storm water systems are missing or inadequate for carrying off rain that falls on a local and confined area. Interior drainage of land behind a floodwall or levee is often subject to this sort of flood problem. Floods can also occur as a result of technological failures, as when a dam breaks, a levee is overtopped or a water main bursts.

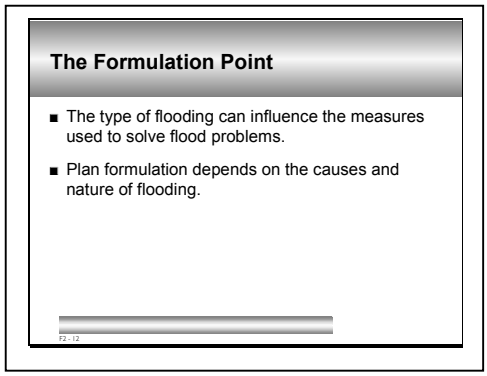
In some parts of the country, such as the Tug Fork of WV, floods are more adequately described as mudflow. The sediment loads in the water can vary tremendously. The Portland District has had experience with floods heavily laden with dust and debris from volcanoes following the eruption of Mt. St. Helen. Their experience was called upon to assist with the lava flows that resulted from the eruption of Mt. Pinatubo in the Philippines.

Northern districts may have experience with ice floods. These could consist of dam break-like flows that result when ice flows jam up and impound a rising wall of water behind them that eventually breaks out. Or it could include a flood flow on top of a sheet of ice.

The point is that floods come in all flavors and sizes determined by the nature of the flood itself. The naturally occurring part of the flood problem, the flood itself, has many types across the country and around the world. The Corps' program is principally concerned with flooding rivers in developed urban areas. Although agricultural flood damages can be severe and their prevention has been an important part of the Corps' program historically, they are not addressed specifically in this course.

In case the point is not painfully obvious, the nature of the flood problem will have a tremendous influence on the types of plans formulated to address it.

Flood Damages



There is not a problem because rivers flood. In fact, it would be easier to argue there is a problem if rivers do not flood occasionally. When resources are threatened or damaged by the floods then we have a problem. The effects of the floods can also affect formulation options. Protecting life is going to be far more important than preserving access to greenways during certain times of the year. Industrial damages may be amenable to different solutions than residential damages are.

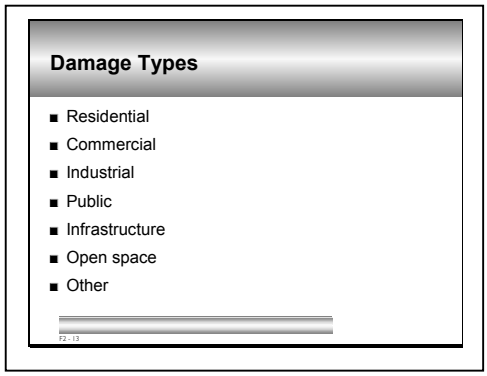
Risk to human life is perhaps the greatest concern followed by the risk to human health. Risks to life vary from one flood type to the next. Risks to human health can be before (flood fighting stress and injury), during (injury and illness), or after the flood (injury and illness especially due to toxins and microbial pathogens in floodwaters and water supply). Although it is not a great concern in most urban settings the threat to the life and health of livestock can be significant in some instances. It is more likely that domesticated animals and naturally occurring species would be of greater concern in urban areas. These have not traditionally been significant concerns in most urban flood studies.

The best-known damages of flood are the "flood damages." These are traditionally the dollar estimates of the damage to real property and their associated economic losses.

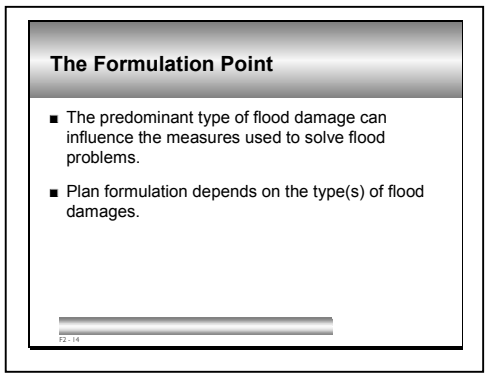
The categories of flood damages and losses to property can be classified several ways. We divide damages into residential--where people live, regardless of ownership; commercial--generally wholesale, retail, and service establishments; industrial--usually manufacturing and assembly; public--includes government buildings, churches, schools, museums and the like; infrastructure--roads, water and sewage lines, power distribution and the like; open space--parks, preserves, and other recreation areas; and the obligatory "other"--for any type not easily classified in one of the other categories. Usually infrastructure damage to the distribution systems, the generation and other facilities comprise industrial damages.

These classifications are useful in helping us understand the magnitude of damages and often the types of plans that will be most successful. If industry damages are largest we can often work with large industry to develop a flood plan that would not be successful with residents because of the coordination costs of the plan, motivations for developing and enforcing it and its probability of success. But no one should lose any sleep worrying about whether the damage estimates for a particular building were included in public category instead of the industrial category!

Now that we have categories of damages let's consider the types of damages that can occur in that category. Some of these damages are reduced by one kind of plan but not by others.



If the average person would leave the item behind when they move consider it structural damage, hence wall-to-wall carpeting is structural damage. Content is every other physical damage that occurs in or on the property. Any costs of flood fighting or mitigation of pending flood damages is a cost of flooding. There are also recovery costs associated with floods. A type of damage that is not so well known is what I call surplus losses. These are losses of consumer and producer surplus that are not reflected in the preceding categories. These include income losses that reflect changes in profit. Consumers can lose income while unemployed and so.



Trauma damages are intangible and include the worry, stress and mental suffering that accompany a flood. There is a willingness to pay to avoid these trauma damages and if that can be estimated it is a legitimate benefit type. Other damages are included to cover all the things we have not discussed, like landscaping, traffic disruptions, interruption of communications and so on.

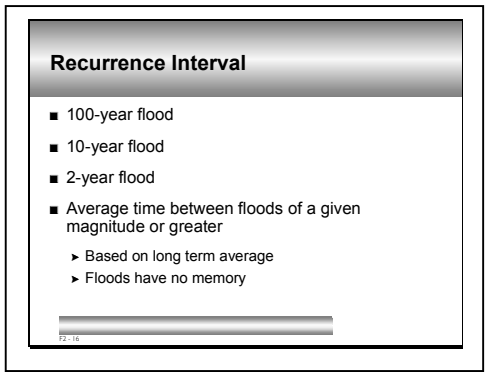
Once again, the point of this taxonomy is to help planners think about the types of plans to formulate. Understanding the type of damages that result in a specific flood problem may spur some creative thinking about formulation.

Talking About Floods

The Tug Fork flooded several counties in WV in July 2001. The newspapers said it was in excess of a 100-year flood. What does that mean?

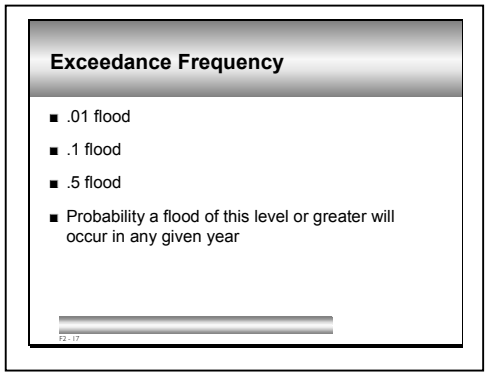
We need a way to talk to the public and each other about events that are uncertain. That is not easy to do. Floods fall into this category. How do we talk about floods? In years gone by we used the recurrence interval.

A recurrence interval gives the average number of years between floods of a given size (magnitude, flow, cfs) when averaged over a very long period of time, say many thousands of years. So, conceptually, a 100-year flood was flow that was equaled or exceeded once every 100-years over a very long period of time. A 10-year flood means if you kept the flows records for say 1,000,000 years you would have seen flows that big or bigger 100,000 times and 1,000,000/100,000 = 10 so you'd see it an average of once every 10 years.

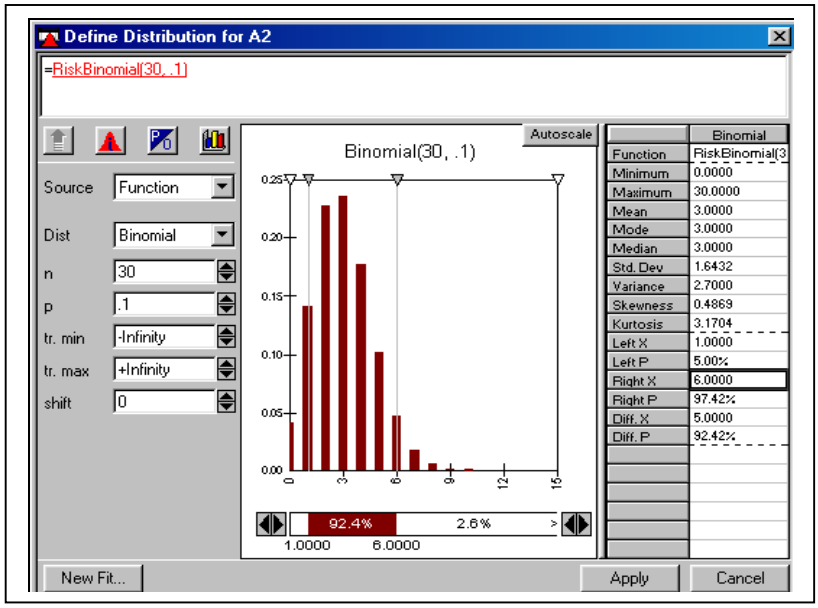


If the recurrence interval did not work well it did not free us from the need to talk about the uncertainty associated with river floods. So what replaced it? We now use exceedance frequency.

Exceedance frequency is not an easy concept. If you find it simple, remember you work with this all the time and the general public and your non-federal partner's do not find it easy. The importance of all this is that we need to talk about exceedance frequency to describe the output of the plans we formulate. We can talk about kilowatts of energy, tons of commerce, even numbers of habitat units, but talking about what our formulated flood damage reduction plans do for people in quantitative terms is not easy.



The slide shows a distribution for a discrete random variable. Suppose there is a .1 chance of rain on any given day of the month and that this shows the distribution of days of rain for September. The biggest bar and most common result is 3 days of rain per month. In technical terms this is called a "no-duh" because .1 x 30 = 3 and 3 is the expected outcome.

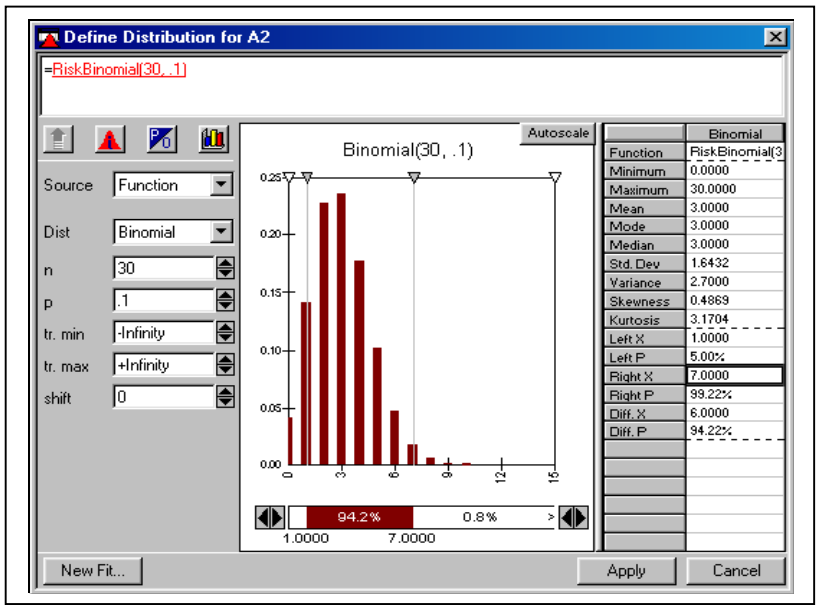


Two days are pretty common as are 4 and 1 per month. The numbers of days it will rain each month vary due to the many and complex reasons for the climate and the weather.

This then is a picture of the many results there could be and their relative likelihood. Notice there is practically no chance you'd get 15 days of rain in a month when there is a .1 chance of rain on any given day. For it to rain 50 percent of the time when it normally rains ten percent of the time is not likely to happen at all. Although it is not impossible it is so unlikely that the chance is very small.

Notice to the right of the distribution. See the highlighted six? Beneath it you see the number 97.42%. That means that 97.42% of all the time it rains six days or less. Conversely, it exceeds six days of rain per month 2.58% of the time. In this case the exceedance frequency is simply the frequency (or estimated probability) with which a given number of days of rain per month is exceeded.

Consider the next slide. The distribution and setting are identical but this time we want to know the frequency with which 7 days of rain per month is exceeded. We see 7 or less occurs 99.22% of the time. Consequently it rains more than that 100% - 99.22% or 0.78% of the time. That is our exceedance frequency.

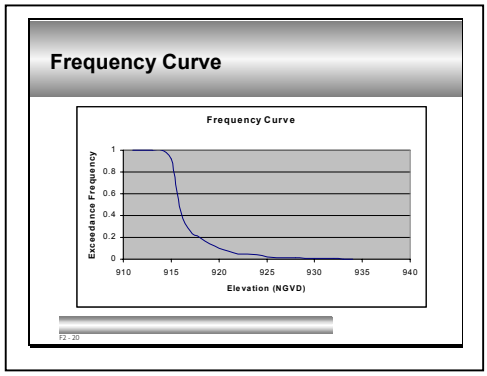


Notice that 8, 9, 10, 11, etc. days up to 30 satisfy our criterion of more than 7 days of rain. So the exceedance frequency is not for any one specific number of days it is for all numbers in excess of an amount.

It is the same basic deal with a flood exceedance frequency. It is a little different because it is a distribution of flows rather than days of rain in a month, but it's the same idea. When we say a flow of say 90,000 cfs has an exceedance frequency of .01 we mean that 1 percent of all the flows that are possible (or that have been observed on this stream) have been 90,000 cfs <u>or more</u>.

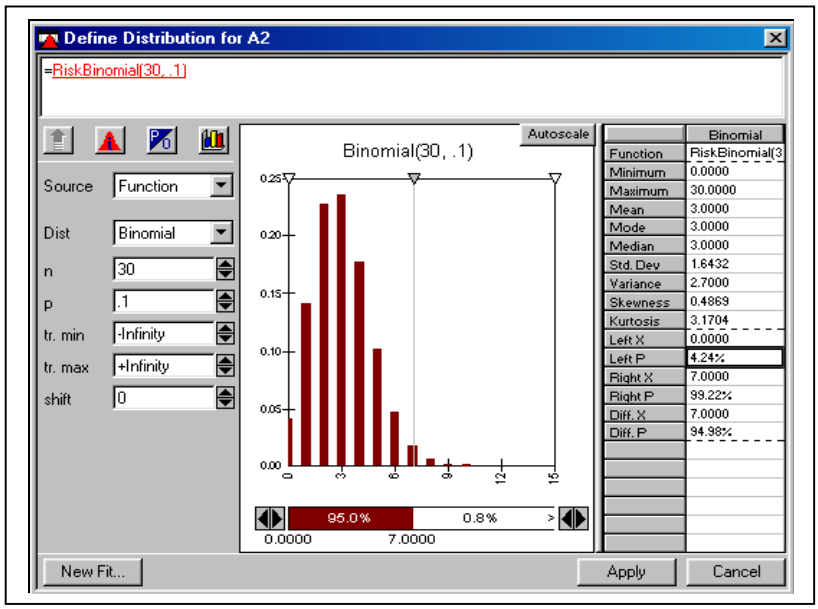
Now wait a minute, there was a subtle point there. With days of rain we said it was more than a specific number. Now we are saying it is equal to or more than a specific number. What's that mean? Flows are continuous variables; any flow at all is possible. Only our ability to measure it limits us. Thus, a flow of 90,000 cfs is one of an infinite number of possibilities (whereas days of rain had a discrete number of possibilities, i.e., 30) and it has a 1 divided by infinity chance of occurring. So when we deal with continuous variables it is okay to say equal to or greater than because the chance it equals an exact value is effectively zero so the probability is the same as the probability it is greater than 90,000 cfs. If that gives you a headache you can understand why our clients have such difficulty with these concepts. This is your job and it's hard, it's even harder for the public.

So there is a 1- percent chance in any year that the maximum flow on the river will be 90,000 cfs or more. Keep working with that concept until you get it nailed down. Now suppose a flow of 34,000 has an exceedance frequency of .1 or 10%. What does that mean? It means .1 of all the flows possible (or that have been observed) are 34,000 cfs or more. That 90,000 cfs flow is one of these. So there is a 10 percent chance we'll see 34,000 cfs or more in the river this year but only a 1-percent chance we'll see 90,000 cfs or more. Same thing next year, and the year after and so on.



Can exceedance frequencies change? Yes, but only if the watershed's hydrologic and hydraulic characteristics change. Paving more land for houses and parking lots and malls increases the runoff and physically chances the system. This can affect the exceedance frequency of various flows.

Exceedance frequency is important because sometimes the formulation strategy is to try to protect against floods of a certain size. In order to talk to other planners, the public and your bosses you need to know what an exceedance frequency is. To know precisely how it is arrived at you have to go talk to your hydrologist.

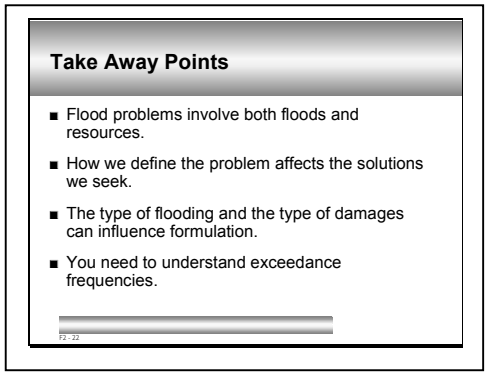


Review Questions

1. What are the two essential elements of a flood problem?
2. Why does the definition of a problem matter for the solution considered?
3. How might the type of flood damage influence the plans formulated?
4. What is a weakness of the recurrence interval estimate of flood frequency?
5. What does it mean if a flood has an exceedance frequency of .02?

Section Summary and a Look Forward

Flood problems involve natural and human systems. Flood problems do not exist unless floods affect resources. How we define a problem has a great deal of influence over the solutions we seek. Thus, flood problems should be defined as richly as possible. Because flood problems involve resources it can be helpful to categorize them because protecting different kinds of resources may require different kinds of solutions. Inasmuch as a flood may or may not occur, we need some language that enables us to describe just what our flood risk is and what our flood damage reduction plans offer people. The concept of exceedance frequency, although not terribly intuitive, is a very useful way to communicate about the risky nature of floods.



The next section addresses the formulation of flood damage reduction plans. It begins by distinguishing structural and nonstructural plans. The Corps' Hydroeconomic model for estimating expected annual damages is presented and then suggested as a possible basis for a formulation strategy. Several other formulation strategies or ways to think about how to "think up" plans are presented as well.

References and Suggestions for Further Reading

Some of the best references for this chapter include any good introductory hydrology textbook. Roy Ward's "Floods a Geographical Perspective" Macmillan Press, London, 1978 provides a good introduction to the nature of floods in a very good non-textbook narrative. The Institute for Water Resources' has prepared a series of manuals on the planning steps and the manual on the second step written by Charles Yoe will supplement the problem identification discussion here.

Discussion of flood damage categories can be found in ER 1105-2-100, the P&G and in a wide variety of old Corps ER's and other documents. Corps documents remain the best source of information on this

topic. Many of them are not formal publications so much as informal guidance, memoranda and such. But every District with a library is likely to have a treasure trove of materials relating to damage categories.

Flood frequencies are well discussed in any number of introductory hydrology textbooks. Although every civil engineer is likely to have a favorite text, try some of the newer ones. Introductory textbooks have become much more user friendly in recent years. For a more official Corps view of exceedance frequency you can try one of these two documents.

Guidelines for Determining Flood Flow Frequency, Bulletin #17B, March 1982, Interagency Advisory Committee on Water Data, U.S. Department of the Interior or *Hydrologic Engineering in Planning*, Training Document No. 14, April 1981, HEC.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will understand the roles of flooding and human institutions in the definition of a flood problem
2. Students will know that the way a problem is defined influences the kinds of solutions we seek, i.e. the plans we formulate
3. Students will be able to apply the why-why problem identification technique
4. Students will be able to identify several kinds of flooding problems
5. Students will be able to identify several categories and types of flood damages
6. Students will be able to define and use the exceedance frequency concept

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Instructor Notes and Exercises:

The objectives of this module are as shown above. It is designed to maximize student participation in discussion. The instructor's greatest challenge will be in not taking too long for this module as discussion can consume a great deal of time.

Ideally, you will elicit responses from students to develop lists that will correspond with your own. That way you can emphasize the knowledge the students already had collectively. If you succeed in doing that, and you will not always because classes vary in their personality, then use the slides as a summary. Otherwise you may use them to stimulate discussion.

Encourage note taking because the slides are rather spare. Most of the substance will come from your guided discussion of these ideas.

Slide F2-5 is rather critical in helping people to understand that flooding alone is not a problem. It is only when flooding and people's use of resources mix that it becomes a problem. I have chosen land use to represent the particular kinds of things done on the land. Development was the word I used to represent the intensity of use. My thought was some homeowners develop intensively with landscaping and extensive improvements, some business use the land more intensively, income levels matter, as does climate and so much more. I was stuck for a word and development leaped out. Feel free to change this.

Slide F2-7 may be confusing. You want to make the point here that it is not just the location of the water but the location of the people and their institutions (i.e. resources) that are part of the problem. Likewise the timing of people and water as well as their amount and intensities at those times and in those locations matter. This is setting up later strategies when we will say you can change the location of water or resources, you can change the timing of water or resources, or you can change the amount/intensity of water or resources as formulation strategies.

Slide F2-8
Exercise F2.1 Problem Identification
Tell students we're going to do an exercise in problem identification that is purposely not in the area of flooding. Divide them into small groups to work together on this. We do not want to bog down in technical arguments and details at this point. There seems to be a consensus in many parts of America that our public education system is in trouble. There are problems with public education. With no more than statements like these ask students to develop a consensus statement of the problem with public education. Forestall any open discussion, you are being purposely vague at this point and want students to resolve the vagueness.

Give them 5-10 minutes to derive a problem statement. Have each group reports its statement. It is likely some will say budgets, buildings, supplies, class size, teacher preparation, support at home and the like. It is unlikely each group will provide a homogeneous statement. Use their problem statement to indicate how they would lead to different plans. Buildings and supplies have one set of solutions, teacher preparation another, violence in schools and lack of support at home have yet others and so on. The point is that our definition of the problem points us at solutions from the outset. Thus, getting the problem identified properly is critically important.

Slide F2-9
Exercise F2.2 Why-Why Approach
Elicit an example of a flood problem from a student. Ask why that is a problem. Then ask why to the response to the first why and continue this process until you arrive at a reasonably fundamental reason. That is a specific problem. Consider the following example.

Flood damages from Augusta Creek are a problem in Old Frederick. Why? Because commercial buildings along the creek are frequently flooded. Why? Because the creek runs through a poorly maintained and overgrown concrete channel in the industrial sector of town. And the walls of the buildings form the walls of the creek channel. Why? Because when the buildings were built I suppose the problem was not as severe? Why? Because there was less run-off in the Augusta Creek watershed? Why? Because housing developments in the Marydell area have increased the run-off. Why? Because we did not have good zoning laws in that part of the state back then? Why? Because this predated the flood insurance program and we simply did not know about things.

And by this point you have the feel of this technique. The trick then is to gather up all of these reasons and use them to articulate one or more specific problem statements about the flood problems in Old Frederick. Problem statements like this can point our formulation rockets in several different directions that we may not have seen with a more superficial examination of the problem. We can now consider the condition of the channels, its maintenance, possible relocations of buildings, zoning laws, run-off controls, flood proofing of buildings and other things in addition to the obligatory channels, levees, and walls.

Slide F2-11
Exercise F2.3 Types of Flooding
Begin by asking students to identify as many different kinds of flooding as they have experience with, have seen, or heard of. Personalize this by eliciting waterway names and writing them down along with dates and a few descriptive words. After you've exhausted the possibilities begin this section and show your list of flood types.

Slide F2-12
Exercise F2.4 Types of Flood Damages
Begin this as you began the previous section. Ask people for broad categories of flood damages. Gradually get more specific with examples. For example, if someone says industrial damages, ask if they have ever seen any post flood industry. Ask for people with actual post flood experience. Ask the name of an industry. Ask their most enduring memory of the visit. Ask what the greatest dollar damage category was. Get them to describe what they saw. When you have exhausted the value of this discussion, move on to make the points. The goal here is to have the class make as many of your points as you can lead them to make. Then you are simply summarizing their discussion with your slides, perhaps embellishing with a detail or two they missed. When they give you more details than you had, modify the slides to include their new material.

Slide F2-13
Exercise F2.5 Damage Types
Show the slide and go through the types of damage. Now ask how the type of damage could possibly be relevant to plan formulation. If you get no volunteers or good answers, pose some extremes like a flood plain with all infrastructure damage vs. all commercial surplus losses vs. all residential contents and so on. Mix the types and categories to get them talking about different kinds of plans. Ask for examples of the less well-known or understood damage categories as you discuss each type. Consider provoking a discussion about FEMA and its National Flood Insurance Program (NFIP) by asking if insured losses are damages. The answer is yes but you can expand on the NFIP as appropriate. That is a subject revisited later in Flood Module 4.

Slide F2-15
Exercise F2.6 Flooding Likelihoods
Tell students they are residents of a floodplain. Tell them that over many thousands of years their house would be on average flooded once every 10 years. Then tell them they just got a 30-year mortgage and expect to live there until it is paid off. Then they will retire and move to Florida. Ask them to estimate how many times they will be flooded in their 30 years here. Then ask them the probability they will be flooded at least once while they live here. Record the answers in a visible place. You will return to this exercise. For now tell them that this is a common sense question a flood plain resident might ask. "Am I going to be flooded (again?) if I live here?"

F2-16
Exercise F2.6 (continued)
Ask what problems could arise from expressing a flood's likelihood of occurrence in this way? The basic answer is that because our heads are not well wired to understand probabilities people frequently mistake this value to be a rule rather than a long run average. It was not uncommon for people to think that after a 100-year flood event they would not have such a bad flood for another 100 years. They were far too literal in their interpretation of what this number represented.

So now that we understand exceedance frequency what is the probability of being flooded once or more in thirty years? Ask people for the estimates they made at the start of this module. Write them down as they are called out.

Slide F2-19
Notice this slide shows the same distribution we have been looking at. This time the p value on the left of the distribution is .1 and it represents the exceedance frequency of flooding for your house. Ten percent of the years the flow will equal or exceed an amount necessary to flood you. The n of 30 now stands for the 30 years you will live here. Look at the highlighted value on the right. Notice just above it is a value of zero. This highlighted value says the chance of getting no flows that flood you in 30 years is 4.24%.

Hence it is possible that you will not be flooded at all in the 30 years you live here. But the flip side of that value is that there is a 95.76% chance you will be flooded at least once in your 30 years. Now check and see how people did with their estimates that you wrote down. The size of the bars on the distribution shows the relative likelihood of the different numbers of floods possible. Six floods in 30 years are slightly more likely than no floods in 30 years. There is virtually no chance of more than 10 floods in 30 years.

Student Learning Objectives

- Students will be able to distinguish structural from nonstructural measures
- Students will be able to identify at least ten different flood damage reduction measures
- Students will be able to identify and use several different formulation strategies for flood damage reduction

F3 - 2

Students Learning Objectives

- Students will know what software tools are available to aid them in flood damage reduction formulation
- Students will understand the Corps' basic hydroeconomic model of expected annual damage estimation and its use in modeling the effects of formulated plans

F3 - 3

Module F3: Formulation – Measures and Strategies
The Measure of a Plan

Word Association

- Corps of Engineers
  - Employees
  - Environmentalists
  - Reporters
  - Floodplain residents
  - Waterway operators
  - Congress

F3 - 4

If you were to play word association with the general public, especially someone with an environmental bent, and said the word Corps of Engineers you might expect to hear "dam builders," or something similar. The Corps is best known for what is most visible to others. This includes dams and reservoirs, locks and dams, floodwalls, and levee systems. The Corps is most appreciated when one of its large projects quite visibly saves a community from crippling flood damage. No one notices when the barges move up and down the river and ships move in and out of our ports. The levees on a town's bank have long since become part of the background. But the success of the Corps' missions is never more apparent than when a flood that has been destroying everything in its path laps at the top of a structure.

Everyone knows about reservoirs, walls and levees but they are only the most visible flood damage reduction measures. What we are after is a comprehensive list of as many flood damage reduction measures as possible.

Structural Flood Damage Reduction Measures

- Dams
- Reservoirs
- Floodwalls
- Levees
- Channels
- Straightening
- Clearing and snagging
- Closure structures
- Bridge modifications
- Conveyance modifications
- Pumping
- Land treatment
- Channel diversions

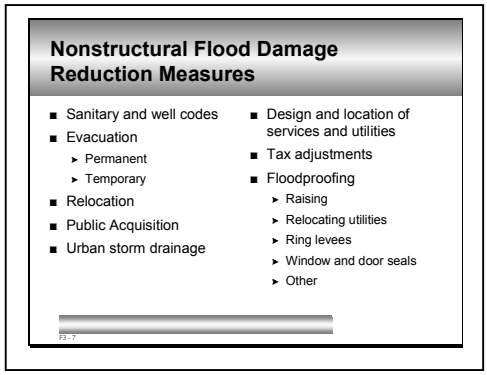
F3 - 5

In the not too distant past this mission was always called "flood control." Gilbert White and other proponents of land use controls and flood insurance gradually had the effect of changing the language by helping us all to realize we really do not and can not control floods at all. We have no control over the flows generated and big as we build our projects nature is always capable of building a bigger flood. Furthermore, there were ways of reducing the basic flood problem, i.e. the commingling of floods and resources at the same time and place in magnitudes sufficient to cause problems to life, health and property that did not involve doing anything to the flood waters. We were beginning to realize there was a class of alternatives to keep the water away from the people. It is a bit of an oversimplification, but only a bit, to call that other strategy, keeping the people away from the water.

Some of the measures we have identified affect the flood; others affect the resources exposed to the flood. Just a reminder that people represent perhaps our most valuable resource and are included when we talk of resources exposed to floods.

The measures identified in our lists are divided into structural and nonstructural measures. Look at the lists. Based on the way these are divided and grouped, how would you define a structural measure? A nonstructural measure?

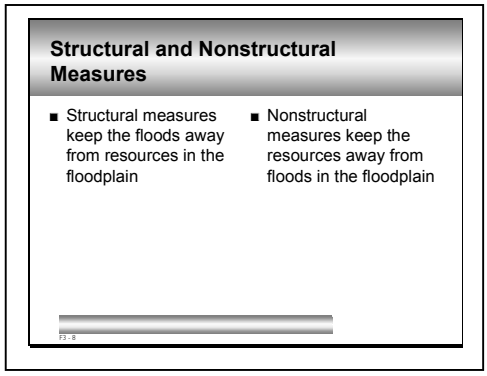
The Principles and Guidelines (P&G) define nonstructural measures as follows: "Nonstructural measures are complete or partial alternatives to traditional structural measures. Nonstructural measures include modifications in public policy, management practice, regulatory policy, and pricing policy." (P&G (1.6.1(f)(1)).



Defining nonstructural measures as those measures that are not structural is not very helpful. The P&G resorts to another common definition technique, a list of examples. We like the simple distinction that emerged during the 1960s and 70s. Structural measures keep the floods away from people and damageable property; what we call resources here. Nonstructural measures keep the resources away from the floods. You may actually need more heavy equipment to implement a nonstructural project, so do not let your understanding of these measures ride too much on the notion of construction activity. To define one as building things and the other as not does not capture all the nonstructural possibilities today.

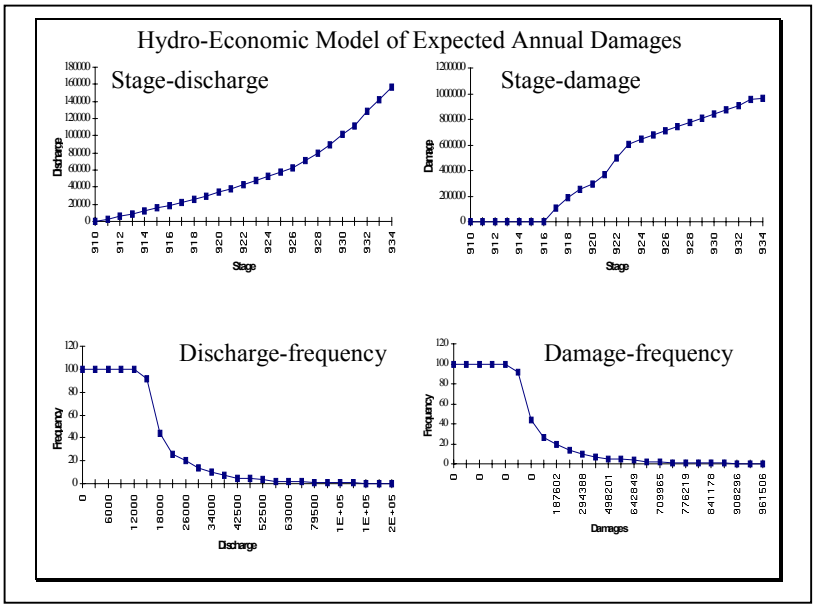
The Hydroeconomic Model

Every course should provide a few twenty-five cent words for concepts with which you were already familiar. Here is one. Every planner should be familiar with the hydroeconomic model the Corps uses to estimate expected annual damages. This model is a principal tool in the description of the without project condition for flood problems. It is also an essential element in the description of with project conditions. It is usually the economists that make detailed use of the model, but the hydrology and hydraulics experts provide much of the input. The plan formulation process will dictate what changes must be made to it so it is an essential plan formulation concept even though it is used most often in the evaluation of plans once formulated. Its value here is that it helps planners to think about ways to formulate plans and although it is introduced as a tool here it can also be thought of as our very first plan formulation strategy.



If you understand the model you will have a richer understanding of the nature of the flood problem. That can provide some insight and structure for approaching the task of "thinking-up plans."

Expected annual damages (EAD) are a principal evaluation criterion for flood projects. We estimate EAD without a project, say they are $10,000,000. Then we change the model and estimate the EAD with a project in place. Say they are $3,000,000. The benefits of the plan thus evaluated are the $10,000,000 in damages we'd have without the project less the $3,000,000 residual damages with the project for a reduction or benefit of $7,000,000 due to the project.



It is largely because flood damage reduction benefits are calculated in this fashion that the Corps of Engineers uses average annual benefit and cost estimates rather than the far more common and intuitively appealing present values the business world and most other agencies use.

It is important to consider this hydroeconomic model in sufficient detail to understand it completely.

The stage-damage curve is based on fieldwork. The stage-discharge curve, also known as the rating curve, is often developed using waterway profile programs developed by the Hydrologic Engineering Center (HEC). Hydrologists usually with the aid of HEC tools develop the discharge-frequency curve or frequency curve. These three relationships are used to generate a composite fourth relationship, the damage-frequency curve. HEC's Flood Damage Assessment (FDA) program is used to develop this relationship and to make calculations from it.

To see how it works pick any point on the positively sloped portion of the stage-damage curve. That point estimates the flood damages that would occur if water reaches the corresponding stage. The rating curve indicates how much flow is required to reach that stage (or elevation) at a particular location in the floodplain. By extension we know how many cfs of water are required to cause the selected amount of damage. The next question is how often does that quantity of water occur? That information is obtained by looking at the frequency that corresponds to the flow for the selected stage. Once again, by extension you know the frequency with which the damage occurs. That frequency and damage amount provide one point on the damage-frequency curve. As many points as desired can be obtained in a similar fashion to trace out the damage-frequency curve.

The vertical axis of the damage-frequency curve is a probability scale and the area under the damage-frequency curve is the probability-weighted value of all the possible damage points. This value is also known as the expected value of the distribution of damages. In this case we've used the probability of flooding as the weights. If you take the area under the damage-frequency curve you obtain an estimate of the expected annual damages of flooding for the economic, hydraulic and hydrologic conditions represented by the three curves.

This graphic presents examples of the actual values that comprise the curves in the preceding figure. The damage curve comprises the stage and the damage columns. Thus at a stage of 914 National Geodetic Vertical Datum (NGVD) no damage occurs. When water reaches 922 NGVD the damages are estimated to be $498,201. So we have $498 thousand in damage at 922 NGVD. How much water does it take to reach 922 NGVD? The associated discharge is 42,500 cfs. Thus, 42,500 cfs causes $498k in damage.

Stage	Discharge		Damages	Frequency
910	0		0	99.999999
911	3000		0	99.99999
912	6000		0	99.9999
913	8500		0	99.999
914	12000		0	99.99
915	15500		0	92
916	18000		0	44
917	22000		107320	26
918	26000		187602	20
919	29500		256667	14
920	34000		294388	10
921	38000		367004	7
922	42500		498201	5
923	48000		607782	4.7
924	52500		642849	3.7
925	58000		676479	2
926	63000		709965	1.6
927	70500		742877	1.4
928	79500		776219	1.2
929	90000		809418	0.9
930	102000		841178	0.65
931	112000		875240	0.5
932	128000		908296	0.38
933	142000		951986	0.3
934	157000		961506	0.22

Hydro-Economic Model Inputs

How often do we get 42,400 cfs? The exceedance frequency for this flow is 5 percent or .05. So there is a 5 percent change we will get $498k in damages or more in any given year. The pair of values (498201, .05) is one point on the damage-frequency curve. Any number of other points can be obtained. In this example, a point is estimated for each whole foot of stage.

The area under the damage-frequency curved is estimated through the calculation of the area of a series of rectangles inscribed beneath the curve. The rectangle dimensions are given by the values in columns 4 and 6. The value in column 7 is the product of columns 4 and 6, i.e., it is the area of one rectangle under the damage-frequency curve. The value in column 8 is the expected annual damage and it is the cumulative sum of the column 7 values.

DISCHARGE 1000's	FEET NGVD	FREQUENCY %	% INTERVA	DAMAGES AT STAGE	AVERAGE	ANNUAL DAMAGES INTERVAL	SUMMATION
0	910	99.999999	na	$0	na		NA
3000	911	99.99999	0.000	$0	$0	$0	$0
6000	912	99.9999	0.000	$0	$0	$0	$0
8500	913	99.999	0.001	$0	$0	$0	$0
12000	914	99.99	0.009	$0	$0	$0	$0
15500	915	92	7.990	$0	$0	$0	$0
18000	916	44	48.000	$0	$0	$0	$0
22000	917	26	18.000	$107,320	$53,660	$9,659	$9,659
26000	918	20	6.000	$187,602	$147,461	$8,848	$18,506
29500	919	14	6.000	$256,667	$222,135	$13,328	$31,835
34000	920	10	4.000	$294,388	$275,528	$11,021	$42,856
38000	921	7	3.000	$367,004	$330,696	$9,921	$52,777
42500	922	5	2.000	$498,201	$432,603	$8,652	$61,429
48000	923	4.7	0.300	$607,782	$552,992	$1,659	$63,088
52500	924	3.7	1.000	$642,849	$625,316	$6,253	$69,341
58000	925	2	1.700	$676,479	$659,664	$11,214	$80,555
63000	926	1.6	0.400	$709,965	$693,222	$2,773	$83,328
70500	927	1.4	0.200	$742,877	$726,421	$1,453	$84,781
79500	928	1.2	0.200	$776,219	$759,548	$1,519	$86,300
90000	929	0.9	0.300	$809,418	$792,819	$2,378	$88,678
102000	930	0.65	0.250	$841,178	$825,298	$2,063	$90,742
112000	931	0.5	0.150	$875,240	$858,209	$1,287	$92,029
128000	932	0.38	0.120	$908,296	$891,768	$1,070	$93,099
142000	933	0.3	0.080	$951,986	$930,141	$744	$93,843
157000	934	0.22	0.080	$961,506	$956,746	$765	$94,608

EAD Calculation

It is worth noting that EAD are calculated for a specific reach of the river. The stage-damage curve represents a total for the entire reach. The rating and frequency curves are considered to be representative of hydraulic and hydrologic conditions for the entire reach.

A formulated plan will affect one or more of the curves in the hydroeconomic model. The graphic shows an example where damages are reduced from the blue curve under the without condition to the pink curve with the plan in place. The new (pink) damage curve would be inserted into the model shown in the preceding figure to estimate EAD with our plan in place.

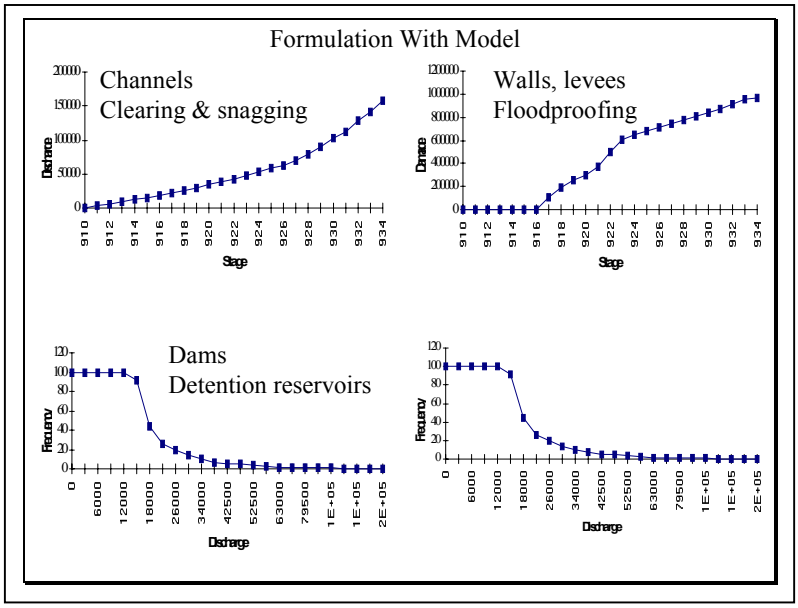
EAD in this figure are $22,422 down from their original $94,608. The benefits for this hypothetical plan are $94,608 - $22,422 = $72,186 in expected annual dollars, also known as average annual damages. Risk assessment refines this analysis by considering the uncertainty and variability in the three relationships and the resulting damage-frequency curve.

DISCHARGE	FEET	FREQUENCY		DAMAGES		ANNUAL DAMAGES	
1000's	NGVD	%	% INTERVAL	AT STAGE	AVERAGE	INTERVAL	SUMMATION
0	910	99.999999	na	$0	na		NA
3000	911	99.99999	0.000	$0	$0	$0	$0
6000	912	99.9999	0.000	$0	$0	$0	$0
8500	913	99.999	0.001	$0	$0	$0	$0
12000	914	99.99	0.009	$0	$0	$0	$0
15500	915	92	7.990	$0	$0	$0	$0
18000	916	44	48.000	$0	$0	$0	$0
22000	917	26	18.000	$25,435	$12,717	$2,289	$2,289
26000	918	20	6.000	$44,462	$34,948	$2,097	$4,386
29500	919	14	6.000	$60,830	$52,646	$3,159	$7,545
34000	920	10	4.000	$69,770	$65,300	$2,612	$10,157
38000	921	7	3.000	$86,980	$78,375	$2,351	$12,508
42500	922	5	2.000	$118,074	$102,527	$2,051	$14,559
48000	923	4.7	0.300	$144,044	$131,059	$393	$14,952
52500	924	3.7	1.000	$152,355	$148,200	$1,482	$16,434
58000	925	2	1.700	$160,326	$156,340	$2,658	$19,092
63000	926	1.6	0.400	$168,262	$164,294	$657	$19,749
70500	927	1.4	0.200	$176,062	$172,162	$344	$20,093
79500	928	1.2	0.200	$183,964	$180,013	$360	$20,453
90000	929	0.9	0.300	$191,832	$187,898	$564	$21,017
102000	930	0.65	0.250	$199,359	$195,596	$489	$21,506
112000	931	0.5	0.150	$207,432	$203,396	$305	$21,811
128000	932	0.38	0.120	$215,266	$211,349	$254	$22,064
142000	933	0.3	0.080	$225,621	$220,443	$176	$22,241
157000	934	0.22	0.080	$227,877	$226,749	$181	$22,422

Hydroeconomic Model and Formulation Strategy

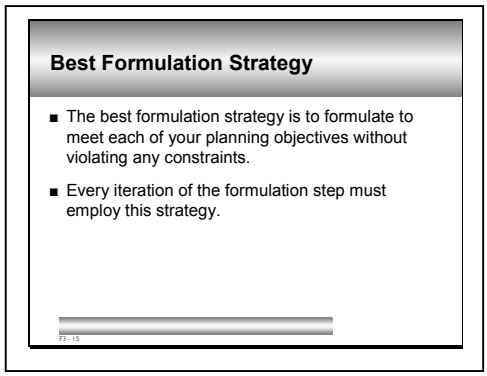
In the current context a formulation strategy is defined very simply as a way of thinking about assembling plans from measures. One way to think about formulating plans from measures in a flood study is to use the model we have been discussing. For each reach in the study planners can think about the three input curves (stage-damage, stage-discharge, and discharge-frequency) and ways these curves can be shifted.

If the stage-damage curve drops lower, all other things equal (a constant assumption here), EAD will decrease. If the stage-discharge curve drops lower, EAD will decline. If the frequency curve drops EAD will decrease. So one formulation strategy is to assemble measures that can cause these relationships to drop. Some examples are provided in the figure. Initially one might think of plans that affect one or another of the curves. These can then be assembled in plans that affect one or more of the three curves. This would be done for each reach.



The Best Formulation Strategy

There is only one best formulation strategy and it is the same regardless of the planning situation. You formulate plans to meet your planning objectives and to avoid your planning constraints. Period. Exclamation point.

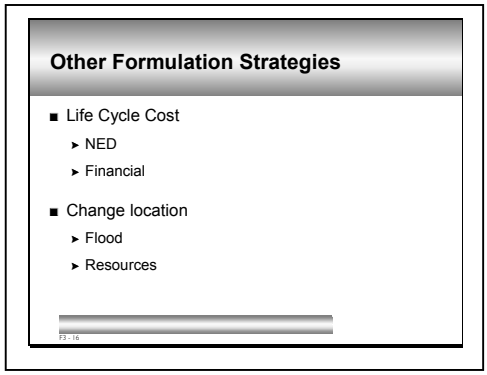


Take your planning objectives and begin with the first one you have developed. Brainstorm ideas for measures that would contribute to the achievement of objective 1. Get as many measures as possible.

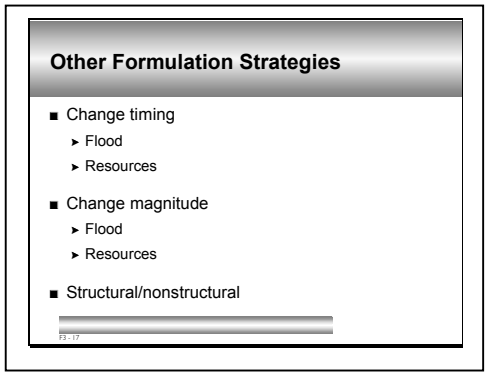
Go to objective 2 and do the same thing. Make sure you consider all the measures that are relevant. The ideal is to find some measures that contribute to all objectives while not violating any constraints.

Once you have assembled these measures and groups of measures for each objective you simply begin to assemble them into compatible packages of measures or plans that now address all objectives. This is the very best plan formulation strategy. Use as many others as you find helpful in stimulating your thinking but make sure that you always use this method before completing any iteration of the formulation process.

Other Formulation Strategies

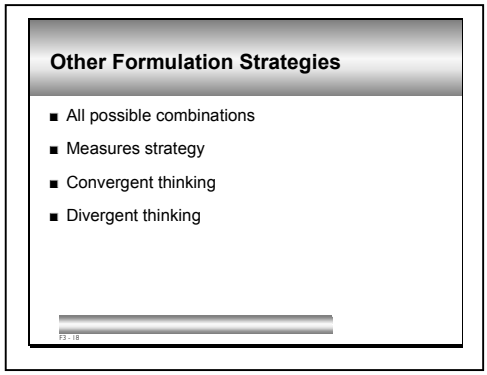


Cost is always important. One useful strategy is to think about plans in terms of their costs over a lifetime. There are some plans that have a large first cost and very low subsequent costs while other plans are just the opposite. A comparison of first costs alone may not be enough. The strategy here is to identify measures that meet objectives at the lowest life cycle cost. Costs here are defined as the NED economic costs that enter into the benefit-cost analysis. An alternative strategy is to formulate plans to minimize financial costs.



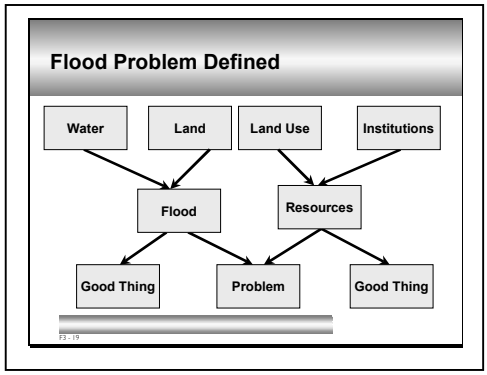
A measures strategy involves the use of structural and nonstructural checklists. Take each measure in turn and look for opportunities to use it in your formulated plans. Build plans from these measures.

Plan formulation strategies can also follow divergent or convergent thinking. Convergent strategies are zeroing in on "the" plan by eliminating ideas. Divergent thinking attempts to expand the number of ideas. From these the best plan will ultimately be chosen.



Imagine that checklist of structural and nonstructural measures. A divergent formulation strategy will seek to eliminate the measures until the best one remains. Convergent formulation would try to identify a plan for each measure. Then once one plan is identified the planner would try to vary and expand the possibilities. From this expanded universe of ideas the best are chosen.

The all possible combination strategies are a brute force method used with IWR PLAN in support of incremental cost analysis. It is an example of a divergent formulation strategy. While it may be a useful algorithm in some computer-assisted formulation exercises it is not very practical for team formulation efforts where a discriminating thought process can greatly and efficiently reduce the magnitude of the effort.



Other strategies include thinking of ways to mitigate the flood problem. One can take any factor that contributes to the problem and brainstorm measures to lessen the impact of that factor on the problem. In the last module the flood problem was identified as the commingling of water and resources at the same place and time in magnitudes sufficient to threaten life, health, and property. The idea is to impose some, structure on the formulation thought process by focusing one-by-one on these elements of the problem. How can we alter the location of the floodwaters? Have any ideas? Examples include reservoirs and detention ponds. How can we change the location of the resources at risk? Land use controls, permanent evacuation of the floodplain and relocation of houses are some nonstructural examples. And so the formulation process goes. But it is a process and a process must be followed if it is to succeed.

In a similar fashion ideas that alter the timing of the flood or the resources in the floodplain can lead to other ideas. Thinking in terms of how to decrease the magnitude of the flood when it occurs or how to decrease the resources (activity) in the floodplain can lead to the identification of measures. Plans can be constructed from one or more of the resulting lists of ideas.

Another strategy is to spend some time specifically thinking of structural measures and some time thinking specifically and only of nonstructural measures. This strategy includes identification of a best all structural plan and a best all nonstructural plan. The resulting ideas would then be blended and assembled into other, potentially better, plans for evaluation and comparison in subsequent planning steps.

The point to be made about plan formulation strategies is simple. Plan formulation is one of the steps of the planning process. The planning team has to spend time together in one place "doing" plan formulation. It helps if the team has some idea about how it wants to do plan formulation. We've thrown out some ideas about how to think about formulating plans in the above strategies. If you see one you like, use it. Feel free to adapt it or to make up one of your own. The important point is that planners spend time together in one, with a richly defined problem statement, with clear planning objectives and constraints, and with input from stakeholders to formulate plans.

Review Questions

1. How does a structural flood plan differ from a nonstructural flood plan?
2. What four relationships are required to estimate expected annual damages?
3. Which relationship of the Hydroeconomic model would a wider channel affect? An earthen levee? Detention ponds? Land use restrictions?
4. Name three plan formulation strategies.
5. Create a new plan formulation strategy.

Section Summary and a Look Forward

Although there are many more sophisticated and perhaps accurate ways to distinguish structural and nonstructural flood plans, you can think of structural plans as keeping the water away from the resources and nonstructural plans as keeping resources away from the water. Plan formulation is a task. You have to spend time doing it. That means the team sitting together to formulate plans. This process can be aided by a plan formulation strategy, i.e., a way to think about formulating plans. You can organize your thinking around the Hydroeconomic model used to estimate expected annual damages. You can aid the process with checklists. You can use convergent or divergent thinking. You can invent your own method. The gold standard for plan formulation strategies, however, is to identify measures that will meet your planning objectives and constraints. Then assemble them into compatible groups of measures that can be used to build plans.

The next section looks at what comes after the initial formulation of plans. This is when data is becoming available and formulation requires incremental analysis of a plan's separable elements. The importance of anticipating and formulating with environmental effects in mind is discussed as are a few plan formulation issues related to the Corps' interaction with FEMA.

References and Suggestions for Further Reading

The best background for this chapter is general planning background reading. The best source of additional information is likely to be the *Planning Manual.* Institute for Water Resources, IWR Report 96-R-21, November 1996. The plan formulation step manual in the IWR series of planning step manuals is another source of information. For a bit more background on the EAD calculation and model one can see the HEC FDA model and its documentation. Additional background can be found in Charles Yoe's *Revisions to the National Economic Development Procedures Manual-Urban Flood Damage,* Greeley Polhemus Group, Inc. This report submitted to the Institute for Water Resources in August 1994 was not published in hardcopy.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will be able to distinguish structural from nonstructural measures
2. Students will be able to identify at least ten different flood damage reduction measures
3. Students will be able to identify and use several different formulation strategies for flood damage reduction
4. Students will know what software tools are available to aid them in flood damage reduction formulation
5. Students will understand the Corps' basic hydroeconomic model of expected annual damage estimation and its use in modeling the effects of formulated plans

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Instructor Notes and Exercises:

Time management will be a challenge. Fight the tendency to go into too much detail. Examples of flood protection measures can be described generally. The expected annual damage (EAD) calculation has been the subject of a weeklong course. Do not try to say or do everything here. Do a few things well. Be clear on the things you think are most important for a new planner to take away from this discussion.

This is a plan formulation course so structural and nonstructural measures are important because they are the building blocks of plans. The EAD calculation is important in the evaluation of plans. Every plan formulated can be modeled as an effect in the Hydroeconomic model one way or another. Understanding the general structure of this model is important for evaluating plans. It can also provide the basis for a plan formulation strategy.

Plan formulation strategies are the most unique part of this module. How does one think about formulating plans? How do we "wrap our heads around this task?" Little systematic thought has been given to this, it is something most planners just do. Most often someone comes up with a plan and we start looking at variations of it.

Several different strategies are offered here to seed the clouds of discussion. If good ideas emerge from your discussion emphasize them and move them to the top of the list. Make sure people understand they can use any technique or process they like but there is great value in having one. Success is much more likely when we know what we are doing.

Slide F3-4
Exercise F3.1 Word Association
Tell students it is time for a word association. You are going to say a word or phrase and they are all going to honestly reveal their very first reaction. Ask for questions, and then begin by saying, "Corps of Engineers." Because they are employees you might get some work-related responses. Have fun with them if you can. Then tell people it is time to role-play. Tell them they are all environmentalists and

repeat the phrase "Corps of Engineers" and the exercise. Then make them all Representatives in the Congress, then reporters for the Washington Post. What you are after here is that many people associate the Corps with large projects, dams, and pork barrel. But we are trying to zero in on what is most visible and that would be locks, dams, floodwalls, and levees. This is our takeoff point for discussing measures. An alternative version of this exercise is to ask everyone to identify five words or phrases that describe the Corps of Engineers.

Exercise F3.2 Identifying Measure

Ask the class, "Do you remember the spelling bees of your grade school youth?" If they do not tell them yours or mine. Mine was boys on one side of the room, girls on the other. Everyone got a word to spell. If you, missed it you sat down. Last person standing won and sometimes that meant a candy bar, sometimes it meant not having to write your spelling words that night. To keep people amused and engaged tell them we are going to have a measuring bee and ask everyone to stand. If you want to divide the class by gender, district, experience or any other way for a little fun go ahead. The rules are simple; by lottery (guess what number I am thinking of) choose a person to start. They name a flood control measure and you write it down. The next person does the same. As the list grows it gets harder. When people come up blank or you reject their idea they sit down. The last person standing wins a candy bar if you plan ahead and buy one. The point is to generate a list. If everyone gets stumped and there is no last person standing then let the last group that was standing try again. This time ask them, if you could suspend the laws of physics what measures would you add to the list? You may use this last as a wrinkle for the exercise to add a little fun. Add any new ideas to the slides below.

Slide F3-3 to 5

Exercise F3.3 Definitions

Ask students to look at the three slides that list the measures. Make sure you add anything the group identified in the measuring bee to the slides, so you might have an extra slide or two now. Challenge a student to define a structural project aloud. Ask others to help if the definition falters. Do the same for the nonstructural definition. We suggest you keep pushing the definition until it gets close to the one we offer in the text. Alternatively, if you find a better one emerging, steal it for future use and compare and contrast it to the one in the text.

Slide F3-7

Exercise F3.4 Hydroeconomic Explanation

This is a good opportunity to ask who has seen this model before. If you have positive responses consider having one of them come to the front of the room to explain how the damage-frequency curve is generated to the others. This can be risky if you accidentally pick the wrong person so be ready with a Plan B to prevent bad information from going out to people. As they approach the task, ask questions like where does the stage-damage curve come from? How is it generated? How much does it cost? How long does it take to generate one? How many people are involved? What kinds of data must you collect to estimate one? And so on. Repeat this for the rating and frequency curve as well. It is not important to have detailed answers so much as a good feel for who and what is involved in getting to the point of having these curves before you. Remember, to new planners this will all look like a very smooth and effortless process once the curves stand before you. After the explanation correct any mistakes and make sure you fill in any blank spots in the explanation. Go to the screen and illustrate how the damage-frequency curve is generated from the other three by tracing points through the first three quadrants to the fourth.

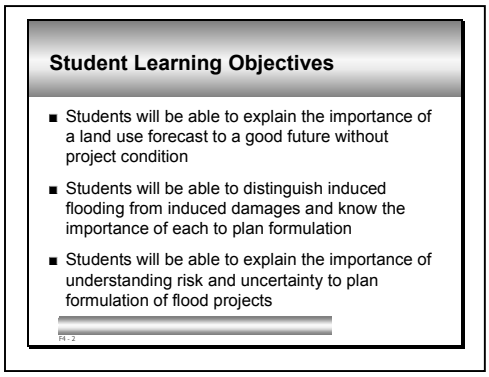
Slide F3-13

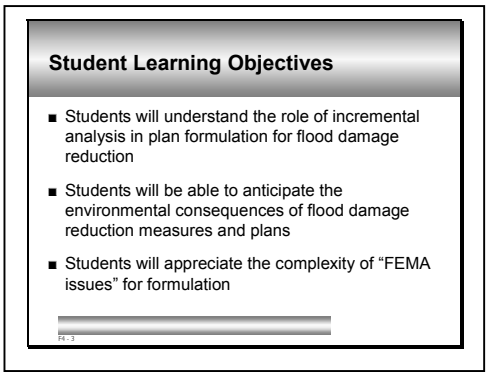
Exercise F3.5 Formulation Strategies

Time to wake people up again. Ask who has ever attended a formulation meeting during which people come up with plans. Ask what formulation strategies the students have used in their planning work.

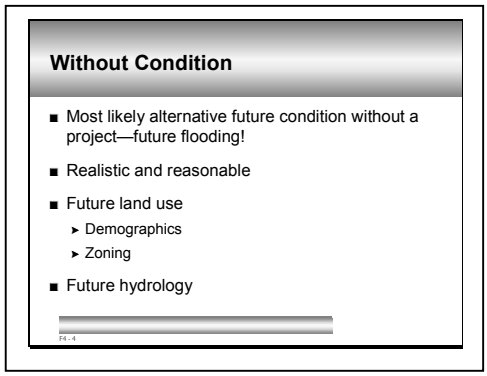
Have them describe the strategy, give each strategy a name and record it on the board. If they do not admit to using a strategy ask how they assemble plans. Ask if planning objectives ever enter the discussion? Now it is time to solicit ideas for formulation strategies. They have heard two, using the model and using the objectives. What else could they use as a strategy for formulating plans? The strategies do not have to be compatible. We are looking for ways to pick each other's brains when we use various formulation strategies.

Module F4: Reformulation – Optimization, Incremental Analysis and Selection of the NED Plan





Without Condition



It is not easy to discuss formulation issues without spilling over into evaluation and comparison issues. The issues discussed at this point in the course are arguably as much evaluation matters as formulation, maybe even more so. The without condition is a critical component of plan evaluation as evaluation is based on a comparison of without and with project conditions of the study area, regardless of the project purpose.

Experienced planners frequently identify a good without project condition forecast as the single most important component of the plan evaluation through plan selection tasks. The without condition requires particular attention in flood damage reduction planning. The flood problem of the future is not always like the flood problem of the present. The nature of the floods themselves can change. Future hydrology is heavily dependent on future land use patterns, which are almost always different from existing ones.

Each of us can easily recall some formerly wooded patch of ground that is now a mall or housing complex. As land use changes, the location, timing and magnitudes of water change. A good forecast of future hydrology is essential to the formulation process.

Land use changes constantly in the U.S. In a watershed the trend is usually toward more dense development of the floodplain and higher intensity uses of the land. Whether this is an issue in your study depends on the nature of the changes and the size of your watershed.

Development of 100 acres in a watershed that drains 50 square miles will be of greater concern than would development of 100 acres in a watershed that drains 18,000 square miles. Development of those 10 acres for a mall and paved parking lots will be of greater concern than will the use of that land for luxury homes on 10-acre lots.

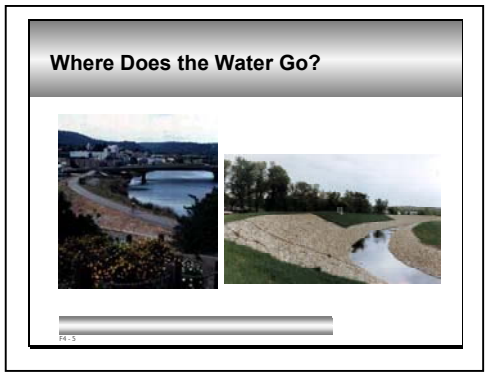
Every good flood damage reduction plan formulation process should be preceded by the preparation of a good, realistic without project condition that considers future land use and its impact on future hydrology in an appropriate manner. Lest the point be overlooked in our focus on hydrology here, changes in land use can change the timing, location and intensity of resources at risk of flooding as well. Consequently, the three empirical relationships in the hydroeconomic model of the last module could look substantially different in the future because of potential land use changes.

As important as land use is in defining the without project condition there are a few assumptions that are to be part of every without project condition scenario. These assumptions, specified in ER 1105-2-100, include the following. First, any existing flood hazard reduction plans are considered to be in place. Do not ignore or overlook them. They need not be Corps projects. They should be considered to be effective for the actual remaining economic life of the structures or policies. Second, if there is a high likelihood of implementation of a new flood hazard reduction plan that has been authorized but not yet constructed, the authorized plan is assumed to be in place as part of the without condition.

The following assumptions are assumed to be true whether or not they in fact are. Third, adoption and enforcement of land use regulations pursuant to the Flood Disaster Protection Act of 1973 is assumed. Fourth, the planning team is to assume that communities in the floodplain belong to the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). Fifth, compliance with Executive Order 11988 Floodplain Management and Executive Order 11990, Protection of Wetlands, is assumed. Sixth, the same assumptions that underlie the without-project condition apply to the with-project condition.

Induced Damages

Are there induced flood damages in the preceding figure? There is if there are more buildings inundated or if the water reaches greater depths in buildings causing more damages. There is an alternative, there could be induced flooding but no induced damages. If the water is 12 feet deep on the right bank before the levees and it goes to 13 feet deep it may make no difference if the affected land is all open space, or single story buildings. All the flood damage is caused by the first 9 feet of water and the extra depth does nothing to increase damages. Be clear on your ability to separate the notions of induced flooding and induced damages.



Some structural flood damage reduction plans do not alter the magnitude or timing of the floodwaters but do alter their location. Walls, levees, and channels are some measures that restrict the area over which floodwaters flow. Walls and levees hold water off of land prone to flooding. By restricting the area over which a given amount of water flows you deepen the water over the remaining area or hasten the speed with which it moves. The former case is called induced flooding. Some protection measures induce a given flow of water at a reach on a stream to reach greater depths of water. The greater depths of water are not themselves a problem, but if these greater depths of water reach new structures or flood structures to greater and more damaging depths then they lead to induced damages.

Another possibility is that the restricted area in which to store the floodwaters or over which the floodwaters can flow, could increase the velocity of a given flow. Higher velocities can cause greater

amounts of damage all other things equal. This is another way that induced damages can result from a structural flood damage reduction measure.

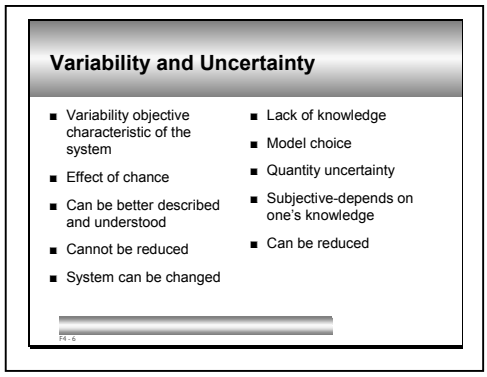
Economists would call this increase in flood damages that afflicts one community when another community's damages are reduced a negative externality. Externalities occur when the economic actions of two parties affect a third party that was not participating in that economic activity.

In this case the economic activity is the production (by the Corps) of flood protection via a levee or wall and consumption of flood protection (by the community) during times of flood. The unintended consequence of this is a worsening of the flood situation for a third party, the community across the river or downstream for example.

When lessening the flood problems of one community makes the flood damages worse for another community we have induced flood damages, a concept we distinguish from induced flooding, which does not necessarily increase damages. When flood damages are induced, efforts should be made to formulate plans that minimize these induced flood damages. If induced damages remain significant, a relative term decided on a case-by-case basis, it is good practice to formulate measures that could mitigate these induced damages. Bear in mind mitigation is a more encompassing concept than the notion of prevention; although preventing the induced damages is often a more desirable option. Mitigation could mean trading off reductions in flood damages elsewhere against the induced damages or it could include improvements in other community values that make induced damages socially acceptable. Plan formulators should think broadly about mitigation.

Risk Analysis

EP 1165-2-1 has this to say about risk analysis:



> "13-5. Risk-Based Analysis. The risk-based analysis framework is defined as an approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty. These risks and uncertainties arise from measurement errors, short data records, and from the innate variability of complex physical, social, and economic situations, particularly those dealing with future occurrences. Because it captures and quantifies the extent of the risk and uncertainty in the various planning and design components of an investment project, this approach has been found very useful. Each of the components can be examined and conscious decision made reflecting an explicit tradeoff between risk and costs. Risk-based analysis can identify which plans are more robust and can be used to compare plans in terms of their likely physical performance and economic success."

Risk analysis is clearly more of an evaluation concern than a formulation issue. However, risk analysis has some implications for the formulation process. Planners need to gain a level of comfort with the language of probability, which is essential to the description of risks and uncertainty. Formulating plans in situations with large uncertainties, e.g., what will future land use be like? Average economic conditions? Future hydrology?, requires large assumptions. Formulated plans, in turn, depend implicitly if not explicitly upon these assumptions.

No planner can afford to remain ignorant of the implicit and explicit assumptions in the description of problems and opportunities, and the inventories and forecasts that are so essential to the plan formulation process. Planners need not be the ones who do the risk assessment but they must be the ones who ask and understand how the variability in the systems they are addressing and the uncertainties with which they are faced could influence their formulation strategies and choices of measures and plans.

Incremental Analysis and Optimization

Incremental Analysis

- Flood plans often comprise several increments
- NED objective dictates an incremental analysis

F4 - 7

Flood damage reduction problems often affect large areas. That fact is indelibly etched into the consciousness of anyone who saw coverage of the Mississippi floods of 1993 on television. Because the problems are often so large in scope the solutions can also be large in scope. Plans may be developed that affect several independent communities. Within a community there may be many flooded areas interspersed with unflooded areas.

The flooded areas are not always contiguous. The affected floodplain can often be approached or thought of as a collection of many floodplains or floodplain segments. Plans can often be formulated that protect some of these segments but not others.

One of the most important evaluation criteria for the Corps' Civil Works program is economic efficiency. The National Economic Development objective formalizes the importance of economic efficiency in policy. If we extend this important criterion throughout the formulation process it leads inevitably to the position that no part of a plan that can be eliminated without jeopardizing the proper function of the remaining plan elements can have costs in excess of its benefits. In the extreme case, the argument devolves into an argument over whether the last nail driven was economically efficient to drive. Clearly what we seek is a balance between the situation where the benefits of one element of a plan are used to carry all the other separable elements of a plan and arguments over individual nails.

Airline Costs and Revenues

Route	Costs	Revenues	Profits
Capital City	$5M	$4M	-$1M
Metropolis	$10M	$15M	$5M
Gotham	$20M	$17M	-$3M
Center City	$2M	$2M	$0M
Amazonia	$6M	$7M	$1M

F4 - 8

Consider a flood damage reduction plan that has the elements shown in the table. Assume the plan can function with all five elements and that any element can function alone or in any combination with any other element. In other words there is no situation in which you can say without that element the others will not work. We define an increment of a plan as any element or part of a plan that can be eliminated without jeopardizing the proper functioning of the remaining parts of the plan.

Although you may not know the benefits and costs of an element at the time you formulate it at some point you will have to evaluate the incremental justification of each identifiable element or increment of the plan. This is important to know because it enables us to collect and organize our data in a way that will support an

incremental analysis. It also enables us to formulate plans in such a way that we pay careful attention to what reasonable increments might look like for our planning situation.

Flood Damage Reduction Plan

Plan Increment	NED Costs	NED Benefits	Net NED Benefits
Levee A	$5M	$4M	-$1M
Levee B	$10M	$15M	$5M
Wall A	$20M	$17M	-$3M
Detention Pond A	$2M	$2M	$0M
Levee C	$6M	$7M	$1M

At some point the benefit and cost information will become available and it is then time to apply a simple economic efficiency criterion to each increment. If the costs associated specifically with adding that increment to the plan exceed the benefits of doing so the increment is not economically efficient and should not be included in the plan. There may be exceptional reasons for doing so and if they are compelling they may be used to override this general rule. If the increment's benefits equal or exceed its costs then it is economically efficient and may be included in the plan.

The plan shown in the table consists of five different measures and costs $43M but returns $45M in benefits. It looks like a good deal to a lot of people. But as stewards of the Nation's water resources, the Corps has been tasked with the responsibility of increasing National Economic Development as much as possible in its choice of flood damage reduction plans. As formulators this is your responsibility too. An incremental analysis results in a different plan.

The plan with all five increments has net benefits of $2 million at a cost of $43 million. If we look increment-by-increment, another kind of plan formulation strategy, levee A has costs in excess of benefits. It is not incrementally "justified." Eliminating it from the plan increases NED by avoiding a $1M NED loss. The four remaining increments cost $38 million with benefits of $41 million, for net NED benefits of $3 million.

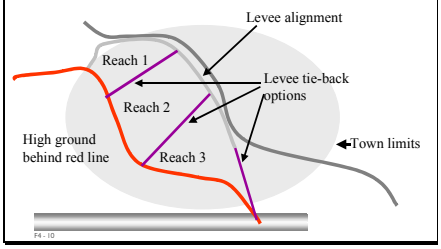
Can we do any better for NED? Levee B has incremental benefits in excess of costs so it stays in our plan. Wall A costs exceed its benefits. If we eliminate it we have three increments with total costs of $18 million and benefits of $24 million for net NED benefits of $6 million. That is $3 million more and reflects our avoidance of the $3 million loss associated with Wall A.

Detention Pond A has benefits that cover its costs so we accept it in our plan as providing value at least equal to its costs. Levee C contributes net benefits to the plan as well. The incremental analysis of our plan components leads us to a plan of Levees B and C and Detention Pond A.

First, you formulate plans without the benefit of cost and benefit information. Then you use the economic data to evaluate the plans via an incremental analysis. The results of the incremental analysis may lead you to reformulate the plans as we have done here.

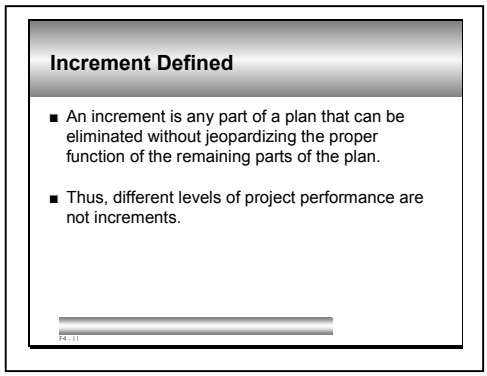
Sometimes it is easy to agree on what is or is not an increment. Other times it is not so clear. In the stylized flood plan in the picture the green levee that protects the ground can be extended to the red highlands via one of three tieback alignments. These alignments identify three damage reaches, 1,2, and 3. Are these increments? Or must this levee follow the reach 3 tieback alignment because the protected area functions as a system? The town might not support anything less than total protection. (Then that would be their choice!)

What's An Increment?



Suppose reach 1 is the only reach with positive net benefits. Using incremental analysis reaches 2 and 3 would not be incrementally justified and would be omitted from the plan because the project can function to reduce flood damages without it. But, as noted previously, if we follow this logic and push it to its absurd conclusion we could end up considering each structure individually.

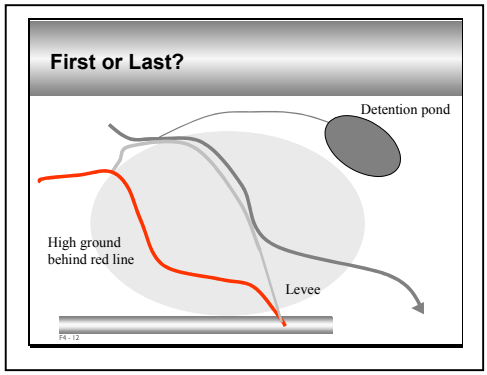
Increment is defined slightly differently in the current context than it is in ordinary English. An increment is here defined as any part of a plan that can be eliminated without jeopardizing the proper function of the remaining parts of the plan.



A pumping station for interior drainage may have costs easily identified separately but it is not an increment if the plan does not function without the pumping station. On the other hand, detention ponds that function with a levee system to reduce flooding may well be considered an increment because levees can function without them.

Plans comprising different measures, especially measures that affect different relationships in the hydroeconomic model can have different benefits depending on what we consider the "without this measure condition." Take our example of the detention ponds and levees.

In the figure, a small creek feeds the larger stream, which subsequently floods the town. Suppose we want to examine the incremental "justification" for the detention pond as shown in the figure. What do we assume the condition without this pond is? The rules governing this analysis are different from those presented in the earlier discussion of the without condition. If we assume the town is without levees and the pond is built first, it will reduce the most frequent flows on the creek and the stream and the benefits will be greater because of the frequency with which they occur. If we assume the levees are in place then the pond only reduces damages from the very infrequent flows that might have overtopped the levee. The benefits associated with reductions of these damages are much less than the other benefits would be. So which benefit estimate is to be compared to the cost of the pond. In this case the unchanging costs of an unchanging measure could be compared to different benefit estimates depending on what we assume about the best way to estimate benefits.



The Corps preferred approach to these kinds of problems is to use the first-added approach. In the current example, this means assume no levees and let the pond be the first measure added to the plan. Its benefits are calculated as the first benefits accruing to the plan. Then estimate the net benefits of the levees if they were built first. Compare the net benefits of the two measures. For economic efficiency purposes, assume the one with the largest first added net benefits is built first. The pond would follow as the next added increment and would be included only if it could be incrementally justified.

The table provides a numerical example of a plan that produces $100 million in benefits at a cost of $80 million. It produces net benefits of $20 million. If the pond is considered the first and only measure of a plan it produces $40 million in benefits and justifies its $30 million costs with net benefits of $10 million. If the levee is added first it produces $30 million in net benefits. If the levee is added second it yields net benefits of $10 million. If the levee is already there and the pond is added second it increases benefits by $20 million, not enough to cover it's cost. Is the pond incrementally "justified" or not? (You might notice this is equivalent to three separate plans. One with a levee only, one with a pond only, and one with a levee and pond. We treat in the fashion presented to minimize the necessary discussion.)

First-Added

Incremental Benefits to	Pond 1st Added	Levee 1st Added	Cost of Increment
Pond	$40M	$20M	$30M
Levees	$60M	$80M	$50M
Total	$100M	$100M	$80M

F4 - 13

Of these two increments the levee produces greater net benefits on a first-added basis. It should be considered the first-added increment for plan formulation purposes. The pond becomes the second-added increment and its incremental benefits do not exceed its incremental costs so it would not be added to the plan. The NED plan for this example becomes the levee alone with net benefits of $30 million. Deviations from this plan would have to be justified on a non-economic basis.

Suppose we had a plan with more than two separable elements or increments? Then the process continues in a similar fashion. First, estimate the net NED benefits if each increment is added first. Choose the increment with the highest net benefits. That is the first-added increment. To identify the second-added increment you consider the first increment already in place. Now consider each of the remaining increments as the second-added increment and estimate its net NED benefits. The increment with the highest net benefits becomes the second added element. The process continues with the third, fourth, etc. increment. For the i-th added increment you always assume (i-1) increments are in place and choose the increment with the greatest non-negative net NED benefits as the i-th added increment. If no increment has benefits greater than or equal to zero then there are no incrementally justified elements remaining and the plan is complete with the (i-1) elements.

What about optimization? An optimization choice is usually minimizing or maximizing some single objective. We need to be clear what it is we are maximizing or minimizing. Pump efficiency is optimized differently than the increments of a plan are optimized and that is different from the way the scale of a plan increment is optimized. Optimization as used here refers to plan formulation optimizations. Most often this means optimizing the scale and/or composition of a plan or a plan measure. And that, in turn, very often means maximizing net NED benefits.

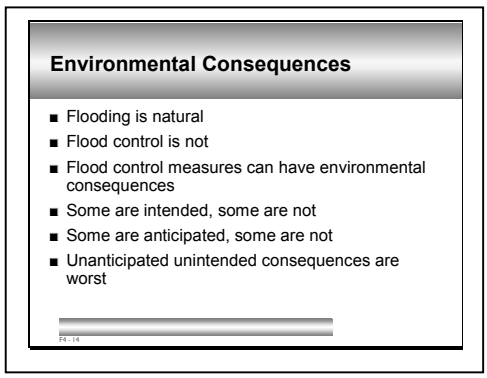
The difference in terminology is more semantic than substantial and it does not deserve much worry. An increment is any part of a plan that can be eliminated without jeopardizing the proper function of the remaining parts of the plan. Can a plan's performance be reduced from the .01 exceedance frequency flow to the .02 exceedance frequency flow and still function properly? The answer is clearly yes. Thus, project performance differences are increments of performance that must be subjected to incremental justification. This process is similar to the incremental analysis applied to separable element although no one would consider different heights of a wall or levee separable elements. Whether the task is called incremental analysis or optimization is less important than that this process be part of plan formulation.

Consequently, we consider the terms to be effectively synonyms. The greatest distinction we might raise is that incremental analysis is but one approach to optimization. Marginal analysis and numerical methods might provide two other approaches. Plan formulation should rely on good without conditions,

economic optimization of separable elements of a plan and rigorous incremental analysis to assure an efficient plan.

Environmental Consequences

Much has been made of the fact in recent years that flood damage reduction is not natural. Flooding is natural. Some flood damage reduction measures are more unnatural than others. The simple point to take from this is that flood damage reduction measures often have environmental consequences. Plan formulation should proceed cognizant of these potential consequences. This provides another plan formulation strategy to add to those of the last module, i.e., developing plans that most closely resemble the natural system or that minimize environmental consequences.



Some measures have predictable and intended consequences. Reservoirs always inundate terrestrial habitat. Others have unintended consequences. These may be anticipated or unanticipated. The greatest danger to the environment is unanticipated, unintended consequences. Planners need to exert considerable effort, perhaps in a risk assessment that asks and answers the questions list them here, to identify the unanticipated unintended environmental consequences.

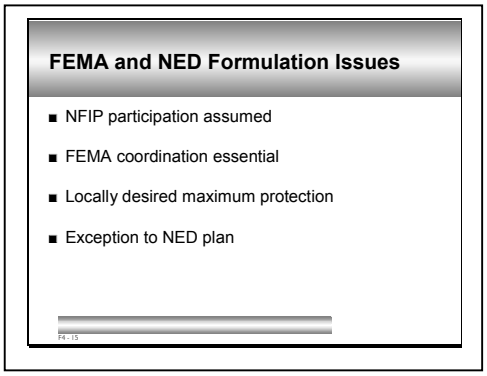
As measures are assembled into plans their environmental consequences, intended and unintended can change. There can be a certain synergy in the way that measures are combined that can be more or less troublesome to the environment. Levees can reduce natural habitat more than walls. Walls are more effective barriers to wildlife movement. Island clearing reduces habitat. The consequences of island clearing and walls versus island clearing and levees may be different than they would be singly.

If formulation can benefit by being cognizant of adverse consequences it can similarly benefit by seeking out opportunities to find more natural kinds of flood damage reduction measures and possibly restoring environmental values. For example, levees with wider tops, larger floodplains between levees, and channels that are wider rather than straighter are more environmentally sustainable measures. Varying the scale and materials of measures can sometimes mitigate environmental consequences and create more sustainable projects.

Planners need to be aware of the environmental consequences of their plan formulation choices.

Federal Emergency Management Agency

Communities participating in a flood damage reduction project with the Corps of Engineers are required to participate in FEMA's National Flood Insurance Program (NFIP) and to comply with the land use requirements of that program. These communities must also prepare a floodplain management plan designed to reduce the impact of future flood events in the project area. Projects or separable increments of projects that primarily produce land development opportunities and do not reduce actual flood damages currently have low budget priority and Federal participation in these projects will not be recommended.



Flood damage reduction projects can affect what is required of a local community's participation in the NFIP. Consequently, consideration of these factors during the formulation process is essential. Consideration should be given to developing flood maps and flood profiles depicting post-project conditions. The information should be in a form useful to FEMA in revising flood insurance rate maps. The appropriate FEMA Regional office will be notified of proposed flood protection works or of changes to established flood protection works. In the near future guidance will be developed for the use of lands cleared under the FEMA hazard mitigation grant program. This guidance is likely to have plan formulation implications.

In cases where the non-Federal sponsor has identified a desired maximum level of protection, such as for a flood of record, and where the with-project residual risks are not unreasonably high, if the plan desired by the sponsor has greater net benefits than smaller scale plans, it is not required to analyze project plans providing higher levels of protection than the plan desired by the sponsor. A common example might be if a sponsor desires a levee of sufficient height to meet FEMA's flood insurance requirements. If it is determined that such a levee has higher net benefits than smaller levees, then the levee desired by the sponsor can be recommended without having to analyze larger levees to identify the NED Plan.

If a recommended plan proposed contains economically inefficient increments an exception from the ASA (CW) must be obtained. An essential element of the analysis of this or any recommended plan is the identification of residual risk for the sponsor and the flood plain occupants, including residual damages and the potential for loss of life, due to exceedance of design capacity.

When the NED Plan has less than a 90 percent reliability of protecting against the 1 percent chance annual flood event, an exception to the NED Plan may be recommended. The conditions and requirements for this exception are found in ER 1105-2-100.

Review Questions

1. What are some specific factors that could cause future expected annual damages to be different from existing expected annual damages?

2. How do induced damages differ from induced flooding?

3. What four questions provide an intuitive definition of risk assessment?

4. Why is incremental analysis important for plan formulation?

5. What broad categories of environmental consequences can flood damage reduction projects produce?

6. Name two exceptions to the selection of the NED plan.

Section Summary and a Look Forward

Flood problems are not always static. Future flood problems are often worse than existing flood problems. Consequently it is important to consider potential changes in land use when assessing flood risks. Flood protection can reduce risks but it rarely eliminates risks, so an estimation of residual risks is an important part of any formulation process. Among the risks associated with floods are the transformed risks. One of these is induced flooding and the often resulting induced damages that accompany it.

Economic efficiency is a key criterion for plan formulation. Economic efficiency is best served when plan elements are optimized to maximize net NED benefits and whole plans are subjected to incremental analysis. Despite the importance of economic efficiency the environmental consequences of a flood damage reduction plan must be considered. Unintended consequences must be carefully considered. Because unanticipated unintended consequences are often the most problematic considerable effort should be devoted to trying to anticipate all potential unintended consequences. This might be accomplished in a risk assessment of the project itself.

It is important to properly integrate the consequences of FEMA's NFIP into the formulation process. It is an important determinant of without and with project condition assumptions. Plan formulators need to be aware of the potential exceptions to the selection of the Ned plan for flood damage reduction projects.

References and Suggestions for Further Reading

Without Condition

Additional discussion of this topic can be found in the following reports at:
http://www.wrsc.usace.army.mil/iwr/Products/reports/reports.htm.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Planning Manual, November 1996, IWR Report 96-R-21.

Planning Primer, November 1997, IWR Report 97-R-15.

Induced Damages

Yoe, C. *Wyoming Valley, Pennsylvania Levee Raising Mitigation Reformulation Report.*" Prepared for the U.S. Army Corps of Engineers, Baltimore District, September 1990.

Yoe, C. *Wyoming Valley Mitigation Supplemental Planning Report*" Prepared for Luzerne County Engineer, Greeley-Polhemus Group, March 1993.

Risk Analysis

The following reports prepared by the Institute for Water Resources can be found at:
http://www.wrsc.usace.army.mil/iwr/Products/reports/reports.htm

Analyzing Uncertainty in the Costs of Ecosystem Restoration, March 2000, IWR Report 00-R-3.

Applied Risk Communication Within the Corps of Engineers, March 1996, IWR Report 96-R-14.

Guidelines for Risk and Uncertainty Analysis in Water Resources Planning Volume I. March 1992, IWR Report 92-R-1.

Gu*idelines for Risk and Uncertainty Analysis in Water Resources Planning Volume II*. March 1992, IWR Report 92-R-2.

An Introduction to Risk and Uncertainty in the Evaluation of Environmental Investments, March 1996, IWR Report 96-R-08.

Incorporating Risk and Uncertainty Into Environmental Evaluation: An Annotated Bibliography. September 1996, IWR Report 96-R-09.

Reliability Analysis and Assessment of Hydropower Equipment. October 1998, IWR Report 98-R-6.

Risk Analysis for Dam Safety Evaluation: Hydrologic Risk. March 1996, IWR Report 96-R-13.

Risk and Uncertainty Analysis Procedures for the Evaluation of Environmental Outputs. August 1997, IWR Report 97-R-7

Tools for Risk Based Economic Analysis. February 1999, IWR Report 99-R-2.

FEMA Issues

"Flood Insurance Study Guidelines and Specifications for Study Contractors." FEMA Document 37. March 1991.

Greeley-Polhemus Group, Inc. "Implementation Plan: section 308 of the Water Resources Development Act of 1990." Prepared for Institute for Water Resources, February 1992.

"Guidelines for Determining Flood Flow Frequency, Bulletin 17B." Geologic Survey. U.S. Department of the Interior, March 1982.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will be able to explain the importance of a land use forecast to a good future without project condition
2. Students will be able to distinguish induced flooding from induced damages and know the importance of each to plan formulation
3. Students will be able to explain the importance of understanding risk and uncertainty to plan formulation of flood projects
4. Students will understand the role of incremental analysis in plan formulation for flood damage reduction
5. Students will be able to anticipate the environmental consequences of flood damage reduction measures and plans
6. Students will appreciate the complexity of "FEMA issues" for formulation

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Instructor Notes and Exercises:

Time management is once again your greatest challenge here. You may well choose to emphasize one or two issues and skip the rest. Use your time to best meet student needs as you best see fit.

The most important thing to remember is that you are teaching inexperienced planners. Do not assume everyone knows any one thing! Explain the without condition again. Distinguish between induced flooding and induced damages.

Incremental analysis is probably the most important item in this module. Be sure students understand it thoroughly. It will be important to bring students back to the fact that these issues are probably more relevant to the evaluation steps. They are important to consider in formulation for that reason alone. But bear in mind that these issues are also important because they can motive reformulation efforts.

Point out that the first round of formulation is usually done without most of the evaluation data you'll eventually have. As evaluation data become available and some plans drop out and other move forward, it is common practice to fix the broken ones and polish the good ones through additional rounds of formulation and reformulation. Make sure students understand that formulation is not something done once and never again. We are still reformulating those 308 Reports from the 1920s in some districts.

Slide F4-2
Exercise F4.1 Future Flooding
By now you have begun a case for the need for future hydrology. Let the class flesh out the ways in which that becomes important. Ask them how a flood problem could become worse. Remember there are people with no H&H background. So if you talk about land use draw others into the conversation. Why is more land going to be needed? Population growth and economic development/prosperity are

common reasons. But if this is so you might want to ask if any areas lose population or if their economies decline. And if so, could the flood problems there "improve"? In addition to land use you can ask about other actions people might take. Might topography change significantly? Landfills or clearing projects? What is significant? You might engage the importance of the size of the watershed at this point. Ask what others might do to affect flooding, e.g. encroachment on the channel via bridges and highways. Suppose there is a change in the allocation of storage space in a system of dams in the basin? Use these and similar questions to seed the discussion. Make a list of their responses.

Once you do get to land use make sure people get a mental picture that works for them. Help them understand the loss of pervious surface to parking lots, streets and roofs. Help them see the improved water conveyance of slanted roofs, downspouts, gutters, storm water lines and such. Stress the importance of magnitude and timing for non-hydrologists.

The goal here is for everyone to understand that future hydrology can be substantially different from present hydrology and it must be considered. This is a good time to refer to the list of factors you have compiled with their help. It is also important for them to understand that paving 100 acres in a local stream watershed has more significance than this would have on the Mississippi. Put the issue into a proper perspective for students.

Slide F4-3
Exercise F4.2 Induced Damages
Again, keep in mind you have relatively inexperienced planners and they may not know what induced flooding is. That is the concept you should begin with, induced flooding. Induced flooding is not the problem it is induced damages that are the problem. Draw a stream on the board and around it a large circle representing a town on both sides of the river. Inside the large circle draw a second smaller one straddling both sides of the river that represents the floodplain. Tell them the water was 10 feet deep during the flood of record. Draw a levee on the left bank but not the right bank and ask what happens to the water that used to cover the left bank flood plain. Some of it may move downstream and some of it may move to the right bank. Because the right bank is fixed in size that means one of three things. Either the water is deeper on the same area, or it covers a greater area, or it covers a greater area and is deeper. The levee has caused induced flooding on the other bank. Make sure students understand that.

Slide F4-4
Exercise F4.3 What Can Go Wrong?
Choose a simple flood damage reduction project with which you are familiar. Describe its basic elements to the class. Use the board to draw a schematic that would help people understand the problem and the project. Then present the following intuitive definition of risk assessment, i.e. the technical description and assessment of the hazard the community faces. Risk assessment is essentially the work analysts do to answer the following questions about their plan.

1. What can go wrong?
2. How can it happen?
3. How likely is it?
4. How bad can it be?

The questions are to be asked of the existing condition and answered and again of the with project condition. Ask the students to answer these questions about the project you have described. As the discussion develops ask what kinds of data would be needed to do this or that task. Ask if they already do this or not. Ask how long it takes, how much it costs and the like.

Make sure that students see that some risks from the existing condition are reduced (e.g., damage reductions) and some remain (e.g., residual damages). Other risks are transformed. The risk of low level flooding may be reduced and in its place the risk of levee overtopping may appear. Pushing down on one

risk almost inevitably causes another risk to pop up somewhere. Understanding and describing the risks that are relevant to the decision process is the key to good risk assessment.

The goal here is for students to see that flooding is fundamentally risky and flood damage reduction is a classic example of risk analysis. Flood damage reduction studies essentially do answer these questions. Distinguish this from more recent advances in which we account for the uncertainty in our flood analysis. HEC's FDA program enables us to enter the relationships of our hydroeconomic model not as deterministic curves but as probabilistic relationships.

Slide F4-5
Exercise F4.4 Airline Profits
Not all of your students will be economists so spend some time with this concept. It is an important one and one that is often misunderstood. Begin by asking students to imagine they individually own an airline that services five cities as shown in the slide.

[Slide F4-6: Airline Costs and Revenues]

Their only goal in life is to make as much profit as possible. Ask them to use the data you provide to make their business as profitable as possible. Profits currently are $2M but could rise to $6M if they dropped those routes that do not pay their own way. Point out that each city must pay its own way or it drags the company's profitability down. This wastes resources in the process. Ask if any student would pay $700 for a $300 television. No one would. And neither would a company pay $20M for a product line that is worth $17M to them. That is a waste of resources. They should drop Capital City and Gotham from their service.

Ask if anyone disagrees with this solution, assuming we decide based solely on profit maximization. If anyone does, probe their reasons and convince them that they are wrong. Once you have agreement ask if there is going to be anyone in the world touched by their airline that disagrees with their decision. Someone should recognize that Capital City and Gotham customers would not like this decision. Once you get that point established ask what criteria they would base their position on if they were to argue to keep the routes at a public meeting.

The point here is they cannot use profit maximization. They can reject profit as a proper criterion. They can argue there are other important criteria too. But they cannot win this argument based on economic efficiency. It is a cut and dried decision based on economics. And if profit is the only criterion the owner is much better off with this decision even if some individuals in the land are not. Lead students to see that, to a great extent, whether this is a good deal or not is a matter of perspective.

Now tell students you are changing the context. You are now supreme ruler of a large country. You have set net National Economic Development and economic efficiency above all other values for your reign. But you care deeply about your subjects and they bring to you a flood damage reduction project for a river community with the following components. They point out the plan costs $43M but returns $45M so it is a good deal. Would you accept their plan as is or would you modify it?

Now introduce the language that each component of the plan provides an increment of protection in the overall picture. To meet the stated objective of net NED attainment each increment must pay its own way or it drags the nation down.

You will not pay $20M to prevent $17M worth of damages. Your choice is to pay $43M to create $45M in value to society, a net gain of $2M to your country, or to spend $18M to create $24M in value to society, a net gain of $6M to your country. Based on economics alone this is a slam-dunk decision. You

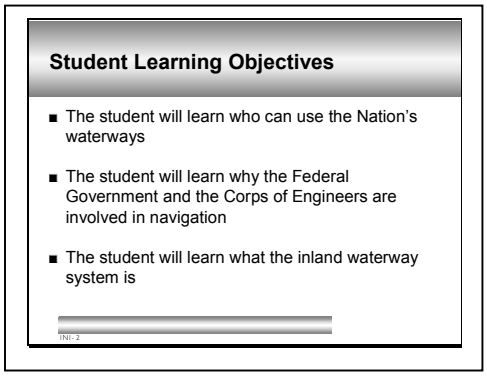
build a plan that consists only of increments that have benefits equal to or in excess of costs. And that is the Corps' plan formulation policy as well.

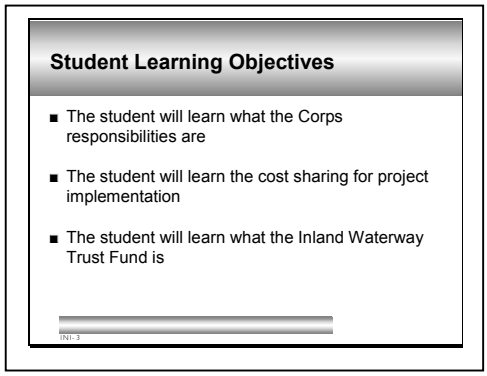
Slide F4-8
Exercise F4.5 Increment of Not?
You want to make sure people do not get confused with the notion of an increment. In this exercise we want to make such people catch on to the idea that some elements of a plan are essential to the plan and cannot be considered separately. So this is a good place to stop and pose a number of questions to the class. Ask people to tell you if you are describing a separable element or an essential element of plan. At the conclusion of the exercise make it clear that the separable elements are suitable increments for an incremental cost analysis while essential elements are not.

Example questions follow: The last ten yards of concrete in a continuous pour of 1,000 cubic yards of concrete wall? Closure structures in a floodwall? Pumping station for a levee project? Spillway on a dam? A detention dam on a channel project? Protection for development on the other river bank? Feel free to make up your own examples.

Chapter 6 – Inland Waterways

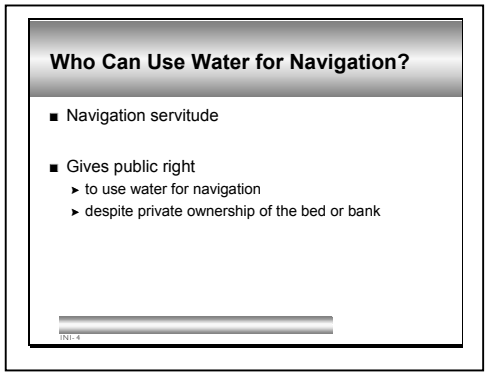
Module IN1: Authorities and Policies





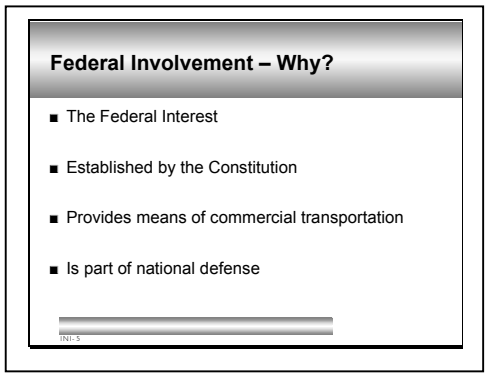
Who Can Use Water for Navigation?

This is set by "navigation servitude" which originates from an ancient common law principal that there is a right of the public to use a stream or other water body for navigation despite the private ownership of the bed or bank. Hence in the exercise of Congress' power over navigation no further real estate interest is required for navigation projects in navigable waters below the ordinary high water mark.



Federal Involvement – Why?

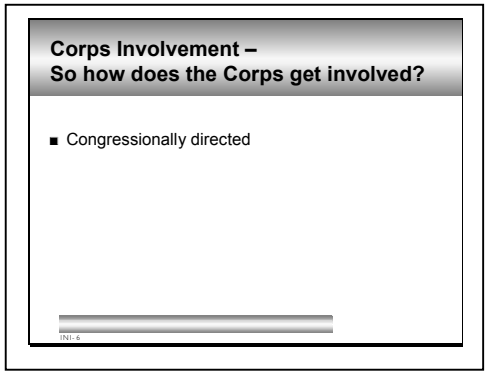
We call this the Federal Interest. Federal interest in navigation is established by the Commerce Clause of the Constitution, and subsequent court decisions, defining the right to regulate navigation and improvement of the navigable waterways. The navigable waters are important to the nation as a major means of commercial transportation and as a part of national defense. The merits of Civil Works projects for improvement of navigation are currently measured against a single Federal objective--national economic development.



Corps Involvement - So How Does the Corps Get Involved?

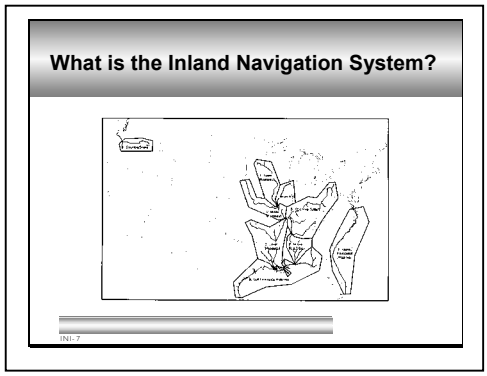
The Corps has jurisdiction over navigable waterways and its mission is considered to have begun in 1824 when funds were appropriated by congress to clear snags from Ohio and Mississippi Rivers. While commerce benefited, navigation works also served defense.

Interestingly, most of the 5,000 plus miles of canals (up to 1860) were originally private enterprise.



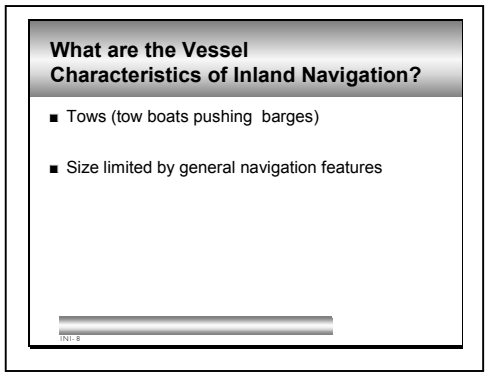
What is the Inland Navigation System?

Actually it is defined by legislation, but it is much easier to explain by a map. Some affectionately call it the inland and intracoastal fuel taxed waterway system. The areas of application are basically rivers and intracoastal waterways. The inland navigation network is really a series of systems, some connected and some not. And there is over lap - geographically - with deep-draft navigation as in the case of the lower Mississippi and Columbia rivers. The size of the system is enormous – approximately 12,500 miles of waterway. There are 230 lock sites and in excess of hundreds of river training structures to reduce dredging requirements and over thousands of miles of armored banks. Collectively the make up of the inland waterway system is not homogeneous. Waterway characteristics vary considerably.



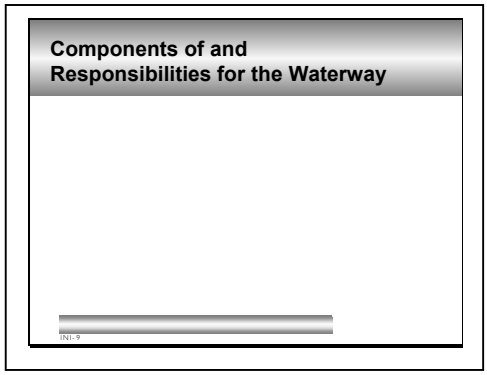
What are the Vessel Characteristics of Inland Navigation?

Two types of vessels use the inland waterway system – commercial and recreational craft. If it isn't obvious already, we are concentrating on the commercial side. Commercial vessels are tows and comprise a towboat (push tow) and barges. The number and size of the barges is somewhat standardized, width-wise, to fit through the locks. Cross currents and bends can limit the length of the tow. For tows too long to fit within a lock chamber, they will "cut" off a barge or barge grouping and fit these "clusters" through and reconfigure on the other side of the lock. Both situations preclude maximum efficiency of the transportation system.



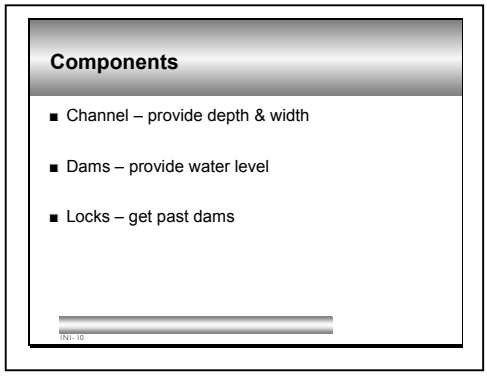
Components to and Responsibilities for the Waterway

As a matter of law and policy, a distinction is made between general navigation features, and other features or facilities serving navigation. The Corps participates financially in general navigation features and special navigation programs only, all other features and facilities (e.g., piers) are non-Federal responsibilities.



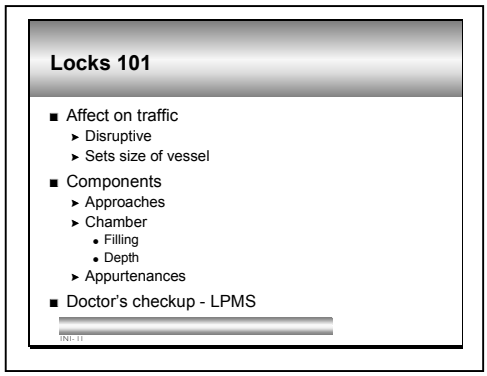
Components

There are three basic components to the system. The primary navigation element is the channel, which is the "lane" the vessels operate within and whose depth, width and extent are dictated by legislation as a Federal channel. Dams are provided in portions of the riverine reaches of the system. They provide manageable currents (versus free-flowing river reaches) and the necessary water depth by controlling the river stages. Locks are necessary for two reasons. On the riverine portions, they pass traffic through the dams. On the intracoastal portions, they may also serve as salinity and flood surge barriers.



While locks facilitate traffic in passing a vessel through a dam that is in place for any number of reasons, it is also a disruption of traffic. All things equal, the fewer locks and lockages the more efficient the traffic.

A basic understanding of the design and how a lock functions allows planners to suggest measures that might be applicable navigation improvements. Over half of our locks are over 50 years old. That, in itself, is an indication of the existence of navigation related problems. Not so much from structural integrity, but from the efficiency of design aspect.



We won't bore you with history here other than to say that the existence of locks goes back hundreds of years and, in this country, predate Corps application. Despite the history and tradition of locks, many of our locks just were not built for modern traffic. The evolution of lock design continues to this day.

When the Corps started building locks and half way through the 20th century, inland traffic was dominated by steam powered, individually sized vessels. As time progressed, the towboat evolved.

Although most of our system included relatively standard widths, for lock chambers, the lengths were more variable. In canalized waterways locks limit tow widths but the channel bends, push tow power, and safety limit the length. The barge and towing industry has responded to the relatively standardized lock widths by constructing barges of widths that when lashed together will fit between the lock walls. Tow lengths have usually been "unitized" to fit similarly between the gates. But for tows too long to fit in the chamber, tow operators have to "cut" the tow and push the "cuts" through and reassemble before pushing on.

If you have never seen a lock, envision a bathtub. It has a pipe with a valve to let water into it to raise the water level. It has another pipe with a valve to let water out of it. The big difference is that it doesn't have doors at either end, one to let you in and the other to let you out.

Lets look at the anatomy of a lock to see what components affect traffic and how. Lock structures are placed in rivers to pass vessels through dams that have created discontinuities in lock water levels. We call the upstream water the upper pool and the downstream, the lower pool. The lock structure and its appurtenances include entrance channels to the upstream and downstream ends of the lock chamber. The chamber is a roofless, four-sided structure with gates at the upper and lower pools connected usually by monolithic walls. These have mooring bits mounted on the top (older locks) or floating in recessed chambers in the walls. Their function is to hold the vessel securely in place so that it won't move too much and otherwise damage itself or the lock wall or gates as the water elevation is changed to either lift the vessels to the upper level or lower them to the lower level.

The filling and emptying system control the water level in the chamber. This is simply a system of pipes, controlled by a value that lets water into the chamber to raise the water level in the chamber to that of the upper pool or to let water out of the chamber so that the chamber level is equal to the lower pool. The beauty of the system is that it is gravity fed. It is, however, a relatively complex system that has evolved through time. It has evolved from a single culvert in the lock wall to a maze of pipes under the lock floor. The purpose of the complex design is allow a "smooth" and rapid rise of the water surface without creating any water slopes and thus minimizing hawser stresses and potential damage to lock walls. For lock improvement studies, the filling and emptying time is a major variable.

When the water level is equal to either the upper or lower pool, the gates are opened. This operation requires minimal power because the opening or closing of the gates is performed when the water level is equal on both sides.

There are two basic considerations to navigation that are a function of lockage or chambering. Foremost is the timing of the operation. In some systems, the second would be the availability of water because each cycle "looses" the volumetric difference of the chamber's capacity between the two levels.

Lock appurtenances such as the guidewalls and tow hauling equipment also affect tow processing time. The former affects river flow directions and velocities and the latter is a pulling devise to speed the movement of a tow or its cuts into and out of the lock chamber.

Another consideration is the depth over sill and the chamber floor. When a vessel enters a chamber it is analogous to a piston inside of a cylinder. For the vessel to enter, it has to displace its volume of water. If it takes up most of the cross section this displacement time increases which negatively impacts the tow processing time. For a single tow, this may not be a big deal but there is a cumulative effect when there are several tows waiting.

Above, we talked about tow size versus chamber size. As traffic increases, the need for an auxiliary lock or its replacement with a "full size" lock will grow.

The Corps lock performance monitoring system (LPMS) database has over 60 data categories, most of which are the various components making up the tow processing time. A study of these times and any change in any of these times can help to identify problems.

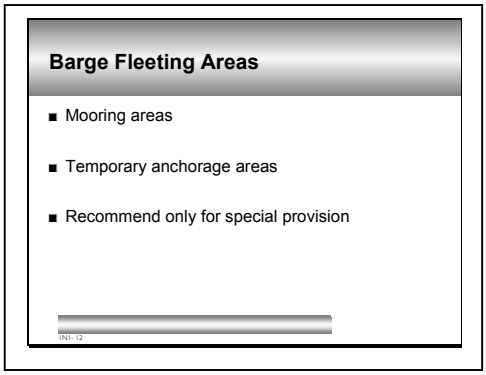
Corps of Engineer Responsibilities - General Navigation Features

The Corps is responsible for the general navigation features except aids for navigation General navigation features is a special term. It includes channels, jetties or breakwaters; locks and dams; basins or water areas for vessel maneuvering, turning, passing, mooring or anchoring incidental to transit of the channels and locks. They also include sediment basins and ice control structures.

One interesting item, training works, is used to confine the river to the navigation channel and simultaneously scour its own channel, especially during lower stages, reducing the need for maintenance dredging. In special cases bridges are general navigation features. The occasion is when they are required by new or realigned channels that cut fast land. It is Corps policy to not recommend new navigation channels cutting fast land however.

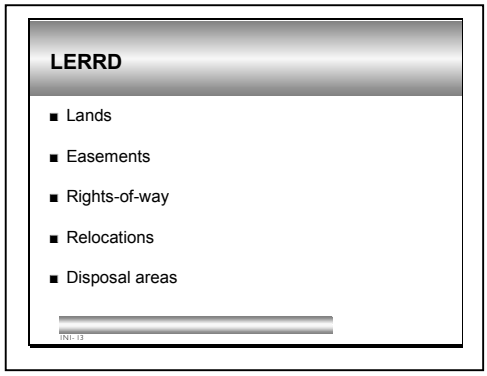
<u>Barge Fleeting Areas</u> – Description and Responsibility

One set of project features generally not well understood is Barge Fleeting Areas. These areas are defined as mooring areas or temporary anchorages used for assembling tows, making barge transfers between tows, transferring supplies, awaiting arrival of additional barges or serving as a barge holding area. Barge fleeting areas should generally not be recommended for Federal participation. Moorages or temporary anchorage areas may be recommended if necessary to implement a non-structural efficiency improvement, for example if reconstitution of tows is necessary to implement a ready to serve lockage policy. These areas should not be considered as fleeting areas in the traditional sense.



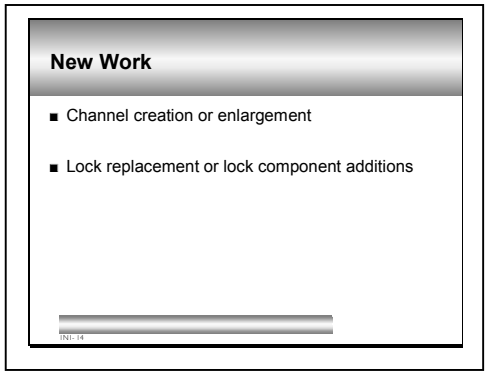
Lands, Easements, Rights-of-Way, Relocations and Disposal Areas (LERRD)

In distinction to harbor navigation, all lands, easements, rights-of-way, relocations and disposal areas are 100 percent Federal, and may be funded up to 50 percent from the Inland Waterways Trust Fund for construction when so authorized by Congress.

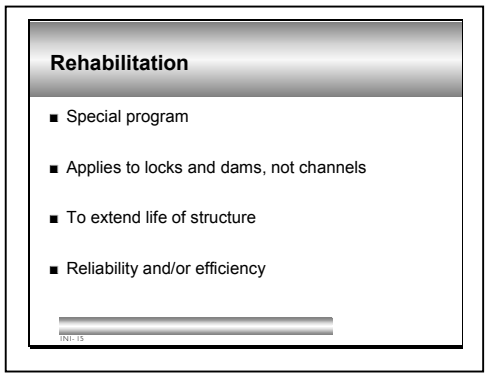


New Work

Planners are involved in new work which, for inland navigation, would be (1) creating a new channel or deepening and/or widening an existing channel or (2) replacing a lock with a larger lock or adding features to it.

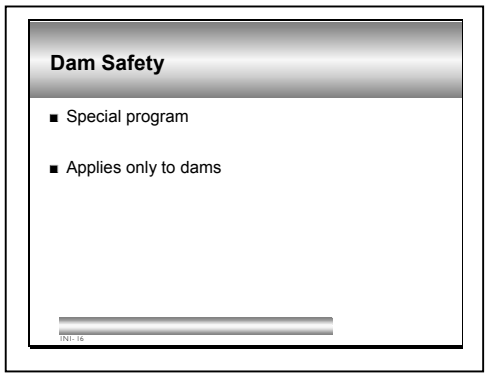


Rehabilitation



The Major Rehabilitation Program deals with existing project structures, and although the problems and opportunities are limited, there is plan formulation. Rehabilitation is a major project feature restoration consisting of structural work on a Corps operated and maintained facility intended to improve reliability of an existing structure, the result of which will be deferral of capital expenditures to replace the structure. Rehabilitation is considered when it can significantly extend the physical life of a feature or is a major works that will improve reliability or efficiency of an inland navigation project or a principal feature thereof. Improvements have to be economically justified. The program is administered by Operations.

Dam Safety

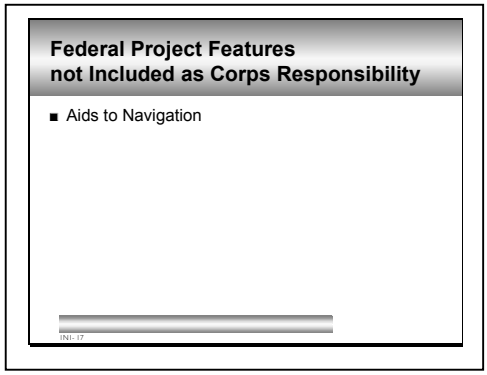


The Dam Safety Assurance Program would be used to repair or replace dams when meeting certain criteria. This program also deals with existing project structures, and although the problems and opportunities are limited, there is plan formulation. This program is administered by Engineering (see ER 1110-2-1155).

Federal Project Features not Included as Corps Responsibility

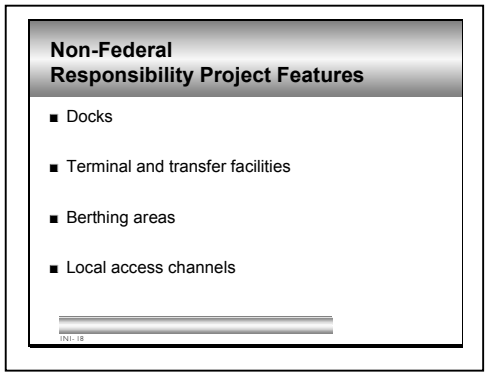
Aids to Navigation

The installation and maintenance of primary navigation aids (buoys, lights, daymarks, regulatory signs) is the responsibility of the U. S. Coast Guard which regulates all public and private aids to navigation for uniformity and conformity with the "lateral system" of buoyage as described in 33 CFR 60-79 (14 U.S.C. 89). These are considered general navigation features.



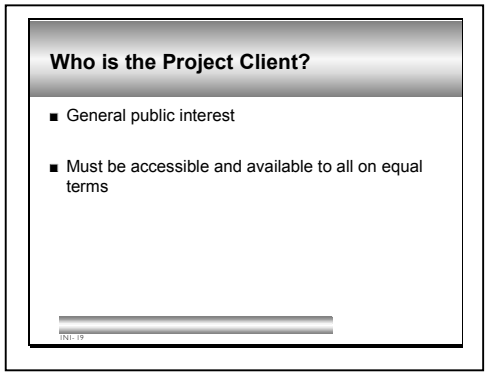
Non-Federal Responsibility Project Features

Traditionally local interests include special purpose dredged material disposal areas, facilities such as docks, terminal and transfer facilities, berthing areas, and local access channels.

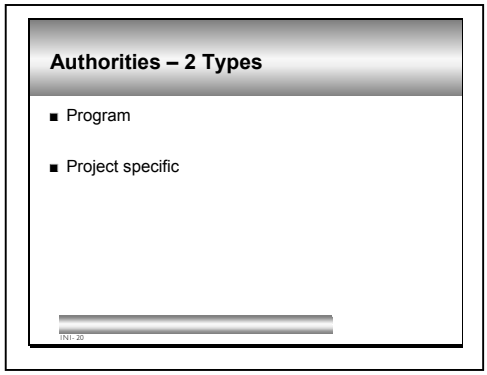


Who is the Project Client?

Federal improvements must be in the general public interest and must be accessible and available to all on equal terms. Although federally-provided general navigation facilities may serve them, improvements are not made to provide navigation access to privately-owned facilities (including commercial marinas) or access to restricted membership yacht clubs and similar establishments not open to the general public on equal terms, nor are improvements undertaken to enhance and primarily benefit land development schemes, waterway cargo transfer and lightering facilities, or to provide barge fleeting areas.



Authorities



Generally authorities are either programmatic or project specific.

Programmatic Authorities

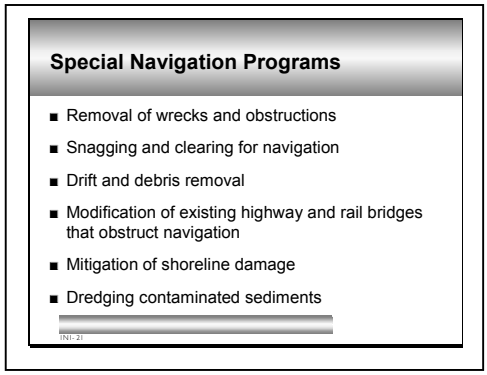
Some programs such as Section 216 of the 1970 Flood Control Act are very broad. For example, it provides for the review of completed Corps of Engineers' projects which have changed because of physical or economic reasons. Further, there are a small number of programs that are of limited scope and fall under the Continuing Authorities Program (CAP). All of the above are nice because the planner doesn't have to wait for project specific study authorization that may be more confining.

CAP legislative authorities, under which the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design and construct without additional and specific congressional authorization. Applicable to navigation is **Section 107, 1960 River and Harbors Act** (PL 86-645) as amended. It allows the Corps to study, construct and maintain navigation projects, using the same procedures and policies that apply to congressionally authorized projects without specific authorization. The Federal share of initial implementation cost for any one project may not exceed $4 million (per Section 915(d), PL 99-662). Secretary of the Army's policy also stipulates that the Federal share of total costs (initial costs plus the capitalized value of future maintenance costs) shall not exceed 2.25 times the initial Federal costs, or $4.5 million, whichever is greater. Because of the fuel tax, the application to the inland waterway system has been limited.

Project Specific Authorities

A member of Congress may ask the Senate Committee on Environment and Public Works, Subcommittee on Transportation and Infrastructure, or the House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, for an authority for the Corps to study a problem. If the Corps has already investigated and reported on a navigation problem, the committee may adopt a study resolution to provide the necessary authority to take another look at the problem and review the earlier study. For projects that only involve locks or dams are the Major Rehabilitation and Dam Safety Assurance Programs which are covered by the authority of the original project.

Special Navigation Programs



Under the be aware of category, these navigation improvements are for specific purposes, and may be projects, elements of projects, or simply Corps activities. They are initiated and/or implemented on Congressional authority (specific or continuing). They are usually subject to program or project expenditure limits, with cost sharing as specified in the original authority or as amended. Also note that these are not major players in plan formulation efforts.

Removal of Wrecks and Obstructions (Section 19, River & Harbor Act of 3 March 1899).

Snagging and Clearing for Navigation (Section 3, River & Harbor Act of 1945).

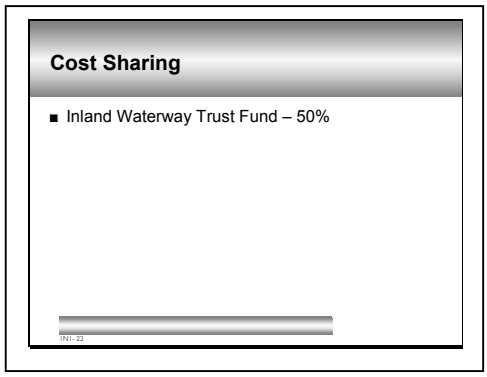
Drift and Debris Removal (Section 202, Water Resources Development Act of 1976).

Modification of Bridges that Obstruct Navigation (Public Law 67-647, the Bridge Alteration Act). The Bridge Alteration Act (1941), commonly called the Truman-Hobbs Act, applies only to **existing** highway and rail bridges. It provides authority to require bridge modification or replacement if a bridge causes an unreasonable obstruction to navigation.

Mitigation of Shore Damage (Section 111, River and Harbor Act of 1968). This program allows addressing bank protection to counter the affects of the navigation protect but prohibits its application to address vessel wave wash. Be careful not to extrapolate this prohibition to Corps of Engineer protects in general.

Dredging of Contaminated Sediments (Section 312 of the Water Resources Development Act of 1990 as amended by Section 205 of WRDA 96 and Section 224 of WRDA 1999). This authority allows for the dredging and removal of contaminated material from outside the limits of the navigation channel under certain circumstances.

Cost Sharing



General Application

For most project components, the responsibility and cost sharing has been determined by legislation, precedent, or practice. In the case of inland navigation, cost sharing is fully Federal with the local sponsor being the Inland Waterway Users Board.

Studies

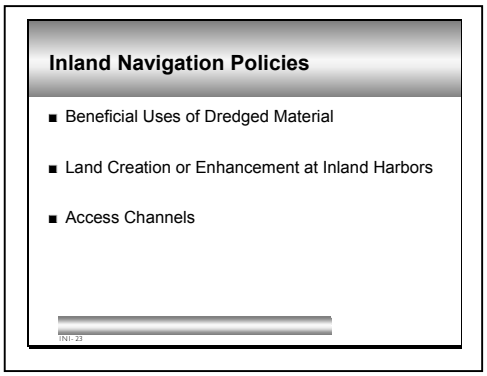
The waterways described in Public Law 95-502 as amended, and such other waterways that subsequently may be determined to be parts of the inland waterway system referred to in Public Law 99-662, are exempt from non-Federal cost sharing of studies.

Construction, Operations and Maintenance

By action of Congress, construction for PL 95-502 defined waterways or other waterways may be 100 percent Federal, the Inland Waterway Trust Fund may be used to fund up to 50 percent of the construction, and the waterway may be made subject to waterway fuel taxes. All other waterways are treated as harbors for cost sharing purposes. Additional local cooperation may be required because of special benefits such as land enhancement from placement of dredged material, betterment in bridge changes, and special limited-interest facilities.

Inland Navigation Policies

Three of the more applicable policies to keep in mind for inland navigation are covered below.



Beneficial Uses of Dredged Material

One of the biggest problems facing navigation projects is dredged material disposal. There is an emphasis to find beneficial uses of the dredged material. Despite this need and emphasis, any application which exceeds the least cost disposal plan (called the base plan) requires cost sharing. In the case of inland navigation, this application is not a general navigation feature and even though if applied for environmental restoration and so justified, it has to be cost shared. So what is the problem? Simple, the Inland Waterway Trust Fund only covers general navigation features which means another sponsor has to come forward.

Land Creation or Enhancement at Inland Harbors

Federal participation in inland waterway harbor improvements under the Civil Works program is not warranted and shall not be recommended when (1) resale or lease of lands used for disposal of excavated material can recover the cost of the improvements or (2) the acquisition of land outside the navigation servitude is necessary for construction of the improvements and would permit local interest to control

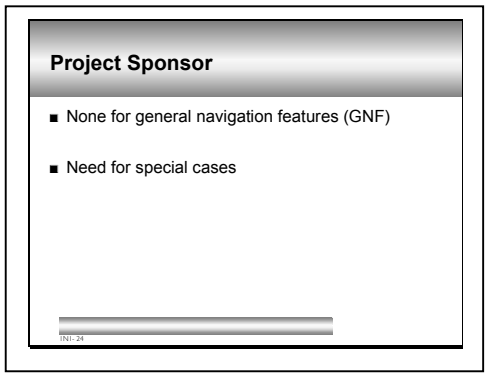
access to the project. The latter case is assumed to exist where the proposed improvement consists of a new channel cut into fast land.

Access Channels

Subsidiary channels may be needed to connect main harbor channels or inland waterways with anchorages, mooring, or berthing areas not located adjacent to the primary channel. An access or connecting channel can be a Federal responsibility only if it provides access to two or more areas; or if access is provided to a single area it, must contain two or more facilities with separate owners, or a facility owned by a public entity.

Project Sponsor

There is no sponsor for general navigation features in the Inland Waterway system. In situations were there are beneficial uses of dredged material that do not constitute the least cost disposal alternative or are not part of project mitigation, these uses require a cost-sharing sponsor.



Review Questions

1. What is Inland Waterways?
2. How big are tows?
3. What are the criteria for major rehabilitation?
4. Name an authorization for initiating a study.
5. What is the cost sharing for inland navigation?

Section Summary and a Look Forward

The student should have a good understanding of what constitutes inland navigation projects, authorities to initiate studies and the cost sharing requirements related to studies and construction. In the next module, the student will review problems and opportunities, data requirements and the role of forecasting.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Policy Digest.

Water Resources Policies and Authorities – Digest of Water Resources Policies and Authorities, July 1999, EP 1165-2-1, CECW-AG.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Navigation Policy and Cost Apportionment of Bridge Alternatives.

Water Resources Policies and Authorities – Navigation Policy: Cost Apportionment of Bridge Alternations, May 1979, ER 1165-2-25, DAEN-CWR-R.

Selected Notes to the Instructor

Student Learning Objectives:

1. The Student will learn who can use the Nation's waterways
2. The Student will learn why the Federal Government and the Corps of Engineers are involved in navigation
3. The Student will learn what the inland waterway system is
4. The Student will learn what the Corps responsibilities are
5. The Student will learn the cost sharing for project implementation
6. The Student will learn what the Inland Waterway Trust Fund is

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Instructor Notes and Exercises:

This Module is a review of the Corps' authorities to implement navigation projects. This discussion will include the types of projects that may be implemented under each authority, the limitations on what may be considered under each authority, cost-sharing requirements and purpose specific policies. There will also be a section on explaining locks.

Exercise IN1.1
Instructor, hand out to the class a copy of paragraph E-15 of ER 1105-2-100. Give them 5 minutes to review. Their task is to provide, through classroom discussion, the differences between the "Base Plan" and "Beneficial Uses of Dredged Material." Tell the class that this has become a major concern due to environmental emphasis on our projects and the need to find places to place material.

At the end of a 5-minute discussion they should basically conclude that the Base Plan is the least costly disposal option and that any beneficial use that is not a general navigation feature that adds to the cost must be identified as an additional cost and cost shared.

Slide IN1-9
This is just an introductory slide. Point out that the next several slides are going to discuss the components of the inland waterways and the associated responsibilities.

Slide IN1-11
Let us digress for a while and study locks. We can call this discussion, locks 101.
You want to show the relationships between lock and traffic as disruptive and limiting the size and/or configuration of tows. You also should describe the lock structure emphasizing those components that affect tow-processing time.

Slide IN1-22
Cost sharing is fully Federal. Studies are exempt from non-Federal cost sharing. The Inland Waterway Trust Fund may be used to fund all or part of the construction, and the waterway may be made subject to

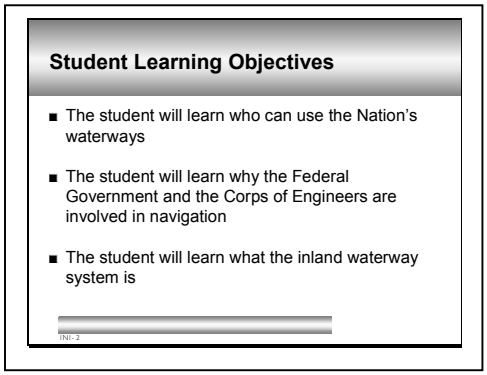
waterway fuel taxes. All other waterways are treated as harbors for cost sharing purposes. Additional local cooperation may be required because of special benefits such as land enhancement from placement of dredged material, betterment in bridge changes, and special limited-interest facilities.

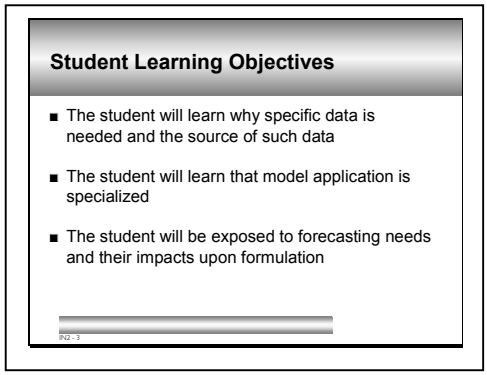
Slide IN1-23
Any application of Beneficial Uses of Dredged Material which exceeds the least cost disposal plan (called the base plan) requires cost sharing.

The Land Creation or Enhancement at Inland Harbors is basically prohibited, but there are exceptions.

An access or connecting channel can be a Federal responsibility only if it provides access to two or more areas; or if access is provided to a single area it, must contain two or more facilities with separate owners, or a facility owned by a public entity.

Module IN2: Problem Identification/ Inventory and Forecast for Formulation



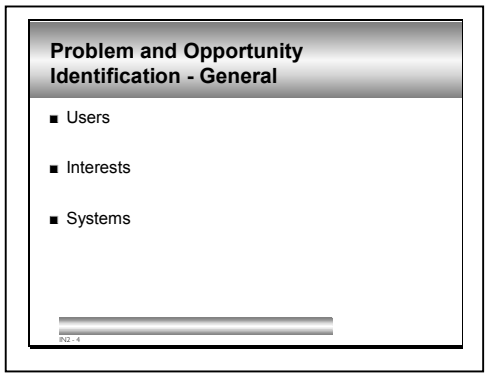


Background

What we, as planners have to embark on is a path that will lead us to an effective, efficient alternative that reasonably maximizes net NED benefits. To do that we have to dissect the perceived problem(s) in order to find the real problem(s). And we do this with our partners as well as interested parties. From these problems, we look at opportunities to eliminate or at least reduce the problems. Some of the opportunities will be actions that the partners can implement and exclude any Corps project as such. We'll get into that under management plans. But to get to that we need to inventory the situation and forecast future scenarios. In this module we will discuss data needs, and sources and how they are used in forecasting.

Problem and Opportunity Identification - General

Users



On the inland system the users are the towing companies and indirectly the commodity owners and/or producers. These groups have strong national representation in Washington unlike municipalities, local companies and individuals you will work with when doing flood damage reduction studies.

Interests

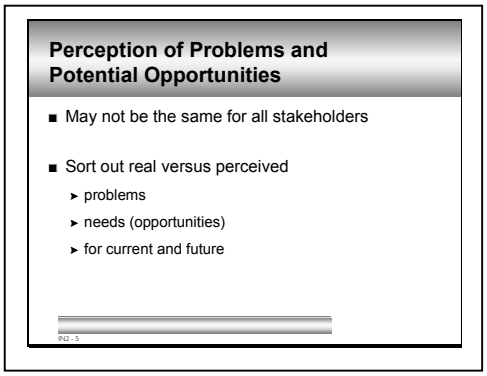
For inland navigation, environmental groups are playing an increasingly important role. Much of this has to do with the fact or perception that these projects and systems have changed the basic nature of the waterway and growing recognition of endangered or threatened species. While the project management plan is consummated with the sponsor, Corps of Engineers regulations requires coordination with stakeholders.

Systems

Inland waterway components are part of an interrelated system. If one part deteriorates, it affects the rest of the waterway or system. The channel size is uniform throughout and lock sizes may vary but in only two to three sizes. Problems are generally associated with component efficiency and dredged material disposal.

Perception of Problems and Potential Opportunities

In most water resource projects, the perception of problems and potential solutions may not be the same for all stakeholders. While this dilemma is minimal in inland navigation, nonetheless, the problem for planners is to sort out real versus perceived problems and determine needs (which we will refer to as opportunities.) This has to be done for the current situation and has to be projected into the future. The initial identification of problems and opportunities may be modified during the subsequent planning process, especially if baseline information does not support the problems and opportunities. Plan formulation is easiest when local interests know exactly what they want and are willing to state it.



Objectives

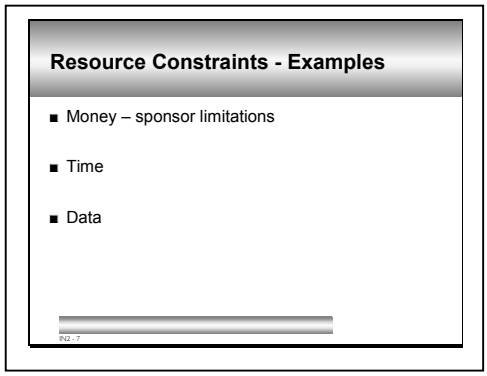
Then you have to develop the objectives, which should be articulated in a clear statement of the study purpose along with what an alternative should try to achieve. It should be obvious that the objectives need to be attainable. The objective statement should be such that it can accommodate different alternatives, which do not rule out other alternatives. Finally they should be measurable. What it should not do is state the solution or Federal objective although it should be based on the Federal objective and special local concerns. An example of what not to do is to have an objective statement such as "the project should provide replacement of Lock X." Instead it could be something like "the project should accommodate larger tows within the next ten years", "improve waterborne transportation efficiency", "reduce delays", "reduce groundings", etc.

Constraints

Constraints need to be identified and considered as needed. And there are two categories.

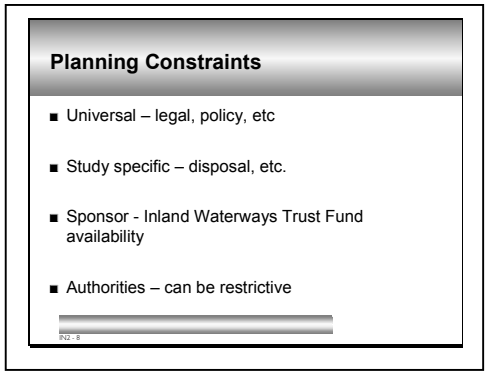
Resource Constraints

Resource constraints could be money, time, and data. An example of a time constraint for inland navigation could be lock replacement. Physically and fiscally, building a new lock is major undertakings. The design and construction could easily occupy a decade and often more. While congressional appropriations can impact progress, they are beyond the control of the planning process.



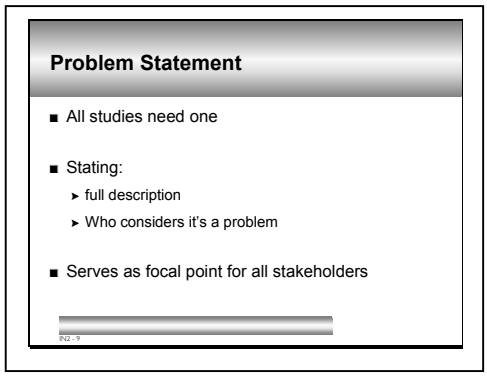
Planning Constraints

Planning constraints could include such universal things as law and policy. A good example is the constraints some states have created by denying open water disposal.

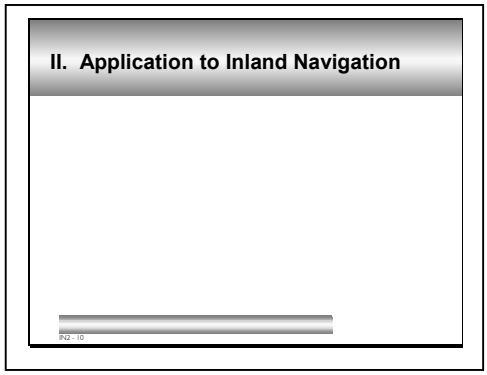


Problem Statement

All studies need a problem statement stating such things as the nature, cause, location, dimensions, origin, time frame and importance as well as who considers it's a problem. This serves as focal point for all stakeholders.

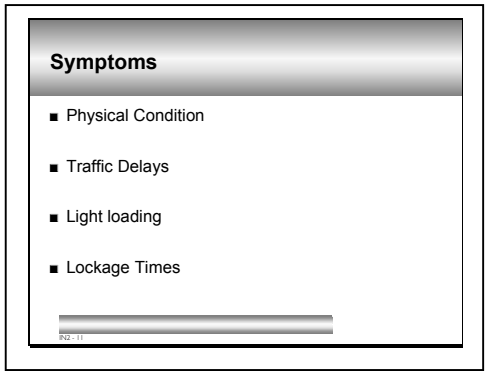


Application to Inland Navigation

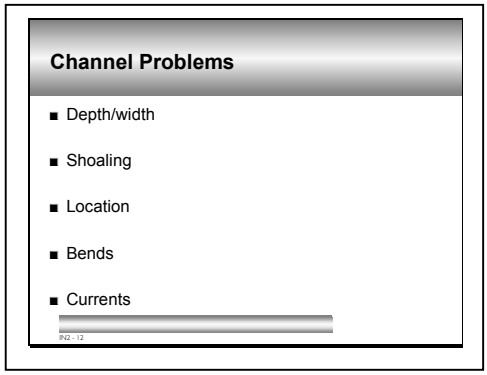


Problem Symptoms

The symptoms of inland navigation problems are manifested in the physical condition of the channels, disposal areas and locks; the existence of traffic delays; and excessive or increasing lockage times.



Problems

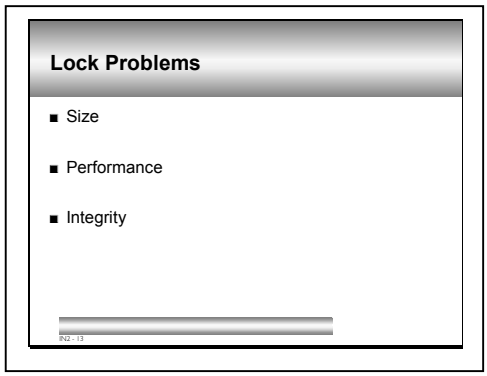


Channel problems are associated with their dimensions, and localized hydrodynamics. Dimensional problems are generally the result of the increase in tow size. This is especially so on some of the intracoastal waterway reaches. These channel reaches received their authorized dimensions decades ago when traffic and tow sizes were smaller and without the benefit of modern analytical engineering tools. Many of the bendways have too short of a radius to handle two-way traffic involving present-day tow lengths. Finally increased size and speed have induced wave wash bank erosion increasing maintenance-dredging needs.

Hydrodynamics are such that relatively localized problems of shoaling create the double problem of frequent maintenance and disposal location/capacity. For the intracoastal waterways some of the shoaling and current problems have existed since project implementation while some have been induced by

breaches in the barrier islands. For the Missouri River, the pending master plan could affect reservoir releases that would adversely impact the river's ability to self maintain its channels. For the lower Mississippi national weather conditions affect river stages which in turn affect suspended load and bed load. River training devices such as bank armoring lock the channel in place and dikes help confine the river to its channel, but cannot offset sudden drops in river stages.

In many inland waterways, especially river systems, a lock is usually the source of the waterborne transportation problem. The vast majority of our locks were built over 50 years ago. Through the subsequent years these locks have suffered the abuses of time, injustices of O&M funding and the insults of repeated tow rammings. Compounding that, traffic and tow sizes have increased.

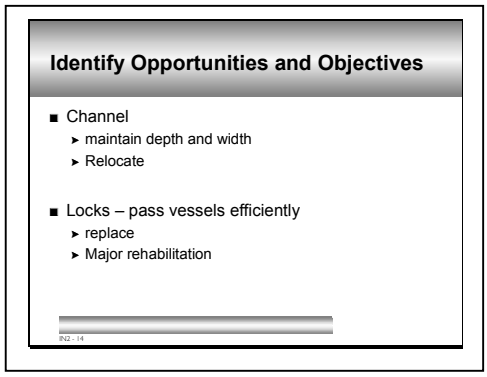


As tow sizes have increased, many tows cannot fit through the smaller locks without "cutting" (unlashing barges), moving a group of barges through, tying them off and then bringing the rest through and reforming the tow before proceeding. These delays increase labor and equipment costs.

The majority of locks were built from less efficient designs than exist today. Increased traffic has placed more demands on the system. Both individual locks and the waterway system have a finite capacity which is partially a function of lock performance. As tow sizes have increased, that alone has increased the individual tow lock processing time. Deterioration of the locks, their appurtenances and components all affect processing time.

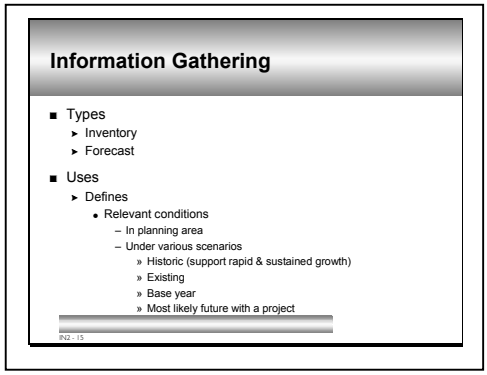
Identify Opportunities and Objectives

The objective of facilitating or increasing tow traffic can involve structural and nonstructural measures. Management strategies such as traffic control or physical changes such as lock replacement to accommodate existing and potentially increasing traffic are the types of improvements usually implemented to benefit traffic.

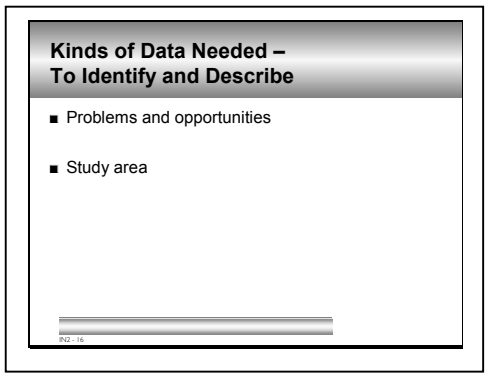


Information Gathering

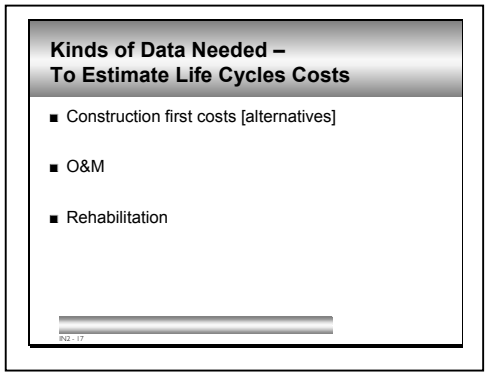
It is a big job to gather the relevant inventory and forecasting data. Fortunately offices within the Corps are charged with keeping the bulk of this data. The data is needed for temporal and spatial definition. What does that mean? It means you need to define the relevant transportation and channel conditions in the planning area under historic, existing, base year and most likely future with project conditions.



Problems and opportunities cannot be defined without knowing the study area. Since inland navigation is a transportation link and a lock and channel are only part of the path of a commodity movement you need the origin and destinations of commodities for the time conditions mentioned above. The implication is that the origins and destinations could change which further implies that there could be competition between transportation modes.



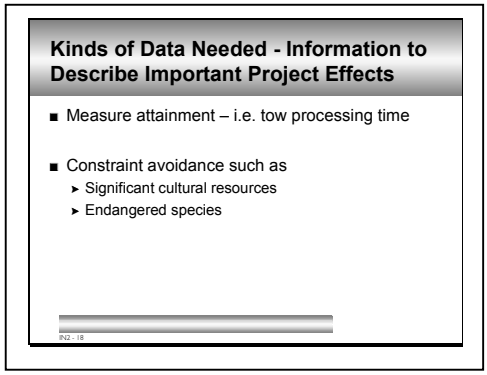
With respect to the existing Federal project, data is needed to estimate the cost to construct alternatives and their life cycle costs as well as data to estimate the existing operations and maintenance costs. The latter are generally for dredging and dredged material disposal sites. Additional data may be needed to estimate any periodic rehabilitation such as for locks and their appurtenances, specifically component (lock) reliability and the level of service that it can be expected to provide.



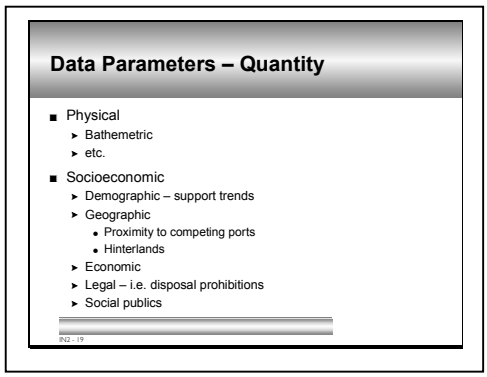
Baseline information is the foundation for NED analyses and benefit calculations. It should describe what is happening at a project and why.

Project Effects Data

You are also going to need data to determine attainment of an alternative. Usually this would be tow transit or lock processing times. You will also need data for constraint avoidance such as significant cultural resources and endangered species. This could affect location and timing of the dredging as well as the dredged material placement.



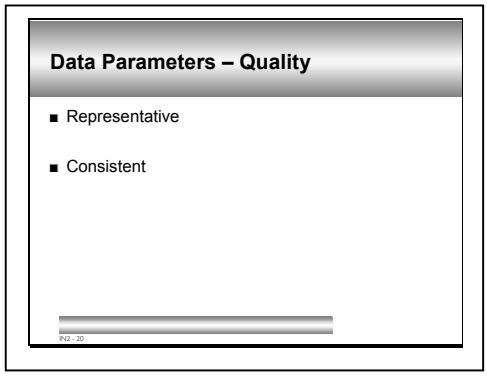
Data Parameters



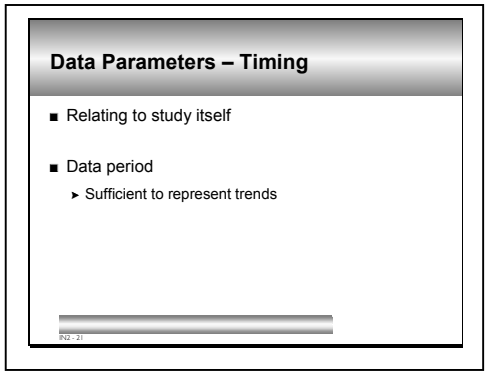
The *Planning Manual* discusses the concepts of the four parameters of data: quantity, quality, timing and location. Things that determine the quantity of data needed are the physical and socioeconomic setting. You need to know about the body of water that the channel is in, and the vessels using it, and information about the infrastructure. Socioeconomic data involve demographics to support trends, geographic data to determine proximity to competing modes, information on where the commodities come from and go to, etc. Legal data could involve identifying areas where disposal is prohibited or that are protected for endangered species. Determining who your social publics are is also important. Although if you don't find them, they will probably find you! But you don't want it to happen that way.

Baseline information must be adequate to document the existence of problems and to provide a basis for quantifying costs and the benefits of the project.

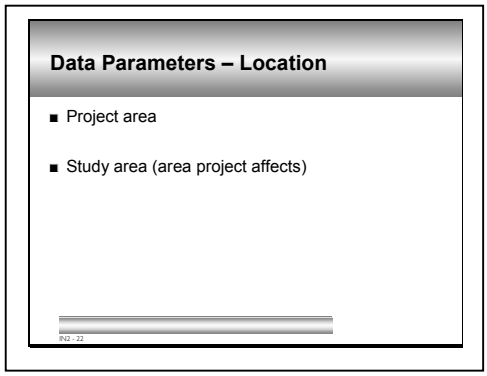
The quality of data may seem like an obvious thing, but often decision documents do not include representative data. Instead authors may selectively display vessels delays based upon interviews – which may be biased- rather than on actual times (which are recorded). And don't forget, because data may come from different sources, it needs to be checked for consistency.



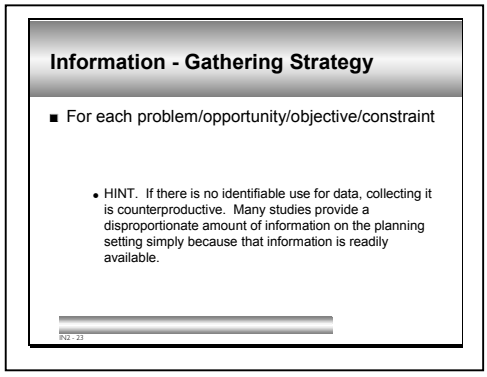
With respect to timing, the timeframe of the study may influence the data collection effort. As for the period of data representation, it should be, as a minimum, that needed to support a trend. This will vary with the types of data gathered. For example, if you are dealing with the intracoastal waterways, hydrodynamic data may only need to represent one lunar cycle while commodity movements may need to cover 3-5 years. You need to work this out with the experts, who often lean toward thoroughness in their area of expertise at the expense of study resources.



The location of data should cover the project under study and its area of commodity influence. And if it influences a port or several ports, the data (primarily their infrastructures) for those ports would also be needed. This is especially true where there are capacity restricting locks under study and they are between ports. The lock performance may drive traffic from the system or to a port not affected by the lock. In essence, the areal extent of data collection should include all significant resources that could be affected by the project.



Information - Gathering Strategy (and data sources)



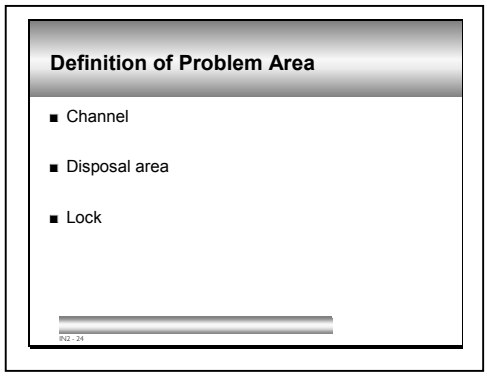
Data Focus

Data acquisition can be minimized by limiting it to the channels that have identified problems, and the vessels and cargo associated with those specific channels. The NEPA scoping process should be used to identify data needs. The key to having the right information at the right time and keeping the data acquisition effort within budget, is to be selective and collect only the information relevant to the problems and opportunities identified in your study. Voluminous socio-economic statistics for the planning setting may have little value for NED analysis.

HINT. If there is no identifiable use for data, collecting it is counterproductive. Many studies provide a disproportionate amount of information on the planning setting simply because that information is readily available.

Information is needed for each problem/opportunity/objective/constraint. A typical but not exhaustive list of items needed for inland navigation is discussed below. While there is a lot of detail, I summarize it because the planner needs to have a good idea of what the various disciplines need to acquire to perform their work on time and within budget.

Definition of Problem Area



Channel

The channel conditions directly affect traffic. Various data are needed to define the baseline condition. Information is needed on the hydrodynamics of the waterbody that contains the Federal channel. For intracoastal waterways, tide table information is readily available, but salinity and velocity data may need to be measured over a tidal cycle, lunar cycle, season or even longer depending on the nature of the environmental impacts. This coupled with the defining bathemetry is used for any numerical modeling to be able to predict changes needed to evaluate environmental impacts and vessel interactions. Bed material data is needed for dredging cost estimates and for designing of both lock sites and confined disposal areas. Core boring may be available from previous dredging studies.

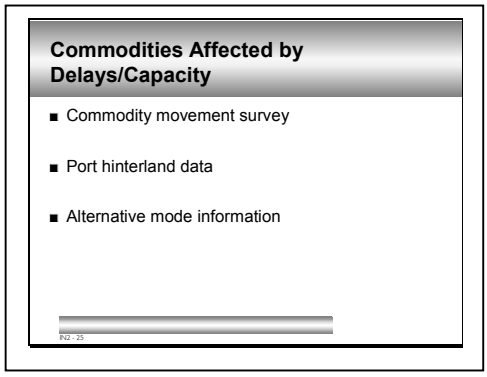
Disposal Area

Benthic organisms need to be identified for any proposed open water disposal and this would require sampling. The existence of threatened or endangered species could impact dredged material placement operations and even considerations for channel enlargement. Published lists are available and critical habitats have been defined for a number, but not all, endangered species.

Lock

Lock traffic information is needed on the magnitude, makeup and queuing of traffic; and lock performance times and vessel waiting times. All of this information is collected by the Corps and is contained in the Lock Performance Monitoring System database. You will also need to know about the lock appurtenances and tie-off facilities.

Commodity Information



Cargo information is used for an initial determination of the economic study area, and to provide the basis for commodity flow projections or forecasts. The information needed includes the size and composition of cargoes (annual tonnage by commodity or commodity categories), the origins and destinations of the cargoes (inland or hinterland, and external), and the inland transportation modes. The desirable level of precision for both commodity analysis and transportation costs is port-dock (or plant) level.

Actual Commerce

The purpose of most inland navigation projects is to lower transportation costs by reducing delays due to channel constrictions and lock size and performance problems. Predominantly, this involves existing commodity flows.

Potential Commerce

New or increased movements are usually viewed as opportunities by waterway interests. This is a very important point so pay attention. Some potential commerce may be only in the mind of the beholder. In order to reasonably limit the baseline effort, it may be necessary to determine which prospective movements are serious candidates.

Commodities affected by delays/capacity

The Corps of Engineers Waterborne Commerce Statistics Center is the best source for historic waterway movements. The alternatives are to obtain cargo information from terminal operators or carriers. Use the Port and Dock Code Book to identify the relevant waterway segment or port or dock facilities. It is desirable to have five or more years of comparative data, but that amount of information may be impractical.

Determining system or project hinterlands

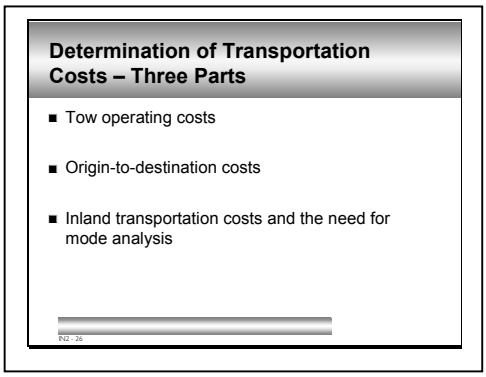
Hinterland Data

In addition to identifying the economic study area for commodity analysis and forecasting, baseline information should identify the extent to which the port's hinterland overlaps the hinterlands of other ports. That information is essential for systems analysis. Unfortunately, there may be no single source that identifies inland origins and destination conclusively. Theoretically, rail and truck transportation

costs should determine hinterland boundaries, but those boundaries are greatly skewed by the economics of transportation modes. Potential single sources, after preliminary identification of relevant commerce, are the terminal operators. They know who their customers are, and generally, who is using competing ports. However, they may be unwilling or unable to cooperate if they believe the information is sensitive, or if a lot of record retrieval is required. The alternatives or supplemental sources are vessel manifest data and truck and rail statistics.

Determination of Transportation Costs

Tow Operating Costs



To determine the expected annual delay/capacity costs, you have to start with tow operating costs. There are three components: the replacement or financial costs, fuel, and fixed operating costs. IWR is charged with producing vessel-operating costs.

Origin-to-Destination Costs

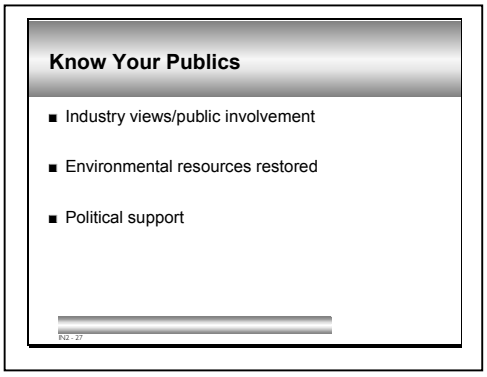
Analysis calls for the current transportation costs in NED evaluations. These costs are to include the full origin-to-destination costs, including necessary handling, transfer, storage, and other accessorial charges. For both theoretical and practical reasons it is necessary to interpret just what costs are costs, and whether all of those costs have to be counted in evaluation. The emphasis, of course, is on transportation costs.

Inland Transportation Costs and the Need for Mode Analysis

Rail and truck transportation costs are needed in order to complete the origin and destination costs if there are traffic shifts attributable to channel improvement.

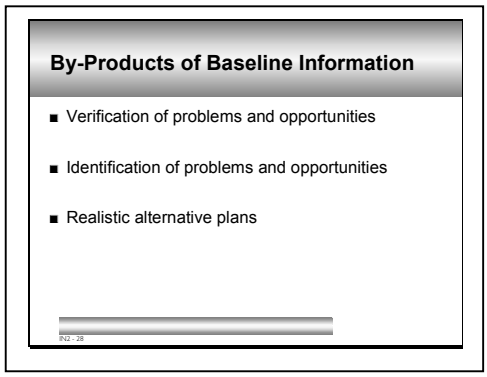
Section 7a of the Department of Transportation Act of 1966 (PL 89-670) requires use of prevailing overland carrier rates for inland waterway studies. The Tennessee Valley Authority can provide cost information on rail and truck while the Federal Power Commission can do the same for pipelines. Another source is the Association of American Railroads and the American Trucking Association. The problem with their statistics (and generalized costs) is that averaging may hide variations due to commodity or volume mix and local or regional conditions.

Know Your Publics



Your publics are important, as in all water resources projects, in achieving reliable service. Obviously the local port authority, shipping industry and grain growers are in favor. However we have seen strong opposition to system improvements and even project improvements. Even though environmental resources must be restored, environmental groups have, initially at least, not been supportive. There also needs to be political support. It can't always be assumed.

By-products of Baseline Information

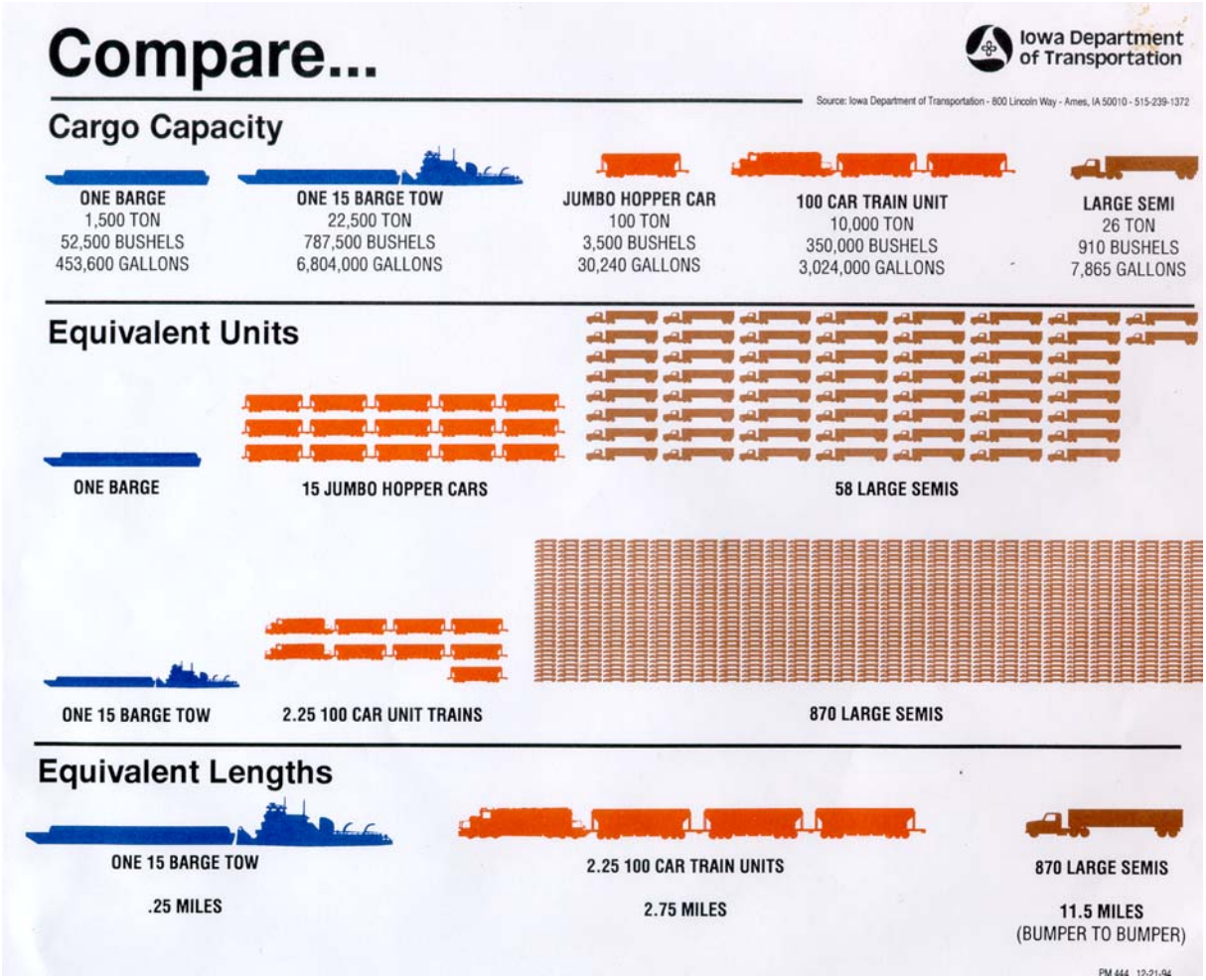


Once you have you baseline information, the iterative process continues. The data allows you to verify and modify, as necessary, your previously stated problems and opportunities. Then you can look at realistic alternative plans.

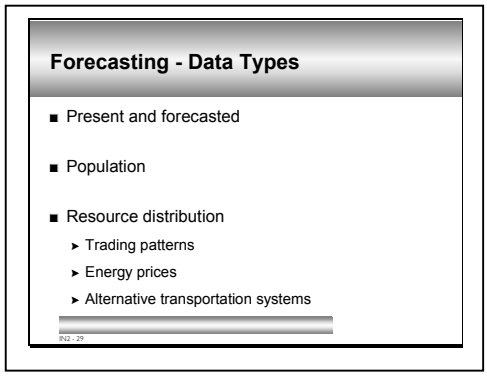
Forecasting

Background

You have to pay for the improvement. If, in the case of no improvement, would traffic shift to other routes and/or modes (move on land by truck or rail)? If it would not, will the improvement be economically justified on the basis of delay reduction cost savings (eliminating or reducing tow delays saves money in terms of labor and operating the tow)? If it is a "system improvement," will it induce traffic from other modes due to cost savings advantages?



Types of Data Needed



The appropriate data is needed in order to forecast the without and with project conditions from the present through the economic life of the project. Population is a key parameter not only for forecasting future demand for commodities but also for defining the so-called hinterlands for which the project or system is a conduit. This goes hand in hand with resource distribution. What are the present and future trading patterns and how are they influenced by energy prices; alternate transportation systems and overland carrier rates; and vessel operating costs? What data feeds that analysis?

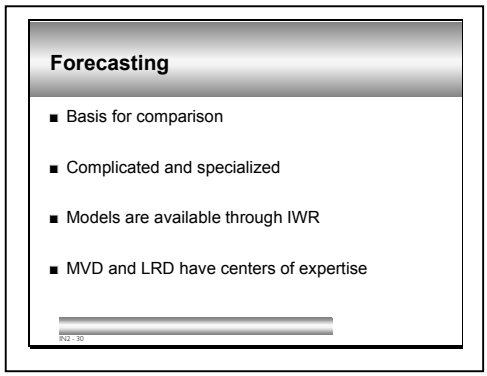
Population data is easy to deal with and changes might support trends in the projected increased movement of commodities carried by barge. It is a little harder to project the range of trading patterns but what is needed is the recent history of commodity movement including origins and destinations. Tow fuel prices are readily available as are numbers representing tow operating costs. If commodity movements are expected to shift, data including overland carrier rates are

needed. Monetary policies and environmental laws may affect national consumption versus export of coal, while the former might affect exports of grain.

The Huntington District is a major source of expertise. Rail origin-destination statistics are in the ICC Waybill Sample available through IWR. It is an annual, one- percent sampling, and identifies the rail origin and termination points.

Forecasting

Forecasting forms the basis for comparison. Economic benefits are dependent on forecasting. System traffic, fleet size, reliability and level of service need to be projected. This can be quite complicated and specialized. Computer models are available through IWR and both MVD and LRD have centers of expertise in this analysis. Or you may wish to contract the analysis. And while some models may be proprietary, the assumptions and support for their projections need to be clearly spelled out. The Corps subscribes to the Reebie model service, which has models for rail, truck and water costs.



Rate Services

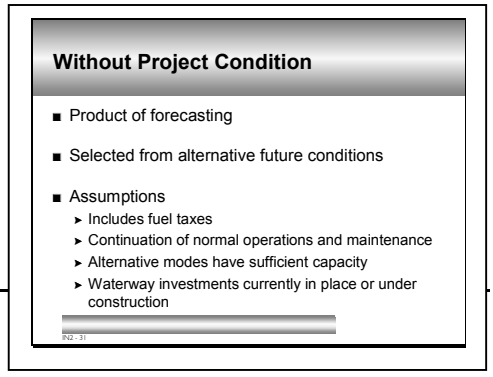
Similar to cost models, there are many commercial services available to supply rates. However, one source used heavily now is the TVA.

Lock and System Capacity

Vessel traffic cannot exceed the lock or system capacity. This too is derived from model studies and involves queuing theory.

Without Project Condition

The without project condition is a product of forecasting and is selected from alternative future conditions. This becomes the basis for evaluating alternatives. Its derivation includes certain assumptions such as it includes fuel taxes, continuation of normal operations and maintenance, all reasonable nonstructural measures, and sufficient capacity on that



alternative modes. Normally you assume that only waterway investments currently in place or under construction are in place over the period of analysis.

Models

Conceptual Model

The concept for modeling is based upon supply and demand. Modeling has to account for movement-level to system-level supply and demand. In the case of inland waterways, demand represents a willingness-to-pay for waterway services and supply represents the cost of the service. Because many of the commodities moved on the inland waterway systems are inputs to an intermediate or final product transportation demands can be derived from the demand for final products, like electricity, as moderated by the production process. At the individual movement level, a given consumer in a region has some level of demand for transporting a commodity from another region. The demand is determined by an array of factors - commodity supply prices, rail rates, barge rates, commodity input requirements, alternative supply region prices, and so on. Consumers/shippers in a region will continue to move a commodity from another region by the waterway up to that point where marginal rate (MRS) savings equals the marginal cost of waterway transportation. The industry or system demand is an aggregation of the individual movement demands.

In theory the demand or marginal rate savings represents, for each level of traffic, the shippers' marginal willingness-to-pay for the use of the waterway. The shippers' marginal willingness-to-pay is measured as the difference in transportation costs via the waterway routing and the routing via the least-cost alternative transportation mode (usually rail or truck).

In arriving at benefits, transportation savings are estimated for each unique origin, destination, and commodity movement in the system. Each movement's savings are estimated as the difference between the least costly alternate mode and the existing water routing. Projecting system benefits necessarily involves being able to project future traffic levels and transportation rate savings for each movement. Projecting rate savings necessitates consideration of factors that can degrade project performance, namely: (a) traffic congestion; and (b) lock reliability.

A project must be viewed in a systems context because of the interdependence of traffic flows among the many individual elements of the system. A change in the performance capabilities of one lock or channel segment can affect the efficiencies of other components of the system. For example, the additional traffic that uses the waterway because of improvements at project A may increase delays at other projects in the system and thereby reduce the benefits for the improvement. Thus, a systems accounting approach is required and the evaluation methodology must measure the performance of the total navigation system. By evaluating the economic performance of the system for each improvement alternative, the marginal system benefits attributable to each alternative can be measured. Alternatives that yield net system benefits can then be determined and compared.

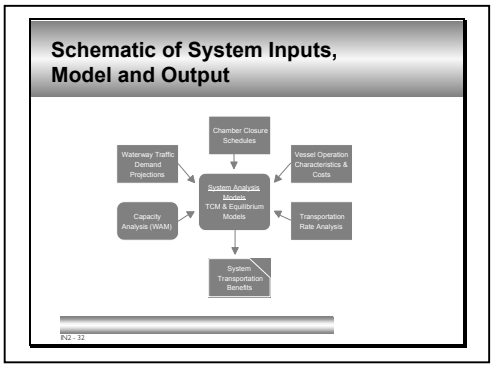
In concept, if not in practice, the equilibrium level of traffic increases, with the reduction in shipping costs due to the improvement. The incremental system benefits of project improvements can be examined by defining the relevant system variables in such a way as to reflect the impact of existing and projected transportation demand together with any desired system description that can be used to compute barge shipping costs with and without the improvements under study.

System Models

Cost-benefit analysis is used to identify the investment alternatives with the greatest net benefit (benefit minus costs) -- the NED plan. This is dependent on the cost estimates as well as the benefit estimation. The Great Lakes and Ohio River Division, uses a systems model to keep track of all the traffic interactions and to estimate the NED benefits. The model is actually a series of models collectively referred to as the Tow Cost Model (TCM). The suite of models includes three distinct modules: 1) the TCM; 2) the Waterway Analysis Model (WAM); and 3) the Equilibrium model. These models are currently being integrated into the single Ohio River Navigation Investment Model (ORNIM).

Part of the package is analytically based fleet sizing and costing model. Its basic function is to compute the barge line-haul costs for port-to-port traffic movements on a given waterway system with defined towing and operating characteristics. The WAM module is a stochastic simulation model used to estimate the transit times (processing and delays) associated with the processing of vessels through a project or projects, taking into account the variability in such variables as inter-arrival times, approach times, chamber entry times, chamber fill/spill times, and exit times. From use of the WAM, the tonnage-transit curves and project capacities are determined for both the without-project conditions and with-project conditions.

The Equilibrium Model uses data generated by the TCM and WAM modules to estimate system equilibrium traffic flows and the resulting system transportation benefits. The solution is presented at both macro and micro levels of detail. This provides the user with great flexibility in choice of analytic characteristics for the entire system, sub-regions of the system, for specific ports, locks and reaches, and for all the traffic between selected port pairs.



The effects of a system improvement are evaluated by specifying an alternative set of input parameters to reflect the improvement and resolving the model. Then the analyst can compute the incremental system benefits (transportation cost savings) for virtually any type of system modification and also to trace and describe the system impacts at a very disaggregate level of detail. The overall organization of the TCM suite of models and major inputs are shown in the figure below. The waterway traffic demand projections and the rate analysis are combined to generate the marginal rate savings demand. The TCM, WAM and the vessel operation characteristics and costs are used to generate the average total cost curve.

The location of each lock and dam project to be considered as a constraint in the calculation of the amount of project transit time incurred by each tow in moving from its origin port to destination port to arrive at a lock capacity. Throughout the simulation, statistics are compiled concerning delays, queue lengths, average processing times, and other variables. The primary item of interest from any single run is the delay for a given traffic level. By making a series of runs over a wide range of traffic levels enough observations can be obtained to develop tonnage-transit relationships for each set of conditions. Capacity is then identified as the traffic level at which an increase in tow arrivals results in a large increase in average delay, with very little or no measurable increase in tonnage accommodated.

The tow size, the resulting number of trips, and the shipping time and cost for each movement are determined on a least-cost basis using a port-to-port algorithm. This algorithm determines the most cost-effective tow size for each movement by cycling through the time and costs for all possible shipping plans

and allowable tow sizes. For each port-to-port commodity-barge type movement, the algorithm calculates the round-trip time from shipping port to receiving port. These times are translated into costs of transport by applying the equipment operating costs per unit time. The major time and cost elements considered by the model include: (1) time loading/unloading barges; (2) time waiting for access to docks; (3) time loaded barges wait for a towboat; (4) time making/breaking tows; and (5) tow trip time (including linehaul, lockage and delay time). This last sentence is important for the student to realize the model inputs that we will mention below.

Using the characteristic shipping costs for each port-to-port commodity-barge type movement, along with additional input data on each movement's waterway rate savings (the demand curve), the Equilibrium Model determines which movements would likely divert to an alternate mode. The model assumes that movements will divert off the waterway system when towing costs increase to the point that it becomes cheaper to move via the least cost all-overland route. Finally the Equilibrium Model identifies the quantity that equilibrates the system, i.e., finds where the system demand and system cost curve intersect.

Model Input

The model requires three input data files to perform the simulation. These consist of: 1) a network description file containing equipment and cargo characteristics along with the configuration of the waterway network being analyzed; 2) a shipment list containing arrival patterns for tows and recreation craft; and 3) a downtime file containing the frequency and duration of chamber downtime events.

Required input data for each waterway link includes its length, minimum and average depth, average current velocity, and maximum tow size in order to compute tow speeds and barge loading, determine miles traveled and total tow transit time on each link and maximum tow carrying capacity.

Port nodes are used in the model to represent the generalized loading and unloading points for waterborne commodities and are an aggregation of individual docks to keep the analysis in manageable proportions. Required input data for each port includes barge pickup and drop-off time, barge loading and unloading time for each of three major handling classes, delay per tow to access loading and unloading facilities by handling class, and the time that loaded barges spend awaiting tow.

Vessel data provide pertinent physical and operating-cost information on the vessel equipment and are used by models in computing shipping costs and includes their maximum loading capability, towboat and barge operating costs, and fuel costs calculated based on the consumption rates, the price per gallon, and the time involved in shipment.

UMS/IW and the ORS Comparison Summary

UMS/IW and the ORS Comparison Summary

- Traffic
- Physical System
- Model Concept
- Concept Application

IN2 - 33

UMS/IW and the ORS Comparison Summary - Traffic

- ORS
  - 260 million tons
  - 50+% coal
  - 60+% internal
  - average haul 460+ miles
  - many geographic destinations
  - primary market--electric utility
- UMS/IW
  - 130 million tons
  - 50+% grain
  - 60+% outbound
  - average haul 1000+ miles
  - one dominant geographic destination
  - primary market--exports

IN2 - 34

UMS/IW and the ORS Comparison Summary - Physical System

- ORS
  - 16 110x1200
  - 3 110x600
  - Auxiliary chambers
    - all projects have auxiliaries
  - Navigation season
    - open all year
- UMS/IW
  - Main chambers
    - 3 110x1200 UMS
    - 23 110x600 UMS
    - 3 56x400 UMS
    - 8 110x600UMS
  - Auxiliary chambers
    - 23 projects have no auxiliaries
  - Navigation season
    - part of system closed in winter

IN2 - 35

UMS/IW and the ORS Comparison Summary - Model Concept

- ORS
  - Commodities not assumed homogeneous across regions
  - Demands fairly inelastic--limited alternative markets
  - Transportation demands less responsive to commodity prices
  - Transportation cost 4% of revenue
- UMS/IW
  - Commodities assumed homogeneous across regions
  - Demands elastic--many alternative markets
  - Transportation demands responsive to commodity prices
  - Transportation cost 20% of revenues

IN2 - 36

UMS/IW and the ORS Comparison Summary - Concept Application

- ORS
  - Base rates exogenous
    - alternative rates constant
    - model forecasts barge rate
  - Demand forecast exogenous
    - quantity forecast with constant price
    - elasticity not specifically estimated
- UMS/IW
  - Base rates exogenous
    - alternative rates constant
    - model forecasts barge rate
  - Demand forecasts exogenous
    - quantity forecast with constant price
    - elasticity estimated

IN2 - 37

UMS/IW and the ORS Comparison Summary - Concept Application

- ORS
  - Lock delays based upon discrete event simulation
  - Static system model
  - Partial model
- UMS/IW
  - Lock delays based upon queuing logic
  - Static system model
  - Partial model

IN2 - 38

Review Questions

1. A lock exhibits increasing processing times. What could the problems be?
2. The State of Texas does not allow open water disposal in Matagorda Bay. Is that a constraint?
3. What is the hinterland for a lock?

Section Summary and a Look Forward

This section has addressed the initial stages of plan formulation by discussing identification of problems and opportunities and using these to create objectives while being mindful of constraints. To that end, it has looked at the data needed, where to find it and discussed how it impacts the planning process. This section has also discussed the role of forecasting, some on the basic techniques involved and their limitations. Finally the role of forecasting and the integration of commodity and fleet forecasts has been reviewed as it relates to defining the with and without project conditions. In the next section, we will discuss formulation.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

National Economic Development Procedures Manual, Deep Draft Navigation, IWR, November 1991.

Bastian, David F, Lock Capacity as a function of Tow Size, Proceedings, Twenty-fifth Annual Meeting, Transportation Research Forum, Vol. XXV, No. 1, PP. 429-438, 1984.

U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Superintendent of Documents, U.S. Government Printing Office.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will understand how to identify problem and opportunity as they relate to navigation
2. Student will be able to determine the constraints to navigation improvements
3. Student will learn the parameters needed for inventory and their relation to time and budget
4. Student will learn why specific data is needed and the source of such data
5. Student will learn that model application is specialized
6. Student will be exposed to forecasting needs and their impacts upon formulation

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Instructor Notes and Exercises:

This Module will emphasize the first two steps of the planning process, problem identification and inventory and forecast. Major emphasis will be placed on the interaction of economics and technological advances as engines of change. This Module will cover the general economics of the navigation systems including the role of population and resource distribution, trading patterns, and alternative transportation systems, as they may relate to formulation. The Module will cover the topics of rate analysis and it's relation to the development of waterway benefits. This Module will discuss the computer models used in the determination of transportation costs and examples will be discussed that demonstrate experience and techniques in making use of these models on successful studies. You need to point out to the class that the navigation chapter will not address environmental restoration or beneficial uses of dredged material in any detail. These topics are covered in other chapters.

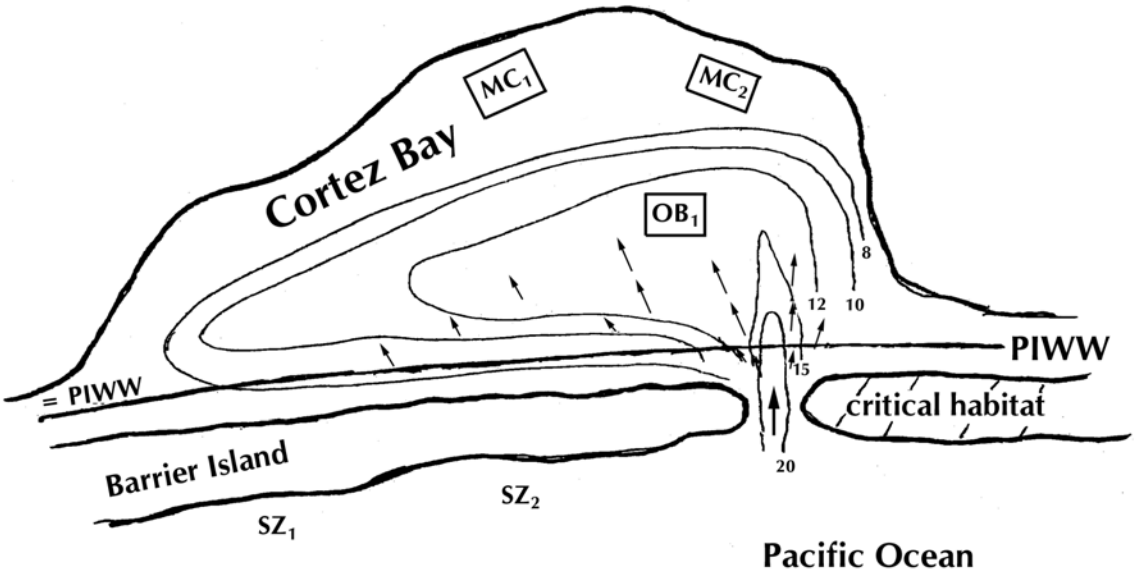
Slides IN2-33 to 38
The purpose of the model presentation and comparison is not to teach the class how to model but give them an idea of what data feeds models and contrast model needs based on system differences, in this case between the Upper Mississippi system from the Ohio system. Slides IN2-33 to 38 accompany this exercise.

Exercise IN2.1 - Identify problems and opportunities.
Give the class the map of the embayment. It shows the bathemetry, major velocity patterns and channel alignment on a portion of the Pacific Intracoastal Waterway. Don't explain that, let them interpret. Tell them that due to a natural increasing enlargement of the channel through the barrier island, that the local reach of PIWW channel has resulted in a much higher rate of channel shoaling. This has resulted in a high frequency of groundings and subsequent PIWW channel closings. The towing industry has come to the Corps wanting the problem fixed. Further tell them that now there is open bay and ocean surf zone maintenance dredge disposal, but that the resource agencies want marsh creation. Also the State will deny open bay disposal if the channel is relocated.

Give the class 15 minutes to write the problems and opportunities, list constraints and come up with an objective statement. Take 10 minutes to let them give the results. Afterwards, critique it.

Answers. The first problem is there is no PIWW. One of the alternatives should include a channel reroute. This should lead to a discussion of dredged disposal constraints and what the base plan is (by definition) when addressing the resource agency preferences.

Embayment Map



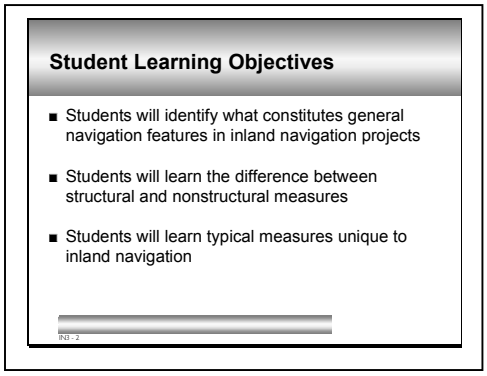
MC_i = marsh creation

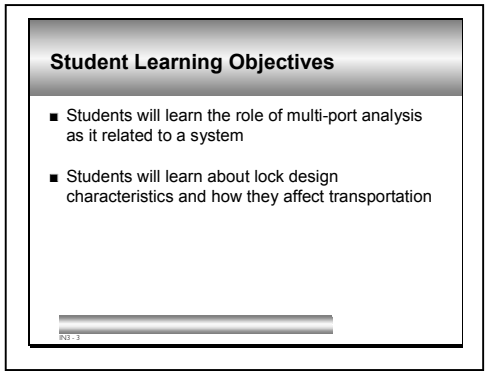
OB_i = open bay disposal

SZ_i = surf zone disposal

contours in feet

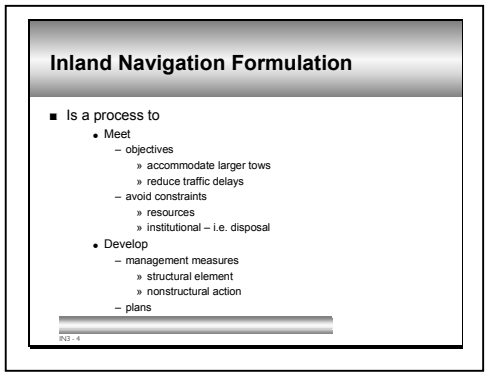
PIWW is 125' wide and 12' deep





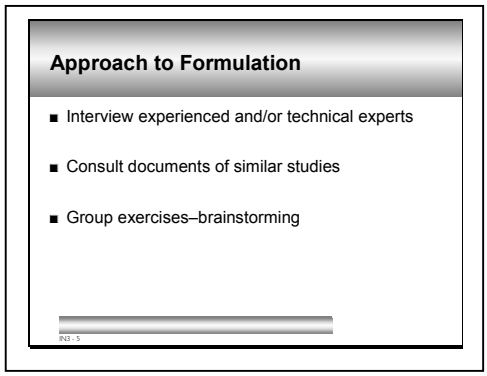
Module IN3: Formulation– Measures and Strategies
Inland Navigation Formulation

Inland navigation formulation is a process to meet objectives which usually revolve around accommodating larger tows and reducing tow movement delays while avoiding constraints in order to develop management measures and plans. First we need to know what some of the potential management measures are for inland navigation improvements. It is important to keep in mind the relationship between the waterway system and the individual project.



Approach to Formulation

Only some of the districts have inland waterways and there are not that many studies ongoing at any one time. So how do you approach addressing inland waterway improvements? There are three good ways.



1. **Brainstorming**. Brainstorm both within the office and with interested parties.

   a. District Disciplines. Your district has been dealing with its Federal channels probably for the life of the district. Even if your district hasn't performed an inland navigation improvement study recently, you still may have a wealth of talent and knowledge within the district to lean on. The operations people have been maintaining the locks and channels and handling disposal so they are aware of potential problems and certainly must have ideas for opportunities. To a lesser degree, your hydraulics and hydrology staffs are acquainted with the waterbodies including those

containing the Federal channels. Your real estate folks will know about access to lock construction staging areas and disposal sites. And the list goes on.

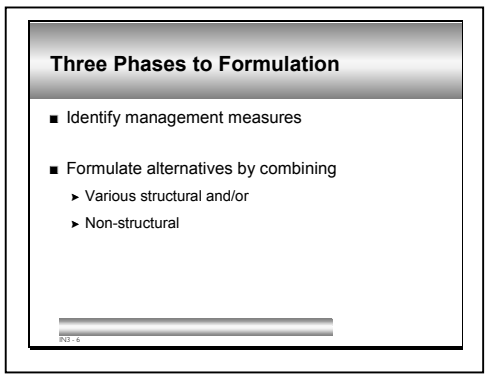
b. Outside the Corps. Tow operators and pilots and industry representatives and affected port authorities are also good information sources. Resource agencies and environmental groups can provide information on sensitive habitats and critical environmental issues and concerns that might be encountered as formulation proceeds. Then there are other government groups that have to be consulted as part of the NEPA process. These groups will see environmental opportunities to augment beaches, mitigate habitat losses, create wetlands, protect cultural resources, etc. They will also try to build on synergies such as by combining with other programs like Brownfields.

2. **Don't Reinvent the Wheel**. Inland navigation improvement studies are relatively universal. Their goal is to find ways to make traffic more efficient on an inland waterway system. There really aren't many options. That doesn't mean it is necessarily easy to come up with a full array of management measures and plans. Therefore another good approach is to look at documents of similar studies. The key to this is to know what to look for. Remember, if information has no use it should not be displayed. Therefore look at the stated problems and opportunities and look at the various measures and plans in these reports. If you don't know what study(s) to look at, contact your division and the policy review folks in headquarters. The latter have reviewed them all!

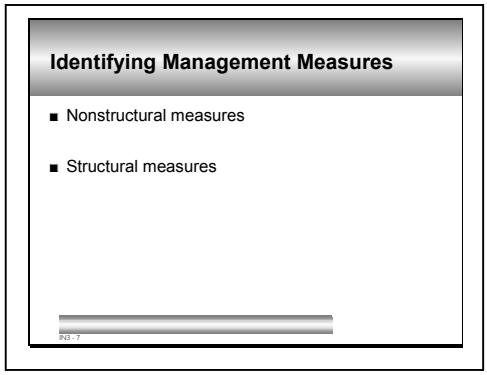
3. **Interview**. There are experienced and technical navigation experts in the district, division and headquarters – the Corps family. They can also be found at port authorities, from tow pilots and in consulting firms and universities.

Three Phases of Formulation

This module will cover the first two phases: (1) identifying management measures and (2) combing them. Module 4 will look at the third phase–reformulation–as part of the discussion on identifying the NED plan.



Identifying Management Measures

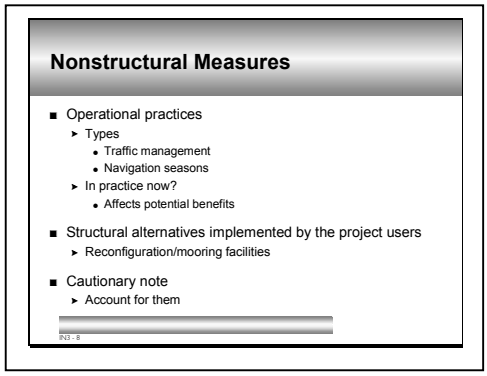


Most of the inland waterways were designed when there was less traffic and fewer vessels. With increased traffic and larger tow sizes, the interval between locks sites, the number of locks at a site and their sizes impact the current flow of traffic. To address this, there are two types of measures; structural and nonstructural.

This is the first phase of inland navigation formulation.

Nonstructural Measures

Nonstructural Measures



The Principles and Guidelines (P&G) define nonstructural measures as follows: "Nonstructural measures are complete or partial alternatives to traditional structural measures. Nonstructural measures include modifications in public policy, management practice, regulatory policy, and pricing policy." (P&G (1.6.1(f)(1)). Defining nonstructural measures as those measures that are not structural does not tell the complete story. In fact, you may actually need heavy equipment to implement a nonstructural alternative, so do not let your understanding of these measures ride too much on the notion of construction activity. To define one as building things and the other as not does not capture all the nonstructural possibilities today. Another way of looking at it is to recognize that structural alternatives are general navigation features, while nonstructural features are not.

Operational practices

One measure used at international canals, like Suez and Panama, is traffic management. In this case the locks and channels are big enough but there would be traffic delays without some management control. It is operated just like air traffic control and is just as sophisticated. Many Corps locks already use management techniques like one up, one down.

Navigation seasons can be adjusted through water release management or ice control. There could be policies imposed by pilots, which result in one-way traffic in heavy shoaling areas to prevent grounding because groundings result in traffic delays.

These operating practices should be identified and a determination as to their applicability in the baseline, and each of the plans being evaluated. But first determine whether these practices are currently in use. If so, then care must be taken to determine the degree to which these practices are currently reflected in transportation costs.

Other applications at locks could include congestion fees and helper boats.

Local Service Facilities

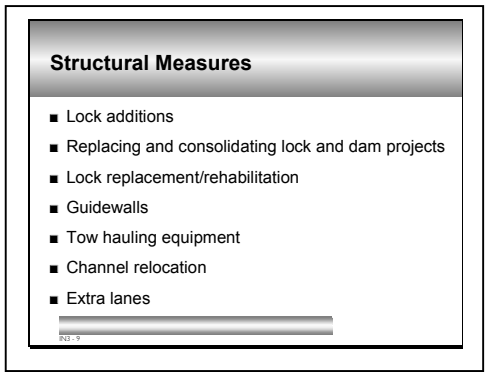
In the physical sense, local service facilities are structural but fall under the category of nonstructural alternatives. They include things like mooring facilities and construction or reconfiguration of loading and unloading infrastructure.

Cautionary Note

A closing cautionary remark on nonstructural alternatives is that they are commonly neglected in plan formulation – they should not be, they should be analyzed and included, as appropriate, in all alternatives (including the no action alternative) being considered.

Structural Measures

Structural Measures

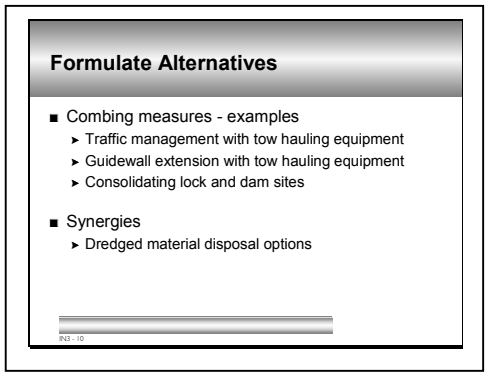


Structural measures are the features that the Corps and Coast Guard are responsible for and the accompanying local service facilities which are needed to achieve benefits afforded by the GNF.

If the objectives include accommodating larger tows, the lock would have to be enlarged or it may also involve relocating bridges or portions of a channel.

If the objective is to reduce traffic delays they should be analyzed and included, as appropriate, in all alternatives (including the no action alternative) being considered. It might involve the width of channel bends, rehabilitation of locks, extending guidewalls, adding tow hauling equipment, building another lock at the site, etc. In congested areas, extra lanes and chambers could be added.

Formulate Alternatives

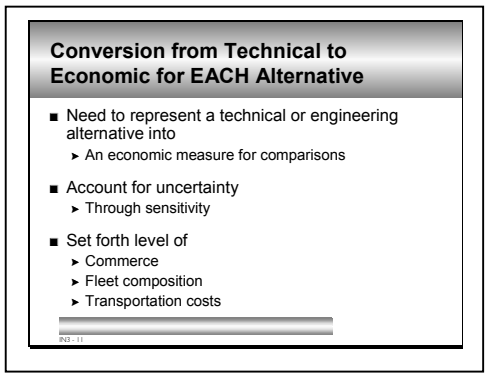


Now that you have identified a comprehensive list of measures to address some or all of the objectives, you need to start combining them to come up with a list of alternatives. Alternatives can differ in their timing as well as in their physical characteristics. They include present and future without plans usually thought of as what the project would be like without Federally constructed improvements.

A logical combination for any channel enlargement or relocation involves the disposition of the dredged material. While the magic phrase is the "least costly disposal plan", we also want to consider beneficial uses for this material. Options are beach nourishment, wetland creation, restoration, mitigation, land creation and any other creative beneficial use. These are synergies.

However, I have to point out that these applications of dredged material depend, in addition to cost increments (if they exist) on the type of material dredged.

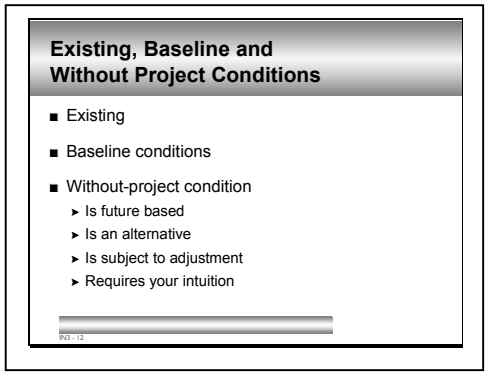
The purpose of explicitly structuring the economics of alternatives is to provide a basis for measuring incremental benefits and costs associated with each alternative. The economics of alternatives have three parts: project costs of implementation; future commodity flows; and relative transportation costs for each commodity flow. Each alternative should include the data, analysis, and underlying assumptions.



Due to uncertainties, there are several project-associated futures. Commodities may enter or exit the waterway at any number of points or bypass it altogether by going directly to or from harbors by other modes. For example, actions by competing ports may be difficult to associate with specific project alternatives. These can be dealt with through sensitivity analysis. The goal is that the alternative analysis provides sufficient information to explicitly set forth the level of commerce, expected fleet composition, and costs by transport alternative for each technical alternative that is under consideration.

Existing, Baseline and Without Project Conditions

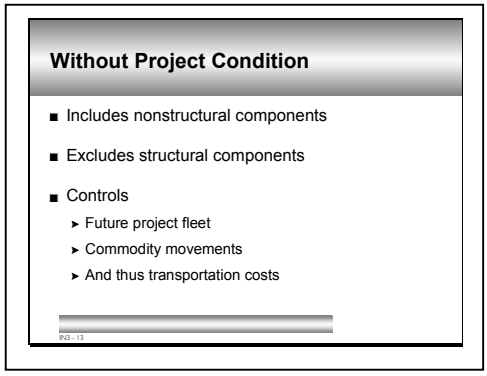
The without-project condition, as we have noted, is one of the alternatives. But before we define it, you first must clearly delineate between the existing and baseline conditions. The baseline condition represents a scenario from which other impacts are to be measured – a point of reference. The with- and without-project conditions represent futures that can be associated with-project implementation; one where no project is implemented and the other when it is. Usually we use baseline and without project interchangeably. And there are no rules on factors that differentiate the two. Further, as analysis leads to better information the baseline/without-project condition is adjusted. To arrive at the specifics that the without condition will represent, you will have to use your best intuition about the future. However, you will be guided not only by commodity movements and fleet compositions, but also by resolved issues, and critical issues. For example, if some actions do not affect commodity flow levels or relative transportation costs, these should be considered resolved issues and incorporated into the without-project condition. Those left will help identify factors critical in reaching the recommended course of action.



A difficult aspect of specifying the baseline condition revolves around what is termed critical issues. During the data collection phase, information will be obtained from shippers and carriers that provides a basis for determining the likelihood that certain actions will be implemented relative to each project alternative.

Without Project Condition

The baseline condition can also be identified on the basis of disaggregation of commodity flows into commodity groups, trade route and benefit category. Conceptually, generating the without project condition commodity flows is a linear decision that begins with the baseline traffic, then proceeds through transportation costs, resulting in estimated project commerce for each study time interval conditional on some project alternative.



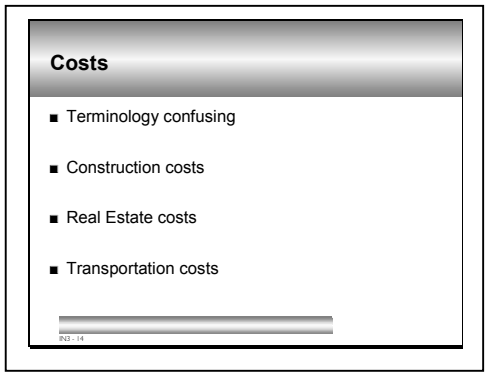
Lets look back at it one more time, but this time more simply stated. One alternative involves no structural changes, just nonstructural if applicable (and they need to be evaluated). This probably becomes the future without project condition. The commodity movements and their transportation costs are going to be based on the traffic projections and their interrelationship with lock capacity and/or channel capacity that would evolve given no structural improvement.

Merging Costs and Benefits

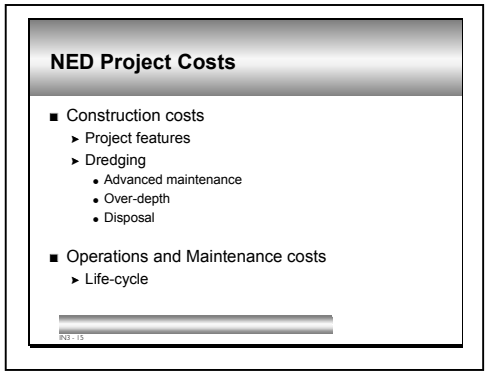
In the previous module we talked about how to go about determining the transportation costs. Now we have to determine the cost to implement the various alternatives. Not only that, we have to put them in the proper category and finally we have to annualize them so we can compare alternatives with different timing components. As we arrive at a common point of comparison, we can then look at adding increments, changing scale and deleting components that are ineffective, inefficient, or unacceptable. And don't forget there is an interrelationship between transportation costs and a given alternative.

Costs

Now as you start to make general navigational feature improvements and decide when you would make them based on availability of commodities, you can determine the unit transportation costs. Because cost terminology is confusing the analysis might be incomplete. What do I mean? Follow me and see for yourself.



NED Project Costs



The first step in completing the feasibility analysis is the generation of a complete cost stream associated with each alternative over the project life. Three types of costs must be assessed: project implementation or construction costs; operations and maintenance costs; and interest during construction.

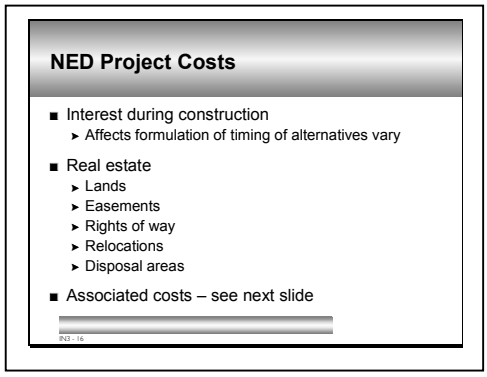
Construction costs. If resources are committed to project implementation, they should be reflected as NED costs. The costs include project features or general navigation features. We are talking about locks (new or rehabilitation) channels (relocations or widenings), disposal containment areas, river training structures, anchorages, etc. Other costs include mitigation, design, engineering, surveying, the acquisition of all lands, easements, rights-of-way necessary for the project including lands for disposal of dredged material and relocations necessary for the project.

Implementation costs almost always include dredging (as does channel maintenance). For the channel construction category you have to account for advanced maintenance and overdepth dredging costs if applicable, even though these are for initial channel depths (and sometimes widths) beyond the project alternative's dimensions.

The examples cited in the above paragraph are general navigation features and are a Federal responsibility. If the user has to construct local service facilities necessary to achieve the benefits claimed, then these would probably be construction costs.

Operations and maintenance costs. Operations and maintenance costs are the on-going claims on resources over the project life. The majority of these costs will have to do with channel dredging and disposal and lock maintenance.

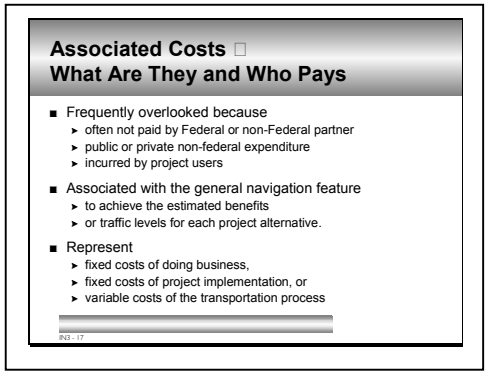
Interest during construction.



Interest during construction reflects the fact that project construction costs are not incurred in one lump sum, but as a flow over the construction period. It is frequently computed on the assumption that expenditures are incurred at a constant rate over the construction period. If details show that construction expenditures would not be constant, compute your interest accordingly, especially if the project will be constructed in phases. This would affect formulation if the timing between alternatives were a factor.

Associated Costs – What are They and Who Pays?

Associated costs are any public or private non-federal expenditure that is required along with the general navigation feature in order to achieve the estimated benefits or traffic levels for each project alternative. These local service facility costs are incurred by project users as part of the transportation or logistics process. They represent (1) fixed costs of doing business, (2) fixed costs of project implementation, or (3) variable costs of the transportation process. Examples are facility enhancements necessary to accommodate larger vessels or larger loads per vessel such as bigger cranes, longer berths and piers, or expanded storage areas. They are often referred to as local service facilities.



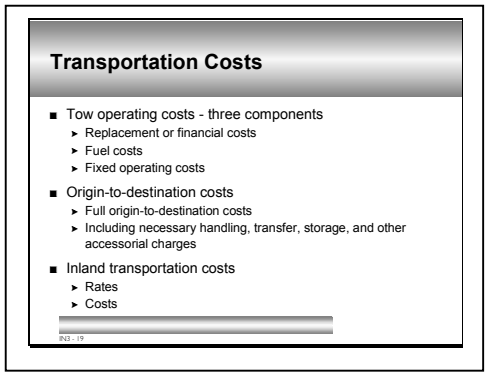
Associated Costs – Transportation or Implementation?

You have to do two things. You have to identify associated costs fully and you have to account for them in some manner in the analysis. That is, they should be reflected in project implementation costs or in comparative transportation costs. There is little general guidance on the best manner to account for associated costs. Consult with your economists.

Of course where all this gets touchy is when the benefit-cost ratio is near one.

Transportation Costs

To compute benefits you have to first calculate transportation costs for each scenario. Knowing the commodities by volume, you can identify the with- and without-project water transportation costs when you account for vessel loadings by size distribution. That coupled with landside transportation costs will allow you to compare effectiveness of alternatives.



Tow/Barge Operating Costs

To determine the expected annual delay/capacity costs, you have to start with tow/barge operating costs. There are three components: the replacement or financial costs, fuel, and fixed operating costs. IWR is charged with producing vessel-operating costs.

Origin-to Destination Costs

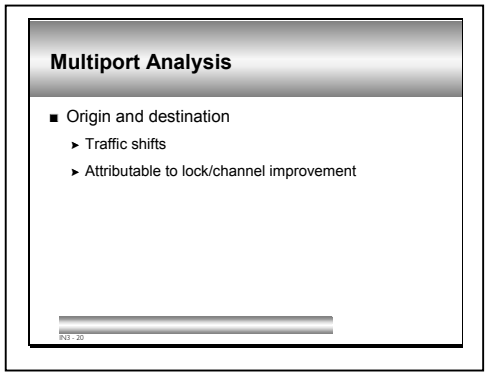
Analysis calls for the current transportation costs in NED evaluation, and those costs are to include the full origin-to-destination costs including necessary handling, transfer, storage, and other accessorial

charges. For both theoretical and practical reasons it is necessary to interpret just what costs are costs, and whether all of those costs have to be counted in evaluation. The emphasis, of course, is on the transportation costs.

Inland Transportation Costs and the Need For Multiport Analysis

Rail and truck transportation costs are needed in order to complete the origin and destination costs if there are traffic shifts attributable to channel improvement. This implies a multiport analysis. To minimize your effort, you should restrict this analysis to those movements of significant size. Regardless, this effort can be significant and it is generally specialized.

Multiport Analysis

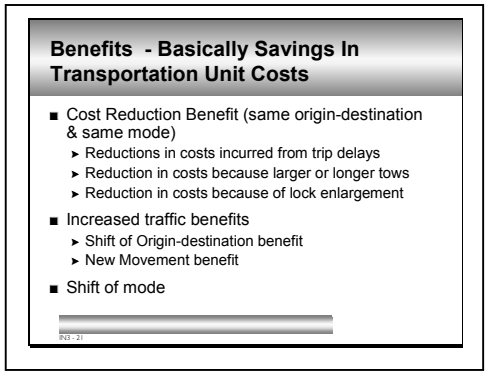


NED Benefits

In arriving at benefits, transportation savings are estimated for each unique origin, destination, and commodity movement in the system.

The primary benefit for Federal investment in commercially navigable waterways is the collective transportation cost savings for barge shipment over the least-costly alternative routing. The benefit, denoted as rate savings, also accounts for any differences in transportation costs arising from loading, unloading, transloading, demurrage, and other activities involved in the point-to-point transportation of goods. Estimates of the benefits from waterway investments require an analysis of the demand for waterway transportation, the costs of moving the goods via both the waterway routing and the least-costly alternative routing, and the volume of traffic that shippers and carriers would actually choose to move on the waterway system, given each shipper's own unique set of economic and non-economic variables and the specific waterway configuration. Project benefits are presented in the form of transportation cost savings and fall under two categories.

Benefits - Basically Savings in Transportation Unit Costs



Cost reduction benefits. Cost reduction benefits result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern in all project conditions. Cost reduction benefits will generally take one of three forms depending on the project formulation.

Delay reductions. Things that apply here are, for example, improvements to the lockage component speeds.

Reduction in costs because larger or longer tows. Project improvements that allow larger loads by allowing larger or longer tows should benefit from economies of scale.

Reduction in costs because of lock enlargement. This is a variation on the one above.

Increased Traffic Benefits. In addition to the decreased transportation costs for existing movements, the proposed project may also increase the level of traffic as a result of decreased transportation costs. It is important to note that this traffic does not represent growth over time, but difference in traffic levels between alternative futures at any point in time.

While we don't want to get into the details of evaluation, I should point out that in the case of induced movements, benefits should conceptually be based on changes of net income to the commodity producer or user. This is not easily estimated so these benefits are often estimated as one-half of the difference in the maximum and minimum transportation costs for each alternative, unless you have better or more detailed information.

Review Questions

1. What is one of the design considerations of a lock filling system with respect to traffic throughput?

2. What are some nonstructural alternatives that would facilitate inland waterway traffic?

3. Name three approaches to formulation.

Section Summary and a Look Forward

This module has addressed major lock features and their relationship to traffic throughput. It reviewed the measures that could be combined to formulate alternative plans for navigational improvements. Plan formulation strategies were discussed. Cost variables were discussed with an emphasis on generating an

understanding of how site and facility performance can influence costs and therefore optimization. In the next module we will discuss identifying the NED plan and how optimization is involved.

References and Suggestions for Further Reading

Bastian, David F, Lock Capacity as a function of Tow Size, Proceedings, Twenty-fifth Annual Meeting, Transportation Research Forum, Vol. XXV, No. 1, PP. 429-438, 1984.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

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U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Superintendent of Documents, U.S. Government Printing Office.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Yoe, C. *National Economic Development Procedures Manual – National Economic Development Costs.* IWR Report 93-R-12, June 1993.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will identify what constitutes general navigation features in inland navigation projects
2. Students will learn the difference between structural and nonstructural measures
3. Students will learn typical measures unique to inland navigation
4. Students will learn the role of multi-port analysis as it relates to a system
5. Students will learn about lock design characteristics and how they affect transportation

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Instructor Notes and Exercises:

This Module will emphasize the third step of the planning process, formulation. It will review the measures that could be combined to formulate alternative plans for navigational improvements. Plan formulation strategies will be discussed. Major lock features including walls, empty fill systems and gates will be covered. The impacts of real estate, OMRR&R, land development and other significant factors in developing formulation strategies will be discussed. Cost variables will be covered with an emphasis on generating an understanding of how site and facility performance can influence costs and therefore optimization.

Slide IN3-4
You want to point out that by now the planners would have collected a large database that has been generated describing possible future economic conditions within which the project could be implemented. This information has only limited reference to specific project alternatives, project implementation or economic evaluation. Inland navigation formulation is a process to meet objectives that usually revolve around accommodating larger tows and reducing tow movement delays while avoiding constraints in order to develop management measures and plans. Although it is repetitive, stress that the waterway is a system and project improvements have to be formulated and evaluated in a system context.

Slide IN3-5
You want to acknowledge that only some of the districts have inland waterways and that the Corps does not conduct many inland waterway studies. Because district experience is likely to be minimal, tell them of three good ways to approach formulation: (1) Brainstorm both within the office and with interested parties; (2) Don't reinvent the wheel, instead use previous studies or their relevant parts; and (3) Interview. Point the class to where the experienced and technical navigation experts are. They are in the district, division and headquarters – the Corps family. They can also be found at the port authority, among tow pilots, in consulting firms and inside the ivory towers on educational institutions.

Slide IN3-7
Exercise IN3.1
What we want the class to do is to produce a comprehensive list of as many navigation improvement measures as possible. Divide the class by gender, district, experience or any other way to add a little fun

to the exercise. Choose a person to start. They name a navigation measure and you write it down. The next person does the same. As the list grows it gets harder. When people come up blank or you reject their idea they sit down. The last person standing wins a candy bar if you plan ahead and buy one. The point is to generate a list.

Discuss how these two terms are misleading. Acknowledge that the problem also applies to deep-draft but much more so.

Slide IN3-8
The critical issues for nonstructural measures are how these factors might affect transportation costs and commodity flows associated with the project. But what are they? You want to emphasize the need to include these in the mix and note that they are often neglected. (Note: All appropriate nonstructural measures should be included in each alternative, including the "do nothing" alternative.) The planner is charged with coming up with a complete array of alternatives, but can't if some of the measures are overlooked.

Slide IN3-9
Structural measures are the features that the Corps and Coast Guard are responsible for and the accompanying local service facilities provided by the users which are needed to achieve benefits afforded by the GNF.

Slide IN3-10
At this point in the process the class has identified a comprehensive list of measures to address some or all of the objectives. They need to start combining them to come up with a list of alternatives. Take time to talk about the limit of measures and combinations thereof, due to the nature of the system. It is a system and thus relatively uniform. Channel widths and depths are set by law (they can be changed). Alternatives can differ in their timing as well as in their physical characteristics. They include present and future without plans usually thought of as what the project would be like without federally constructed improvements. Discuss ideas on how to incorporate synergies to create a win-win for a "larger community". You could ask the class for examples of both measures combining and synergies.

Slide IN3-12
It appears that baseline and without project conditions are interchangeable terms. This may be because there are no rules on factors that differentiate the two. Further, as analysis leads to better information the baseline/without-project condition is adjusted. To arrive at the specifics that the without condition will represent, you will have to use your best intuition about the future. However, you will be guided not only by commodity movements and fleet compositions, but also by resolved issues, and critical issues. For example, if some actions do not affect commodity flow levels or relative transportation costs, these should be considered resolved issues and incorporated into the without-project condition. More simply stated, one alternative involves no structural changes, just nonstructural if applicable. This probably becomes the future without project condition. The commodity movements and their transportation costs are going to be based on the lock capacity and delays that would evolve given no structural improvement.

It wouldn't hurt to remind the class of definitions for the three:

1. Baseline condition – A scenario from which project impacts can be measured, i.e. a point of reference. The baseline may coincide with the without-project condition.
2. Existing condition - A description of the project setting based on present conditions; it simply describes "what is" at the time the analysis is undertaken.
3. Without-project condition – The set of future conditions most likely to prevail in the absence of the proposed project. It does not describe conditions as they exist at the time of the study, but describes the conditions that are expected to prevail over the planning horizon in the absence of a project.

4. With-project conditions - The set of future conditions the analyst believes most likely to prevail for each project implementation over the planning horizon.

These conditions may vary for each project alternative.

Slide IN3-13
This is really a prototype for all alternatives.

Slide IN3-14
You want to point out that the terminology presents a problem similar to the structural/nonstructural situation. Acknowledge that the terminology is confusing at least with respect to NED and associated costs. You also want to point out that there are different uses for costs, that is, between analysis and accounting (which includes cost sharing). The former is for plan formulation and the latter is for presentation and cost sharing. As you go through the various categories below, be sure to point out what parameters affect costs and their impact on alternatives. Aside from the warning on terminology, what is important is to bring all costs and benefits to a common point in time. This often means discounting of future values. The period of analysis is usually truncated after future values. The period of analysis is usually truncated after 20 years but there are no rules on this.

Slides IN3-15 and 16
The first step in completing the feasibility analysis is the generation of a complete cost stream associated with each alternative over the project life. Discuss each of the bullets above using the text as your guide.

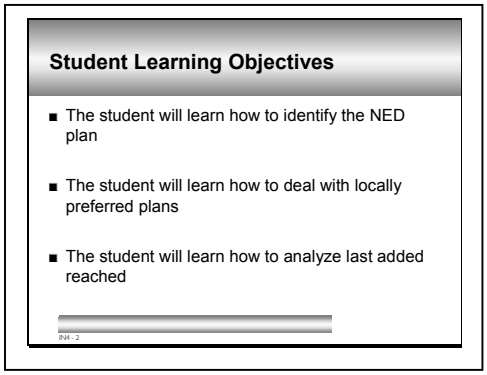
Slide IN3-17
The first thing to try to get across is what it is. The slide highlights the word "associated" on purpose. After discussing who is responsible and what it is for, then we have to see where it fits in formulation, which the next slide should help.

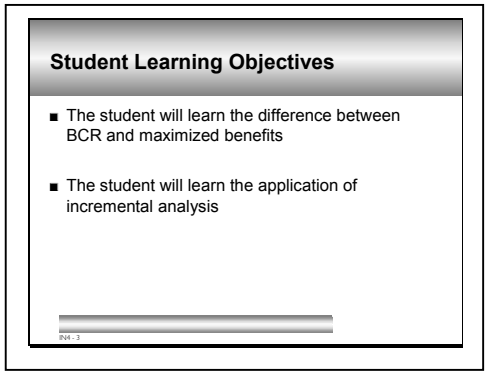
Slide IN3-18
The major problem related to associated costs (local service facilities) is the frequent assumption that certain types of associated costs are self-liquidating. These costs are typically related to project throughput, either explicitly or implicitly. The basis for this assumption is that certain costs can be provided at constant per unit average costs and are accounted for in other aspects of the benefit-cost analysis. For example, increased storage area for additional grain or coal could be provided at the same per unit cost as existing storage area. If this were the case, the associated cost of increased storage area would be reflected in the transportation costing analysis. The cost would be self-liquidating and would not need to be specifically reflected in project implementation costs.

You have to do two things. One, you have identify local service facilities or associated costs fully and account for them in some manner in the analysis. That is, they should be reflected in project implementation costs or in comparative transportation costs. There is little general guidance on the best manner to account for associated costs.

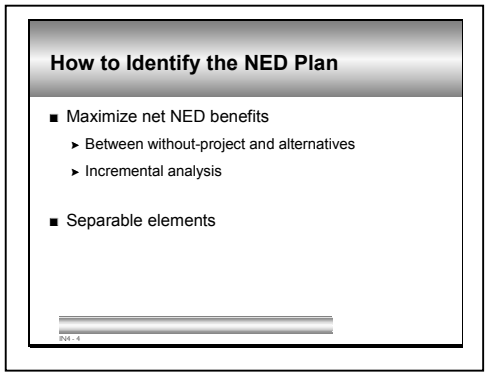
Slide IN3-19
For both theoretical and practical reasons it is necessary to interpret just what costs are NED costs, and whether all of those costs have to be counted in evaluation. For most things it is obvious, but not necessarily the accessorial charges.

Module IN4: Reformulation - Optimization, Incremental Analysis and Selection of the NED Plan





How to Identify the NED Plan



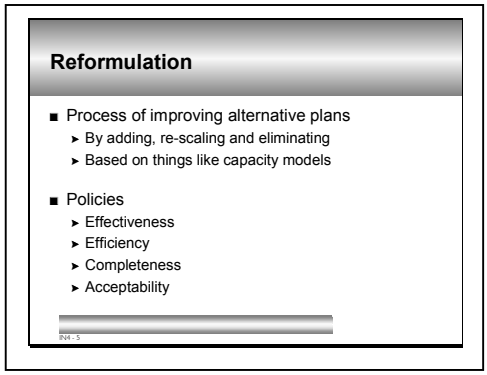
Maximizing the NED Plan

Formulating the NED plan is partially a function of the alternatives studied. As a trade off between the resources available – time and money, the planners have to be efficient and pragmatic. Helping in this regard is the fact that options in inland navigation are somewhat constrained by the system. Even so, one is not inclined to look at larger locks than those already in the system in any of the three dimensions although that may be where the future is. But back to the present. In the intracoastal waterways there may be more opportunity for pushing the system limits within busy reaches. While that is part of the formulation which we discussed earlier, it helps lead into examples we will discuss below.

One plan that you are required to develop is the NED plan. This is the plan that reasonably maximizes net NED benefits, subject to protecting the Nation's environment. It is not necessarily the plan with the highest benefit-cost ratio. As you start formulating your alternatives and comparing benefits to costs, you will keep adding increments, chamber surface area in the example in table 1, until the incremental costs just equal the incremental benefits. Of course, it should be obvious that we only add increments that have greater benefits than costs.

At this point we should have an economic analysis of a number of alternatives that have been formulated and reformulated. Included should be any applicable and justified separable elements (discussed below).

Reformulation



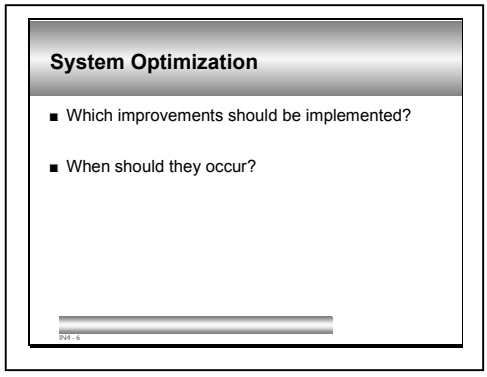
It is probably not clear where you draw the line between formulation and reformulation in terms of actual analysis, but after you have combined whatever measures and created a number of alternatives, the iterative part starts. You are going to be adding bits and pieces, re-scaling and eliminating. While you are headed in the direction of maximizing benefits you need to be measuring these alternatives and their evolution against the parameters of effectiveness, efficiency, completeness and acceptability.

Lets put these parameters in the context of navigation improvement through example. Adding tow hauling equipment to a guidewall certainly is effective for expediting the movement of tows or portions of tows into and out of a lock chamber, but does not eliminate the need to "cut" or break tows too large to fit into the chamber. Does decreasing chambering times increase efficiency if "fleeting areas" are lacking? Is it complete if, say for larger locks, that the local service facilities are not built? Is it acceptable to mitigate in an area outside of the project?

System capacity models. Without getting into the mechanics of models and evaluations, the iterative process of reformulation will hinge on system capacity models. They will show the scaling necessary to provide an efficient alternative.

Various prescribed meetings such as the feasibility scoping meeting, alternative formulation briefing and technical review will play a key part in the iterative process of reformulation.

System Optimization



In a system study optimization relates not only to features or lock sizes, but also to investment priorities within the spatial and temporal context. This approach should lead to further economic optimization resulting in deciding which improvements should be implemented in the waterway system and when should they occur?

Example of Optimization. For argument sake, lets assume that you have the latitude to increase lock width for a tributary system of a larger inland waterway system. You decide to optimize both the combination lock chamber width and length after determining the system capacity with relation to a given lock project. You do this on the basis of the most common barge and tow sizes and settle on four chamber area dimensions. These are 900 feet by 90 feet, 900 feet by 110 feet, 1200 feet by 90 feet, and 1200 feet by 110 feet. Using the data you have calculated including the most probable growth scenario, you make the following table.

Benefit-Cost Summary
Barge Lock Alternatives

(Most Probable Growth Scenario)
12 feet floor elevation

	900x90	900x110	1200x90	1200x110
Capacity (million tons)	44.8	57.0	61.3	73.5
Total annual benefits	112, 781	118,366	114,663	115,553
First Cost	485,816	503,816	523,816	544,816
Total Annual Cost	67,168	68,949	70,745	544,816
BCR	1.68	1.72	1.62	1.58
Net Benefits	45,613	49,417	43,888	42,391

IN4 - 7

Notice capacity, a measure of throughput, increases as one might expect with the increase in chamber size. And, thus, so do the benefits as seen on the next row. Just as logical, the first costs are progressive. The results of our optimization process, as shown in the table 1 above, clearly identifies the 900-foot by 110-foot depth as he plan with the maximum net benefits (the NED plan). This could be considered a misleading example because the alternative with the highest BCR is the same as the alternative with the maximum net benefits and that is not always the case.

Incremental Benefit-Cost Comparison

900x110 foot chamber @
11, 12, and 15 foot Floor Elevations

	15' to 12'	12' to 11'
Increase in Avg. Delay time (min)	5.0	43.0
Increase in Processing Time (min)	.0.8	4.1
Average Annual Benefit Decrease ($1,000)	125	1,484
First Cost Decrease ($1,000)	1,500	3,800
Avg. Annual Cost Decrease ($1,000)	144	365
Change in Net Benefits ($1,000)	19	(1,119)

IN4 - 8

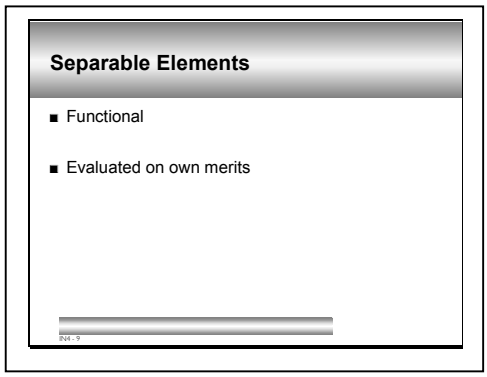
(Note: It seems that we should have some explanation of why we are doing this. (i.e. once we evaluated our original set of plans what did we learn that led us to look at these new modifications?) As part of the iterative reformulation we may have also considered the depth over the sill and the depth of the floor of the lock. Should we have looked at that simultaneously with the chamber area? Certainly we could have. However with incremental analysis, we could subsequently optimize on the chamber floor depth. For example, consider in the above analysis that the floor was initially set at a depth of 15 feet and the sill depth at 12 feet. For comparison we raised the floor elevation to match the sill at 12 feet and then raised both the floor and sill to 11 feet. See Slide IN4-8 for the results.

Through this incremental analysis we arrived at the 12-foot floor elevation.

What we did not go through in the example is the trade off analysis that would have been performed to determine whether to put the filling and emptying system in the lock wall or the lock floor. I mention that as just one of many things considered that we don't have time to cover.

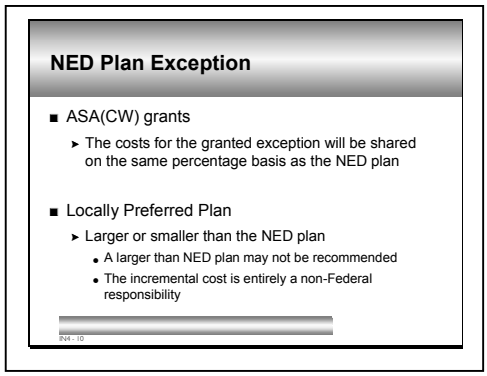
Separable Elements

A separable element is a functional general navigation feature that can be evaluated separately from the rest of the project. For that reason, its justification is based upon its own merits. You would look at the incremental cost and the incremental benefit of a separable element to determine whether it is economically justified. You won't find much about this written in navigation formulation. Here we could consider elements like guidewall extensions or tow hauling equipment, both for lock improvements.



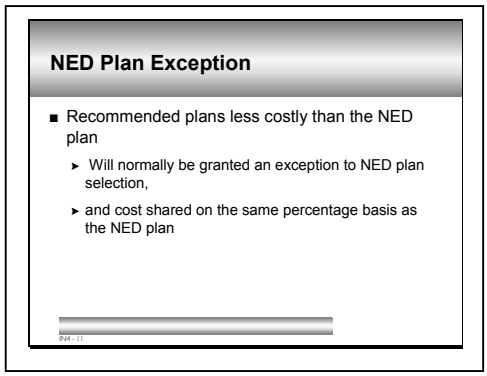
NED Plan Exception

Policy allows a recommended plan may deviate from the National Economic Development Plan if it is requested by the non-Federal sponsor and if it is approved by ASA (CW). There is little application in inland waterway projects because of the uniformity of the system. On the intracoastal waterways it is plausible that local interests would want a wider channel in busy areas, but that would probably prove to be the NED plan.



Locally preferred plan example - Industrial Canal

The only application I can think of is in the New Orleans District were the Inner Harbor Navigation Canal connects the Mississippi River with the Gulf Outlet. While this connection is for the intracoastal waterway, deep-draft vessels use both of the other waterbodies and it is logical that they would use the connection if it were larger. The Port of New Orleans agreed to pay the difference for building a larger lock and channel than what was identified as the NED inland project.



Review Questions

1. Is the plan with the highest benefit cost ratio the NED plan?
2. What is a way to analyze separable element?

Section Summary and a Look Forward

This module has looked at comparison of plans from the aspect of maximizing net benefits and the continuation of this process until the incremental benefits begin to decrease. It has also addressed the conditions for deviating from the NED plan as well as how to look at separable elements. Combined with the previous 3 modules, the planner should have a good grasp on formulating for inland navigation studies.

References and Suggestions for Further Reading

Bastian, David F., *Grant's Canal, White Mane.* 1995.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Kanawha River Navigation Study: London Lock Replacement Interim Feasibility Report. June 1997. U.S. Army Corps of Engineers, Huntington District, Huntington, W.V.

U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Superintendent of Documents, U.S. Government Printing Office.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Yoe, C. *National Economic Development Procedures Manual – National Economic Development Costs.* IWR Report 93-R-12, June 1993.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will learn how to identify the NED plan
2. Students will learn how to deal with locally preferred plans
3. Students will learn how to analyze last added reaches
4. Students will learn the difference between BCR and maximized benefits
5. Students will learn the application of incremental analysis

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Instructor Notes and Exercises:

This Module covers optimization and designation of the NED Plan. Incremental analysis and the policies separable elements will be discussed. Exceptions to the NED selection criteria will be discussed as well the impacts of locally preferred plans on the selection process.

Slide IN4-4
As the fourth and final module, we want to spend some practical time with the class by looking at comparisons. We have already reviewed what goes into the without-project condition and the various items that generally constitute improvements so now we want to direct their attention to determining what makes for reasonably maximizing NED benefits through an example from a feasibility report.

Slide IN4-5
Point out the fine line between formulation and reformulation in terms of actual analysis. For classification or lecture purposes, note that after combining whatever measures and creating a number of alternatives, the iterative part starts. At this point the planner is going to be adding bits and pieces, re-scaling and eliminating while heading in the direction of maximizing benefits. In this process these alternatives and their metamorphoses have to be measured against the parameters of effectiveness, efficiency, completeness and acceptability.

Put these parameters in the context of navigation improvement through example. Adding tow hauling equipment to a guidewall certainly is effective for expediting the movement of tows or portions of tows into and out of a lock chamber, but does not eliminate the need to "cut" or break tows too large to fit into the chamber. Does decreasing chambering times increase efficiency if "fleeting areas" are lacking? Is it complete if, say for larger locks, that the local service facilities are not built? Is it acceptable to mitigate in an area outside of the project?

Slide IN4-7
Using the table, make sure that the students understand that it is the net benefits that determine the NED plan and not the BCR. If the question arises about the seemingly strange lock width of 90 feet, note that it is an example from a real report. Assumedly the 90-foot width was to accommodate one nominal 35-foot wide barge lashed to one nominal 54-foot wide barge common on the intra-coastal waterways. The other

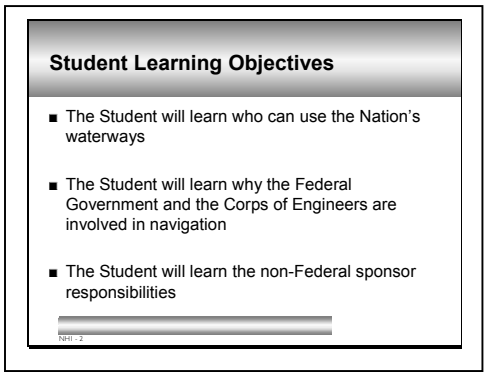
thing that you can make a point of or see if the class picks up on it, is the out-dated interest rate on this and the other tables.

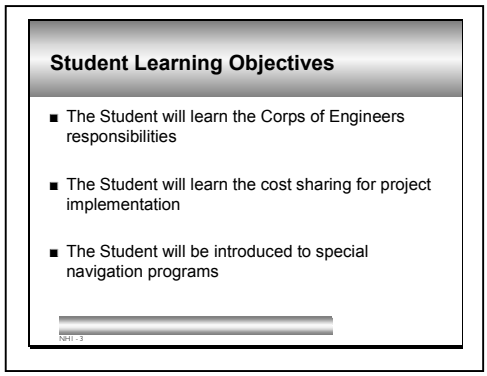
Slide IN4-8
Discuss the pros and cons of treating this as reformulation or incremental analysis. The conclusion should be that it is not so important what jersey it wears as much as that it be performed. You might conclude that the impact of items saved for incremental analysis is large enough that it should be incorporated as a variable in a previous analysis (in this case as part of the lock sizing table above). Review the results of the analysis presented in this slide and point out that this is just to serve as an example.

Slides IN4-10 and 11
This slide is self-explanatory. Use it as a lead in to the fact that there is little application in inland waterway projects because of the uniformity of the system. Note that on the intracoastal waterways it is plausible that local interests would want a wider channel in busy areas, but that would probably prove to be the NED plan.

Chapter 7 – Harbors

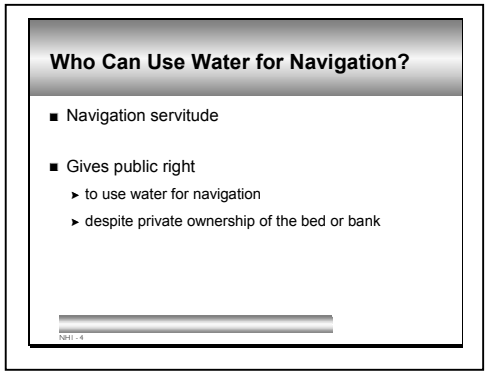
Module NH1: Authorities and Policies





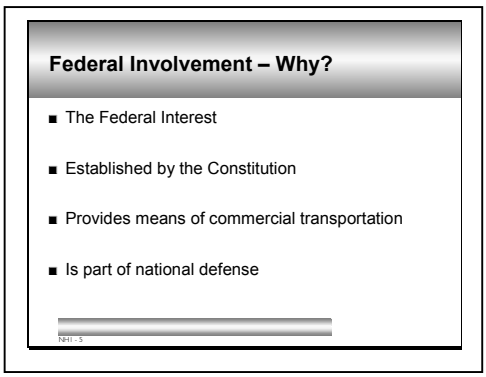
Who Can Use a Waterway for Navigation?

This is set by "navigation servitude" which originates from an ancient common law principal that there is a right of the public to use a stream or other water body for navigation despite the private ownership of the bed or bank. Hence in the exercise of Congress' power over navigation no further real estate interest is required for navigation projects in navigable waters below the ordinary high water mark. However, as a practical matter, the River and Harbor Act of 1899 authorized the Secretary of the Army to define harbor lines beyond which no obstructions could be placed without a permit.

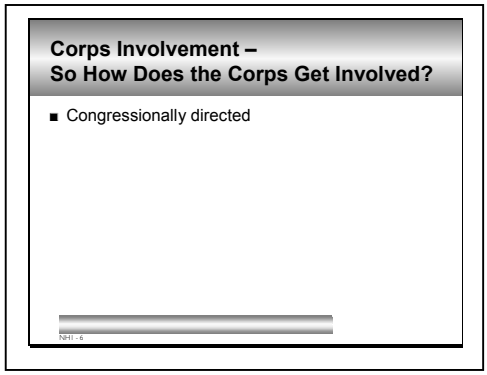


Federal Involvement – Why?

We call this the Federal interest. Federal interest in navigation is established by the Commerce Clause of the Constitution, and subsequent court decisions, defining the right to regulate navigation and improvement of the navigable waterways. The navigable waters are important to the nation as a major means of commercial transportation and as a part of national defense. The merits of Civil Works projects for improvement of navigation are currently measured against a single Federal objective--national economic development.



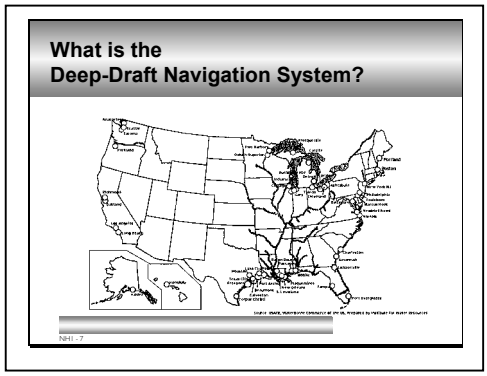
Corps of Engineers Involvement–So How Does the Corps Get Involved?



The Corps of Engineers has jurisdiction over navigable waterways and its mission is considered to have begun in 1824 when funds were appropriated to clear snags from Ohio and Mississippi Rivers. While commerce benefited, navigation works also served national defense.

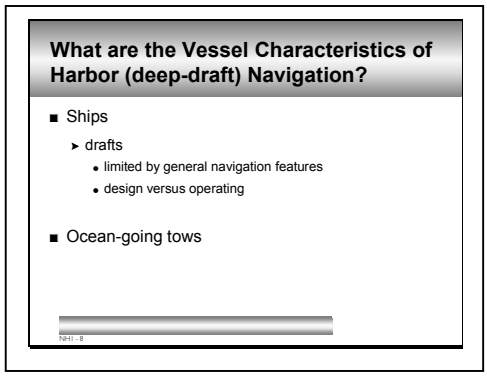
As a matter of law and policy, a distinction is made between general navigation features, and other features or facilities serving navigation. The Corps of Engineers participates financially in general navigation features and Special Navigation Programs only; all other features and facilities (e.g., piers) are non-Federal responsibilities.

What is the Deep-Draft Navigation System?



It is the system of independent channels that serve individual ports. For Corps of Engineers purposes, these channels are in excess of 14 feet deep and they are found in coastal waters, bays, major rivers and the Great Lakes. With the exception of the latter, they are generally in tidal saline waters.

What are the Vessel Characteristics of Harbor (deep-draft) Navigation?

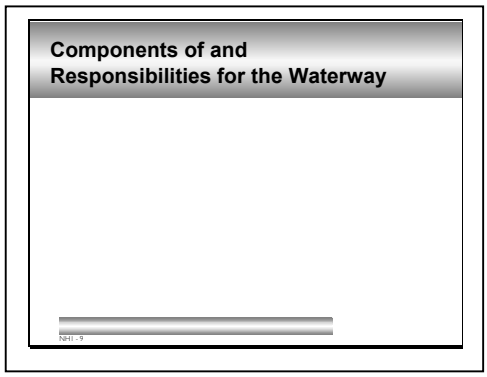


Two types of vessels comprise commercial deep-draft navigation. They are ships and ocean-going tows. The former constitute the concerns of most deep-draft harbor studies and the majority of these concern accommodating the ever-growing size of container ships.

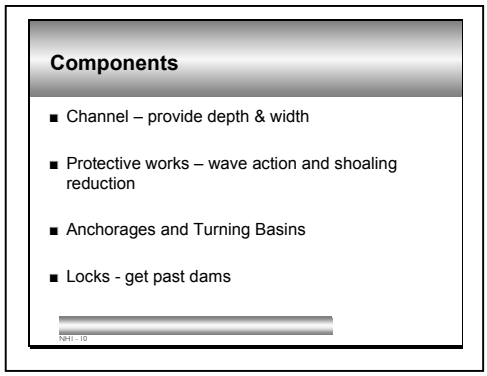
> **HINT**: All too often in Corps of Engineers studies, ship sizes are masked by using terms relating to loading capacities instead of dimensions. The deadweight tonnage (DWT) or twenty-foot equivalent units (TEU) are not good surrogates for ship size or operating drafts. Studies should use representative dimensions and operating drafts. Ships called dry bulkers or tankers are generally the largest type of ships but are severed only by a select number of ports. One of their operating characteristics is that they often experience empty backhauls which give rise to "notched" channel considerations. More universal are containerships which serve all major ports, operate on a schedule, and generally carry loaded containers. These "boxes" are filled until they

either "weigh out" (carry their maximum weight allowance) or "cube out" (fill their volume allowance before reaching their allowable weigh limit). It is the distribution of boxes on board, including "empties" that determine the amount of design draft the that these vessels actually use.

Components of and Responsibilities for the Harbor Waterway

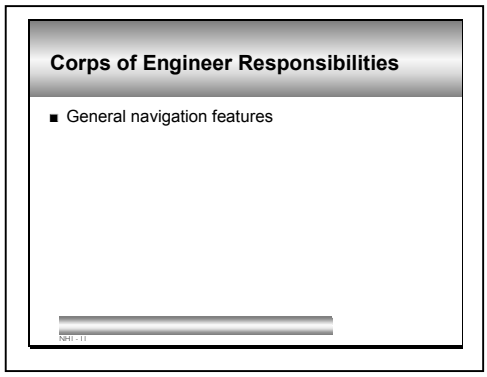


Components



There are four basic components to the system. The primary navigation element is the channel which is the "lane" that vessels operate within and whose depth, width and extent are dictated by legislation as a Federal channel. Protective works (i.e. breakwaters, jetties, etc.) attenuate wave action, usually at the offshore entrance channels where they also help to deflect littoral drift, thus reducing maintenance dredging requirements. Anchorage areas and turning basins serve waiting and turning around, respectively. In a few cases locks are necessary.

Corps of Engineer Responsibilities – Partners in General Navigation Features



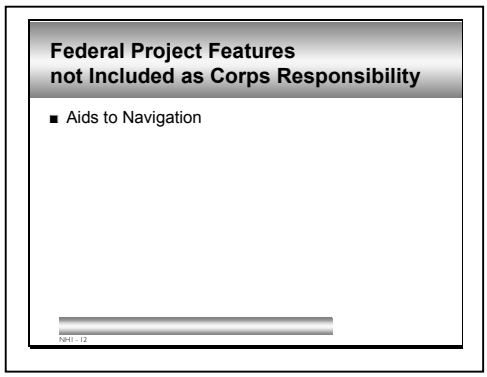
The Corps of Engineers is responsible for and the general navigation features. General navigation features is a special term. It includes channels, jetties or breakwaters; locks; basins or water areas for vessel maneuvering, turning, passing, mooring or anchoring incidental to transit of the channels. Also included are sediment basins and ice control structures. Increasingly, the biggest features excluding the channel(s) are the disposal areas. The Corps is also responsible for a number of items referred to as "control works" needed to confine channels to definite alignments, reduce or relocate shoaling, reduce wave action in

harbor areas, improve navigation conditions, prevent or reduce salinity intrusion, or prevent or reduce flooding. These include sediment basins, ice control structures, salinity barriers, revetments, etc.

In special cases bridges are general navigation features. The occasion is when they are required by new or realigned channels that cut fast land. However it is Corps policy to not recommend new navigation channels cutting fast land.

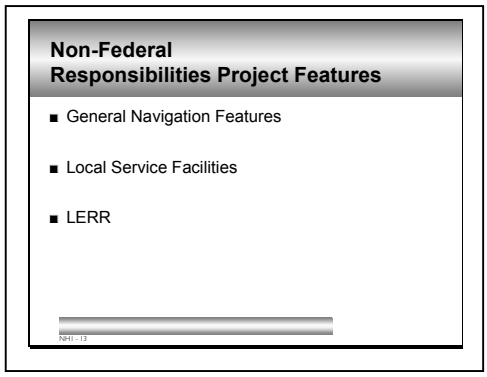
Federal Project Features not Included as Responsibility Aids to Navigation

The installation and maintenance of primary navigation aids (buoys, lights, daymarks, regulatory signs) is the responsibility of the U. S. Coast Guard which regulates all public and private aids to navigation for uniformity and conformity with the "lateral system" of buoyage as described in 33 CFR 60-79 (14 U.S.C. 89). These are not classified as general navigation features.



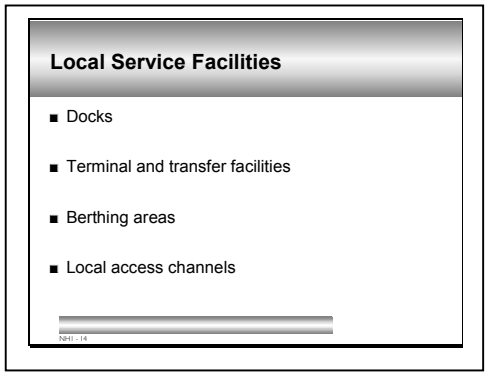
Non-Federal Responsibility Project Features

General navigation features are cost shared with the Federal Government. The non-Federal sponsor and users are responsible for construction and maintenance of all local service facilities. The sponsor is responsible for all lands easements, right-of-ways and relocations.



Local Service Facilities

Traditionally facilities such as docks, terminal and transfer facilities, berthing areas, and local access channels, are the responsibility of local interests and are called local service facilities. They are not included in the project costs but are part of the cost for economic justification.

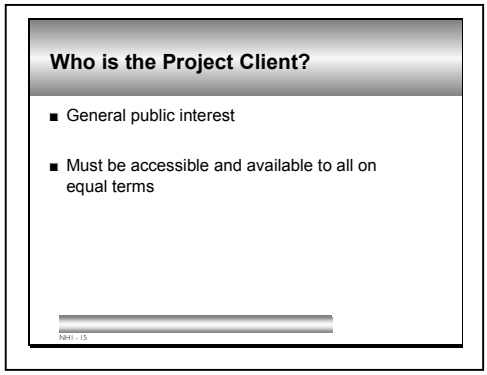


Lands, Easements, Rights-of-Way, and

Relocations (LERR)

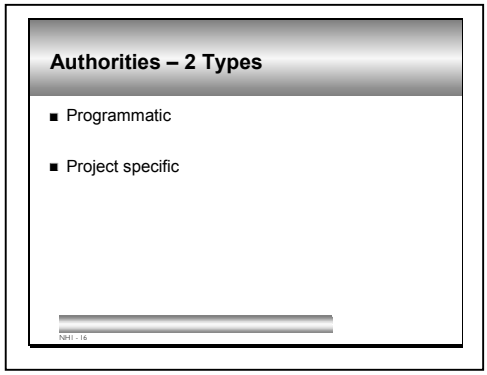
Non-Federal sponsors are required to provide all lands, easements, rights-of-way, and relocations for a navigation project or a harbor of any kind, and for waterways that are treated as harbors for cost sharing purposes. The value/cost of these is used to offset the addition 10 percent cost of general navigation features assessed to be paid after construction.

Who is the Project Client?



Federal improvements must be in the general public interest and must be accessible and available to all on equal terms. Although federally-provided general navigation facilities may serve them, improvements are not made to provide navigation access to privately-owned facilities (including commercial marinas) or access to restricted membership yacht clubs and similar establishments not open to the general public on equal terms, nor are improvements undertaken to enhance and primarily benefit land development schemes, waterway cargo transfer and lightering facilities, or to provide barge fleeting areas.

Authorities



Generally authorities are programmatic or project specific.

Programmatic Authorities

Some programs such as Section 216 of the 1970 Flood Control Act are very broad. For example, it provides for the review of completed Corps of Engineers' projects which have changed because of physical or economic reasons. In addition, but not as useful, are a small number of programs that are of limited scope and fall under the Continuing Authorities Program (CAP). These are useful because the planner doesn't have to wait for project specific study authorization that may be more confining.

CAP legislative authorities, under which the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design and construct without additional and specific congressional authorization. Applicable to navigation is **Section 107, 1960 River and Harbors Act** (PL 86-645) as amended. It allows the Corps of Engineers to study, construct and maintain navigation projects, using same procedures and policies that apply to congressionally authorized projects without specific authorization. The Federal share of initial implementation cost for any one project may not exceed $4 million (per Section 915(d), PL 99-662). Secretary of the Army's policy also stipulates that the Federal share of total costs (initial costs plus the capitalized value of future maintenance dredging costs) shall not

exceed 2.25 times the initial Federal costs, or $4.5 million, whichever is greater. As you can see, its application to major harbor studies is rather small. But it is a good tool for small harbors.

Project Specific Authorities

As the title say, some project studies are specifically authorized. A member of Congress may ask the Senate Committee on Environment and Public Works, Subcommittee on Transportation and Infrastructure, or the House of Representatives Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, for an authority for the Corps to study a problem. If the Corps has already investigated and reported on a navigation problem, the committee may adopt a study resolution to provide the necessary authority to take another look at the problem and review the earlier study. For projects that only involve locks or dams are the Major Rehabilitation and Dam Safety Assurance Programs which are covered by the authority of the original project.

Special Navigation Programs

Special navigation programs exist for specific purposes, and may be projects, elements of projects, or simply Corps of Engineers activities. They are initiated and/or implemented on Congressional authority (specific or continuing). They are usually subject to program or project expenditure limits, with cost sharing as specified in the original authority or as amended. Also note that these are not major players in plan formulation efforts.

Removal of Wrecks and Obstructions (Section 19, River & Harbor Act of 3 March 1899).

Snagging and Clearing for Navigation (Section 3, River & Harbor Act of 1945).

Drift and Debris Removal (Section 202, Water Resources Development Act of 1976).

Modification of Bridges that Obstruct Navigation (Public Law 67-647, the Bridge Alteration Act). The Bridge Alteration Act (1941), commonly called the Truman-Hobbs Act, applies only to **existing** highway and rail bridges. It provides authority to require bridge modification or replacement if a bridge causes an unreasonable obstruction to navigation.

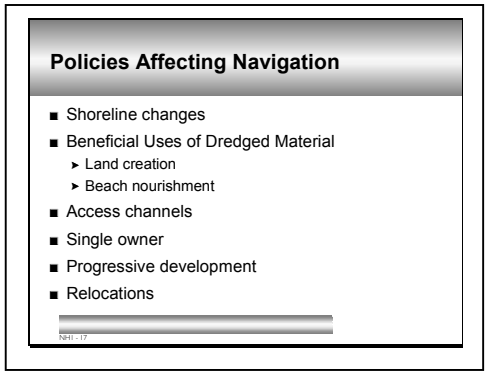
Mitigation of Shore Damage Due to Federal Navigation Projects (Section 101 (c) of the WRDA of 1986 and Section 111, River and Harbor Act of 1968). The Corps of Engineers can recommend measures for the prevention or mitigation of erosion or shoaling damages attributable to Federal navigation works. Costs are shared in the same proportion as is applicable to the project, which causes, or is projected to cause, the erosion or shoaling. The non-Federal interests shall agree to be responsible for O&M. Guidance for Section 111 projects is presented in Appendix F of ER 1105-2-100 and EP 1162-2-1. The latter (paragraph 12-24) precludes the application of this program to vessel-generated wave wash damage.

Dredging of Contaminated Materials (Section 312 0d WRDA 1990 as amended by Section 205 of WRDA 1996 and Section 224 of WRDA 1999). Under this authority contaminated material can be dredged from outside of the Federal navigation channel under certain circumstances.

Policies Affecting Navigation

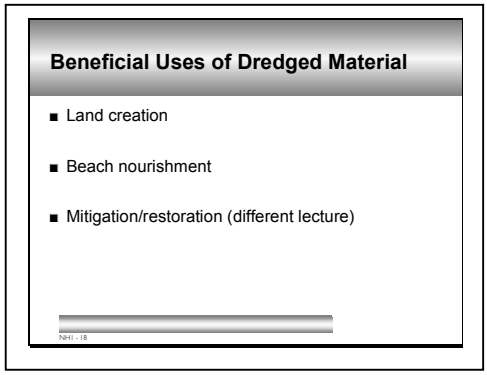
Shoreline changes

If a navigation improvement has the potential to affect the shoreline, this potential has to be analyzed. The extent of analysis is a minimum of 10 shoreline miles on either side of the channel.



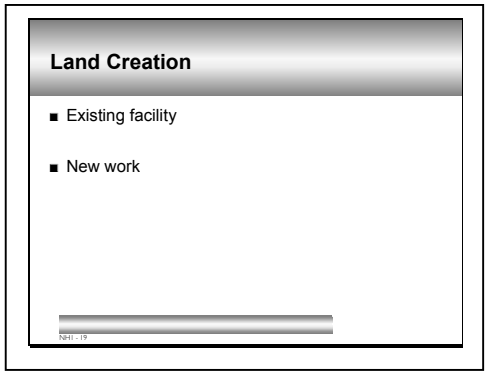
Beneficial Uses of Dredged Material

One of the biggest problems facing navigation projects is dredged material disposal. There is an emphasis to find beneficial uses of the dredged material. Despite this need and emphasis, any application which exceeds the least cost disposal plan (called the base plan) generally requires the non-Federal interest (which is not necessarily the project sponsor) to pay the difference.



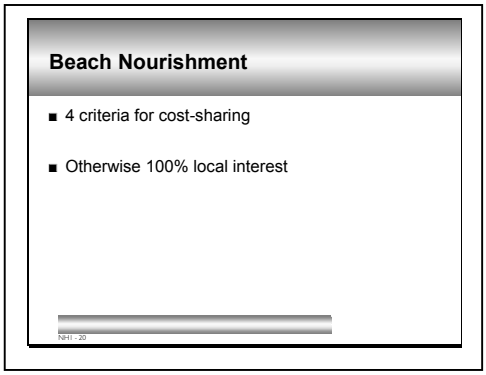
Land Creation

With the scarcity of terminal space and disposal sites, port authorities are increasingly looking to create terminal space using dredged material. There are two scenarios. The first is to create a new disposal site to create usable land. The second is to use an existing dredged material disposal site. In the first case, if it is the least cost disposal it is cost shared as a GNF and lands, easements, rights-of-way and relocations are a 100% non-Federal sponsor cost. In the second case, it is more complicated. If an existing disposal facility use is terminated for land development usage, the cost of providing similar capacity is the burden of the non-Federal partner.



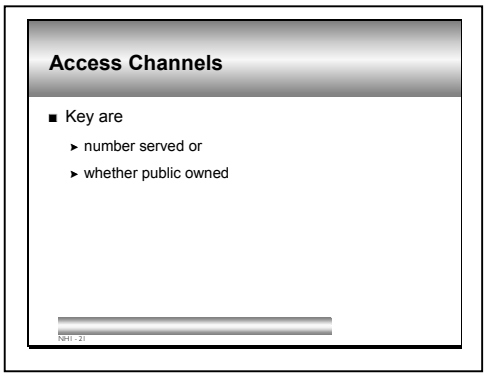
Beach Nourishment

If placement on the beach is not part of the least cost disposal, the additional costs can be cost shared if the four conditions are met: (1) the States requests and (2) the Secretary of the Army considers it in the public interest, (3) hurricane and storm damage economically justify the additional expense and (4) its placement is open to public use. In this case the non-Federal share is 35 percent. Otherwise the additional cost is 100 percent local interest.



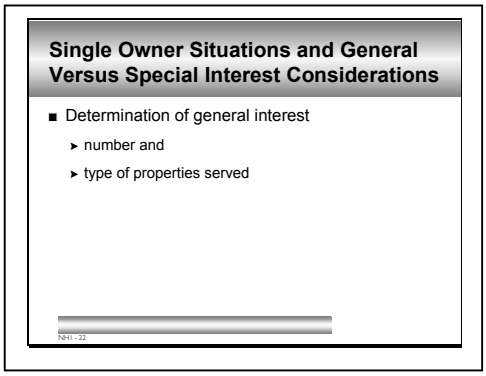
Access Channels

Subsidiary channels may be needed to connect main harbor channels or inland waterways with anchorages, mooring, or berthing areas not located adjacent to the primary channel. An access or connecting channel can be a Federal responsibility only if it provides access to two or more areas; or if access is provided to a single area it, must contain two or more facilities with separate owners, or a facility owned by a public entity.

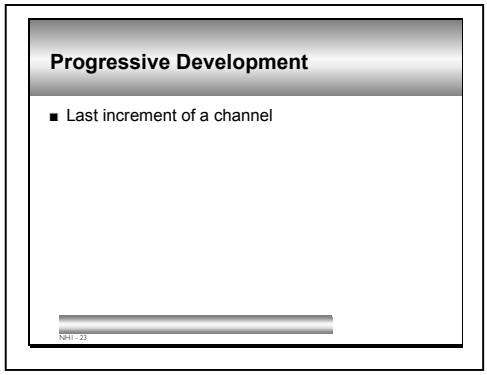


Single Owner Situations and General Versus Special Interest Considerations

Section 2 of the River and Harbor Act of 5 June 1920 provides that the Chief of Engineers shall make a determination of the general versus the special interest in an improvement, and recommend an appropriate sharing of costs between Federal and non-Federal interests. When there is a general interest the cost sharing prescribed by Public Law 99-662 will be the basis for recommendations. If there is no general interest there is no Federal financial participation. The determination of general interest requires consideration of the number and type of properties served by a proposed project.

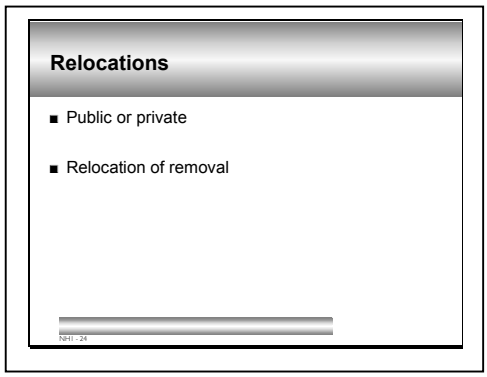


Progressive Development



Progressive development includes situations where the last small increment of a channel serves a non-public owner. The last property owner served may be "at the end" in terms of length, depth, or width, necessitating some project investment in his service alone. This is treated as a multiple-owner situation unless a disproportionate incremental investment is required, but there is no written definition.

Relocations



Relocations involve moving obstacles to widen and/or deepen the channel. Pipelines which have previously been placed in the bed below the channel (through the permitting process) are classified as private or public utilities which helps determine whether they are "removed" or "relocated." Policy Guidance Letter 44 goes into great detail in defining relocations and differentiating them from removals and even makes a distinction in handling cases involving projects with depths greater than 45 feet.

Dredged Material Management Plans

All Federally maintained navigation projects must demonstrate that there is sufficient dredged material disposal capacity for a minimum of 20 years. In the case of proposed projects, Management Plan studies are to be included in the feasibility study and include a full range of alternatives. The study costs will be allocated between the existing project and the feasibility study for the project modification. The base plan will be identified as the least cost plan.

Cost Sharing

General Application

For most project components, the responsibility and cost sharing has been determined by legislation, precedent, or practice.

Studies

Reconnaissance studies are a Federal requirement, but the feasibility phase is cost shared at 50 percent.

Cost Sharing – Studies & PED

- Reconnaissance – 0%
- Feasibility studies – 50%
- PED – 25%

NH1 - 25

Preconstruction Engineering and Design (PED)

Preconstruction engineering and design is all engineering, design, and planning accomplished after the feasibility phase and the non-Federal share is 25 percent.

Construction, Operations and Maintenance

All waterways (except waterways defined as inland waterways by PL 95-502) are treated as harbors for cost sharing purposes. Additional non-Federal cooperation may be required because of special benefits such as land enhancement from placement of dredged material, betterment in bridge changes, and special limited-interest facilities. The following table does not include all details of cost sharing. Consult ER 1105-2-100, Exhibit E-1 and Policy guidance Letters, 44 and 62.

Cost Sharing - Construction

- Local Sponsor Share of Construction, in percent

Project depth	20 feet or less	20 to 45 feet	Greater than 45 feet
General navigation feature**	10/10*	25/10*	50/10*
Mitigation	10/10*	25/10*	50/10*
Aids to navigation	0	0	0
Service facilities	100	100	100
LERR	100	100	100

* The second number, 10%, is the amount of total cost of general navigation features that the local sponsor must pay over a period not to exceed 30 years. This amount may be offset by the value of LERR.

** Further clarification: If the project only involves widening, the cost share is the same as the existing project. However, if there have not been any improvements, the widening is assessed at the **naturally** controlling depth.

NH1 - 26

Entrance Channels Cost Sharing

Increased depths provided in entrance channels for transit of vessels between protected interior channels and the wave action zone, e.g., across an outer bar, will be cost shared the same as the deepest protected interior channel. Breakwaters, jetties and channel width increases are cost shared in the same manner.

If the improvements are at project depths greater than 20 feet, any widening that is in depths less than 20 feet is still assessed at the project depth.

Cost Sharing – Operations and Maintenance

- Local Sponsor Share of Construction, in percent

Project depth	20 feet to less	20 to 45 feet	Greater than 45 feet
General navigation feature	0	0	50
Aids to navigation	0	0	0
Service facilities	100	100	100

NH1 - 27

If portions of the project involve different depth categories, the portions of the project are assessed according to the respective project depths. (see Policy Guidance Letter 62 for further details)

Cost sharing for disposal areas also includes: (1) the cost of construction of a rehandling facility for dewatering and for stabilization of dredged material, (2) excavation from the rehandling facility, (3) transportation to the landfill, and payment of a tipping fee if it is a commercial landfill.

Project Sponsor

The sponsor for general navigation features is a governmental body and in the case of harbors, is usually the local port authority.

Project Sponsor

- Non-Federal

NH1 - 28

Review Questions

1. What is Harbor Navigation?
2. Who has the responsibility for the construction and maintenance of deep-draft channels?
3. Who is responsible for relocations, lands, easements, and rights of way?
4. Name an authorization for initiating a study.
5. What is the cost sharing for harbor navigation?

Section Summary and a Look Forward

The student should have a good understanding of what constitutes harbor or deep-draft navigation projects, authorities to initiate studies and the cost sharing requirements related to studies and construction. In the next module, the student will review problems and opportunities, data requirements and the role of forecasting.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Water Resources Policies and Authorities – Digest of Water Resources Policies and Authorities, July 1999, EP 1165-2-1, CECW-AG.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Civil Works, Pocket Reference, IWR 1998.

Engineering and Design – Tidal Hydraulics, March 1991, EM 1110-2-1607, CECW-EH-D.

Selected Notes to the Instructor

Student Learning Objectives:

1. The Student will learn who can use the Nation's waterways
2. The Student will learn why the Federal Government and the Corps of Engineers are involved in navigation
3. The Student will learn the non-Federal sponsor responsibilities
4. The Student will learn the Corps of Engineers responsibilities
5. The Student will learn the cost sharing for project implementation
6. The Student will be introduced to special navigation programs

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Instructor Notes and Exercises:

This Module is a review of the Corps' authorities to implement navigation projects. This discussion will include the types of projects that may be implemented under each authority, the limitations on what may be considered under each authority, cost-sharing requirements and purpose specific policies.

Exercise. Instructor, tell the class that the NED plan calls for deepening the channel from 43 feet to 46 feet and that there are two pipelines in the way. One is a municipal water line and the other is an Exxon oil pipeline. Hand out to the class a copy of Policy Guidance Letter 44. Give them 5 minutes to review.

Their task is to provide, through classroom discussion, a determination as to whether the pipelines are relocations or removals.

The water line is a relocation and the oil line is a removal.

Slide NH1-9
Just a lead-in for the next slide.

Slide IN1-11
Point out that general navigation features is a special term. Note that the text includes most of the items mentioned in ER1105-2-100 and EP 1165-2-1 as general navigation features. But also note that they aren't exactly the same.

One could say that physical features that relate to navigation are general navigation features. This is close, but doesn't explain why channel markers are not general navigation features. Just as confusing is the fact that "control works" which help align the channel or minimize shoaling are included in the category of general navigation features.

Discuss the growing importance of dredged material disposal areas (another general navigation feature as defined by Corps of Engineer policy).

Lastly don't forget to discuss with the class the item falling under "control works"–revetments – which are used to prevent vessel wave wash bank damage especially if that would contribute to shoaling. Point out that this appears to conflict with Section 111 below.

Slide IN1-14
Non-Federal sponsors and users are responsible for facilities such as docks, terminal and transfer facilities, berthing areas, local access channels and connecting infrastructure. They are not part of the project costs but are part of the economic costs. Point out that often in Corps of Engineer literature local service facilitates are often referred to as associated costs.

Slide IN1-16
Section 216 of the 1970 Flood Control Act is great for study initiation.

Slide IN1-17
These items will be discussed on the following slides.

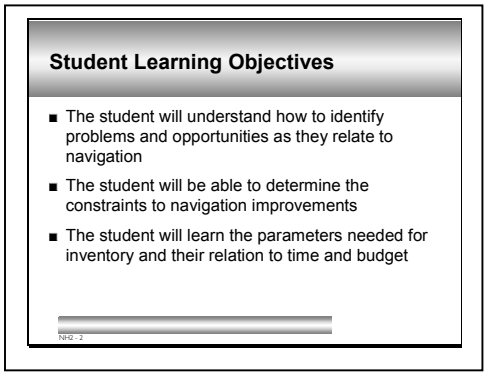
Slide IN1-22
If there is no general interest there is no Federal financial participation. The determination of general interest requires consideration of the number and type of properties served by a proposed project.

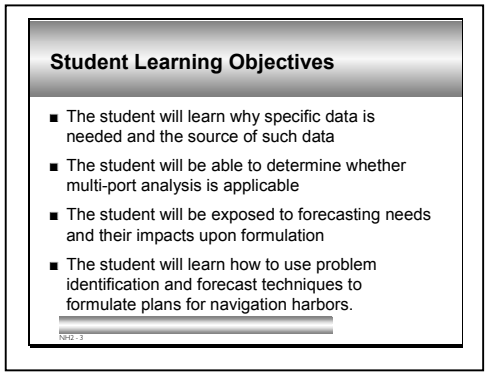
Slide IN1-24
Point out without going into great detail that "removals" is a misleading term because the reality is that usually the object (i.e. a pipeline) is relocated to a deeper depth. However, if the "relocation" is classified by real estate as a removal, it is still part of the economic cost of implementing the project.

Point out the potential complication over the fact that while most pipelines are private and therefore are removals, the term "public necessity" provokes legal challenge. In some projects, notably Texas, the number of pipelines in the navigation servitude is so great that it severely affects the benefit to cost ratio. The relationship between the sponsor and the pipeline owners has resulted in litigation. The point is that while there is policy, pending court decisions may impact the policy as well as plan formulation.

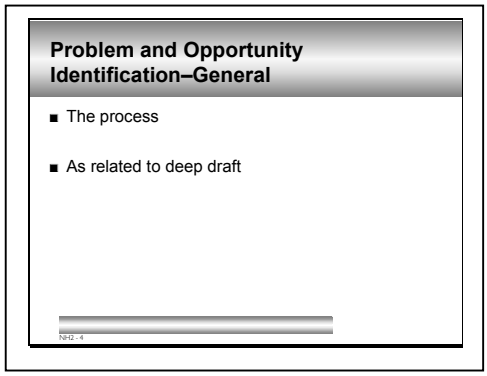
Slide IN1-26
*The second number, 10%, is the amount of total cost of general navigation features that the non-Federal sponsor must pay over a period not to exceed 30 years. This amount may be offset by the value of LERR.

Module NH2: Problem Identification/Inventory and Forecast for Formulation

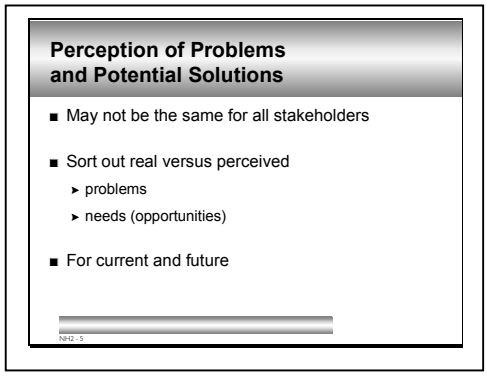




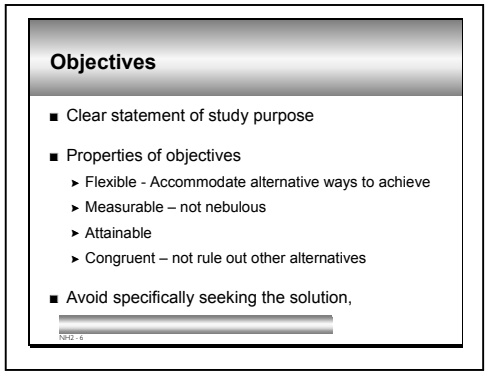
Problem and Opportunity Identification–General



In most water resource projects, the perception of problems and potential solutions may not be the same for all stakeholders. While this dilemma is minimal in deep-draft navigation, nonetheless, the problem for planners is to sort out real versus perceived problems and needs which we call opportunities. This has to be done for the current situation and has to be projected into the future. The initial identification of problems and opportunities may be modified during the subsequent planning process, especially if baseline information does not support the problems and opportunities. The initial identification process relies on extreme examples of problems (usually associated with existing port commerce) or opportunities (usually commerce the port would like to attract).

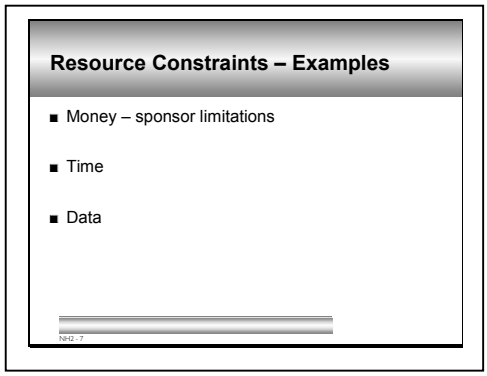


Objectives

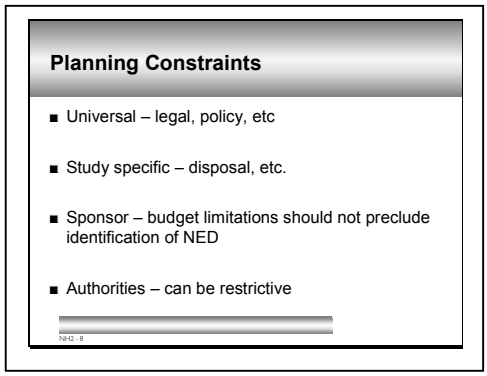


Next study objectives should be developed which articulate a clear statement of the problems and opportunities that the alternative plans are to address. It should be obvious that the objectives need to be attainable. The objective statement should be such that it can accommodate different alternatives which do not rule out other alternatives. Finally there should be measurability. What it should not do is state the solution or Federal objective. An example of what not to do is to have an objective statement such as "the project should provide a 50-foot channel." Instead it could be something like "the project should accommodate larger ships in certain interior channels (cite them) within the next five years.

Constraints



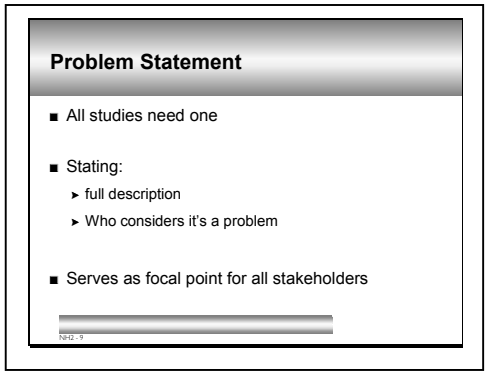
Constraints need to be identified and considered as needed. One constraint is resources such as money, time, and data. If the non-Federal sponsor is potentially unable to implement a National Economic Development Plan, that could preclude identifying the NED plan. Not to play on words, but sponsors have to dig much deeper into their pockets to fund project channel depths in excess of 45 feet and may not be able to do so (see Policy Guidance Letter, 97-10, dated 26 March 1997 for conditions that would allow not having to identify the NED plan).



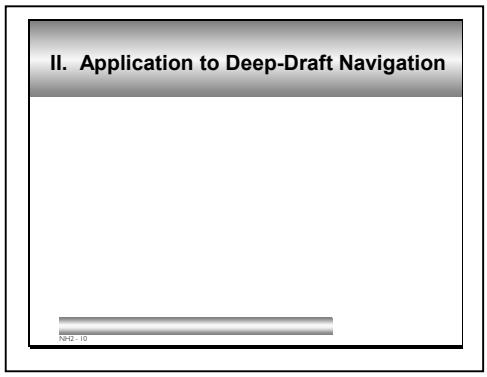
Planning constraints could include such universal things as law and policy. A good example is the constraints some states have created by denying open water disposal in estuaries. Study specific and/or authority constraints might limit the channels that can be addressed. We mentioned the sponsor's budgetary problems above.

Problem Statement

All studies need a problem statement stating such things as the nature, cause, location, dimensions, origin, time frame and importance as well as who considers it to be a problem. This serves as focal point for all stakeholders.



Application to Deep-Draft Navigation

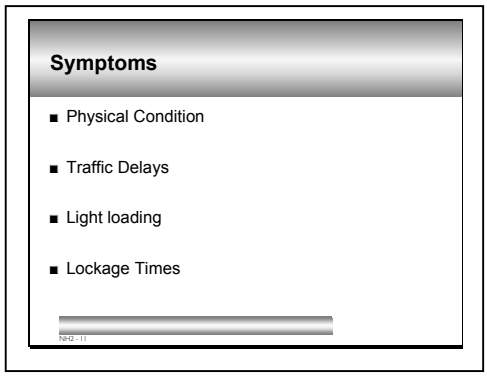


Background

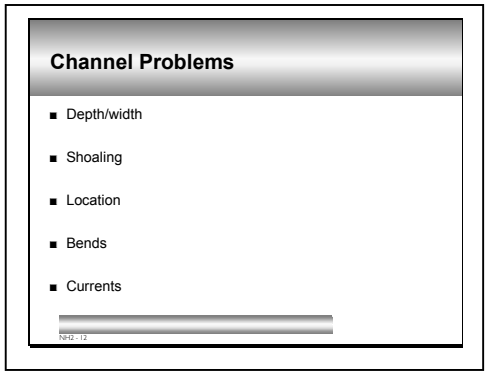
Although shipping impacts the national economic development, navigation problems and opportunities are limited when compared to flood damage reduction studies. First, navigation improvements directly impact only the shipping industry, whereas flood prevention directly impacts individuals, industry and municipalities. Thus navigation plan formulation has greatly reduced stakeholder interests, which makes for easier consensus building, but also leads to more narrow-goaled opportunities. Shipping interests are more national because of large corporations affected, which make for a more politically powerful interest. Finally, the opportunities and alternative plans afforded flood control are far wider ranging than that affecting navigation, although developing more environmentally sensitive plans for dredged material disposal and ports' needs for land creation have broaden the potential for reformulation. These are things to think about as we discuss the impact of inventory and forecasting on formulation.

Problem Symptom

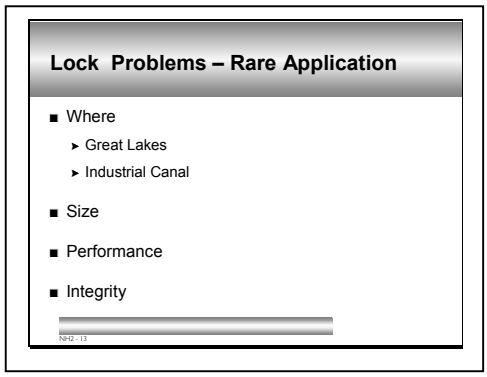
The symptoms of deep-draft navigation problems are manifested in the physical condition of the channels, disposal areas and locks; the practice of light loading or lightering; and the existence of traffic delays. In rare application to deep-draft navigation would be excessive or increasing lockage times.



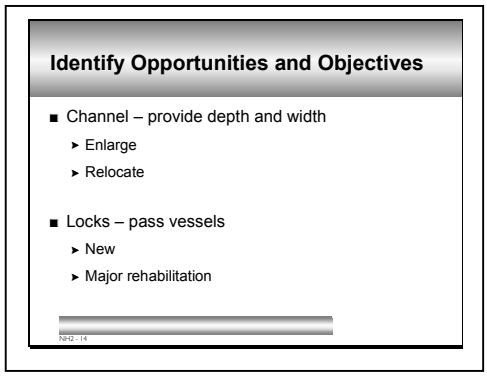
Problems



The navigation channel is the first suspect. On the surface (not to play on words) what appears to be the problem is that with increasing ship sizes, the channel is usually too shallow and narrow to accommodate two-way traffic involving the most modern ships. Less likely are problems involving channel locations because of localized bends, currents and shoaling. These problems are universal to navigation and have been dealt with for decades in pretty much the same manner in a rather prescribed formula. However, the accompanying problem is disposal of dredged material. This issue is playing an increasingly greater role in plan formulation, especially during reformulation.



Identify Opportunities and Objectives



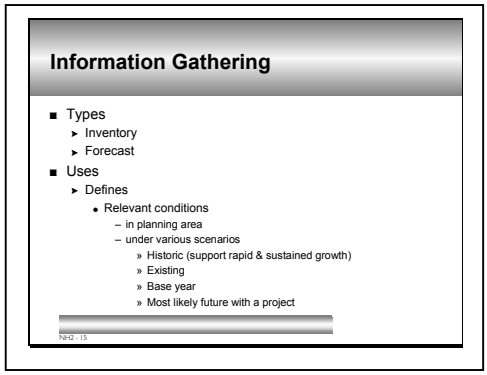
The objective of facilitating or increasing ship traffic can involve structural and nonstructural measures. Management strategies such as traffic control or physical changes such as channel enlargement or relocation, and providing anchorages or turning basins are the general improvements needed to benefit traffic. In rare occasions a lock may be involved in which case it usually needs to be replaced to accommodate modern ship sizes or rehabilitated to improve reliability and/or efficiency. Alternative plans shall not be limited to those the Corps of Engineers could implement directly under current authorities. Plans that could be implemented under the authorities of other Federal agencies, State and local entities and non-government interests should also be considered.

This leads to "if you build it, will they come?" and what we have learned is, not necessarily. Was the formulation flawed? In some cases, yes. Some of our planning has lead to long-term solutions to, what turned out to be, a short-term problem. This is one of the impacts of forecasting upon formulation.

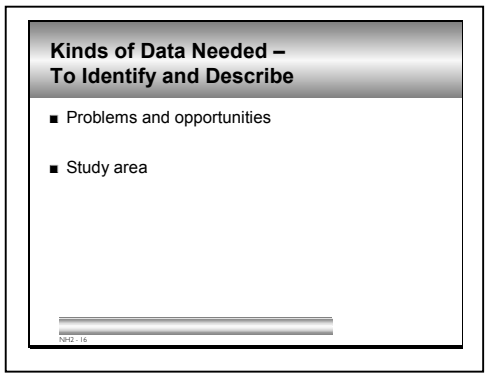
Because the Corps' prescribed analysis requires accounting for origin-destination costs we can show a positive benefit to cost ratio for ports quite distant from the ocean. Yet traffic shares at these ports often do not compete well, if at all, with their coastal competition, because the ocean shipping business is based on shipping profits.

Information Gathering

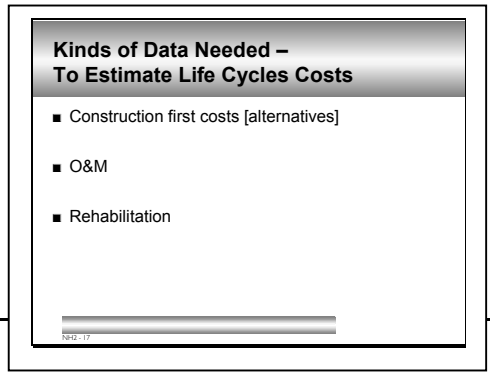
It is a big job to gather the relevant inventory and forecasting data. Fortunately offices within the Corps of Engineers are charged with keeping the bulk of this data. The data is needed for temporal and spatial definition. What does that mean? It means you need to define the relevant transportation and harbor conditions in the planning area under historic, existing, base year and most likely future with and without project conditions.



Problems and opportunities cannot be defined without knowing the study area. Since navigation is a transportation link and a harbor is a pass through facility you need the origins and destinations of commodities for the time conditions mentioned above. The implication is that the origins and destinations could change which further implies that there could be competition between ports.



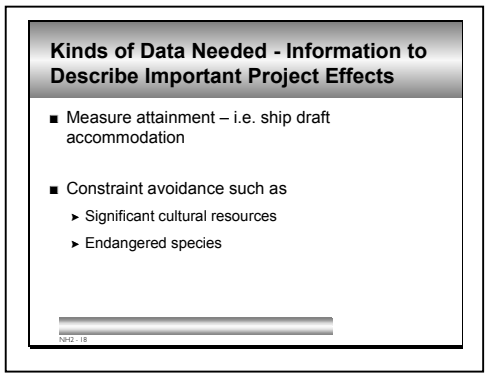
With respect to an existing Federal project, data is needed to estimate the life cycle costs to construct, maintain, and operate the alternatives as well as to estimate the existing and future operations and maintenance costs of the Federal project. The latter are generally for the associated dredging and dredged material disposal sites. Additional data may be needed to



estimate any periodic rehabilitation such as for breakwaters and jetties.

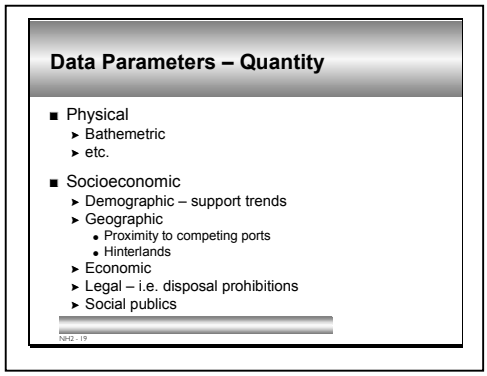
Baseline information is the foundation for NED analyses and benefit calculations. It should describe what is happening at a harbor and why.

Project Effects Data



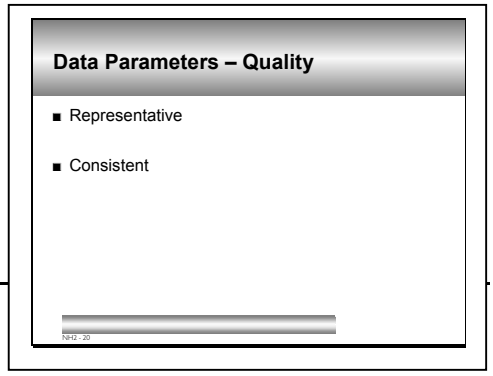
You are also going to need data to determine attainment of an alternative. Usually this would be associated with channel surveys and dredged material disposal capacity and capacity rates accounting not only with the new work but any input from other channels including non-Federal interests. You will also need data for constraint avoidance such as significant cultural resources and endangered species. This could affect location and timing of the dredging as well as the dredged material placement.

Data Parameters



The *Planning Manual* (IWR Report 96-R-21, November 1996) discusses the concepts of the four parameters of data: quantity, quality, timing and location. Things that determine the quantity of data needed are the physical and socioeconomic setting. You need to know about the body of water the channel is located, and the vessels using it, information about the berths and infrastructure. Socioeconomic data involve demographics to support trends, geographic data to determine proximity to competing ports, information on where the commodities come from and go to, etc. Legal data could involve identifying areas where disposal is prohibited or that are protected for endangered species. Determining who your social publics are is also important.

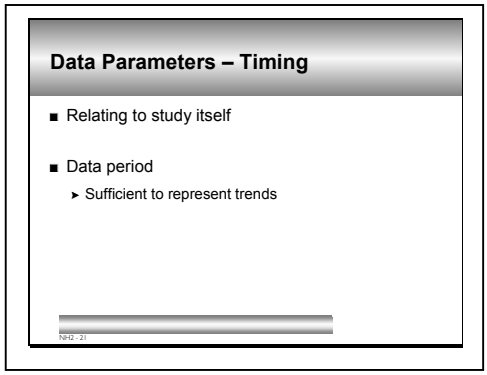
Baseline information must be adequate to document the existence of problems and to provide a basis for quantifying costs and the benefits of the project. The amount of data required will be roughly proportional to the number of different vessel sizes and commodity movements that may benefit from the project. Adequate documentation requires hard numbers. It doesn't have to be hard work.



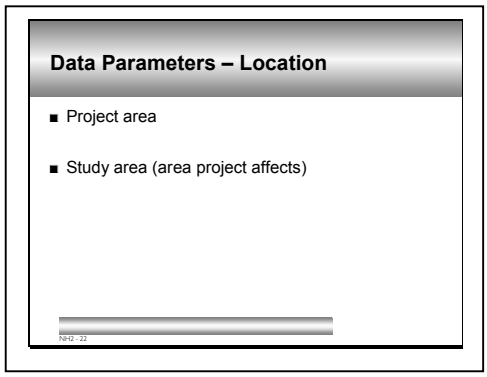
The quality of data may seem like an obvious thing, but often decision documents do not include representative data. Instead authors may selectively display design ships with distorted design drafts or claim loading patterns based on design drafts rather than operating drafts. And don't forget, because data

may come from different sources, it needs to be checked for consistency.

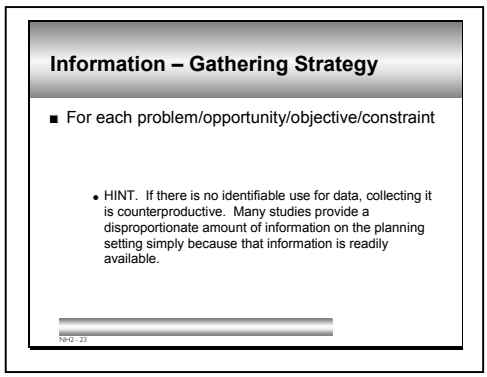
With respect to timing, the timeframe of the study may influence the data collection effort. As for the period of data representation, it should only be that needed to support a trend. This will vary with the types of data gathered. For example, hydrodynamic data may only need to represent one lunar cycle while ship loading and draft patterns may need to cover 3-5 years.



The location of data should cover the port under study and its area of commodity influence. And if it influences another port, that port's data would also be needed.



Information - Gathering Strategy (and Data Sources)



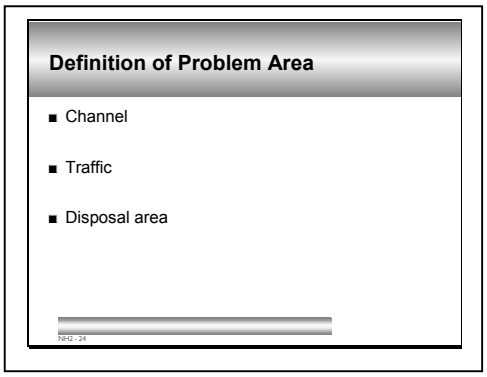
Data Focus

Data acquisition can be minimized by limiting it to the channels that have identified problems, and the vessels and cargo associated with those specific channels. If an interior channel is the identified problem, there is no need to analyze the whole harbor. If the channel serves most or all of the port's commerce, the problems are likely to affect only vessels above a certain size. Occasionally, when there is a question of whether there will be physical capacity to handle all port commerce, such as main or entrance channels, or port facilities, it will be necessary to account for all port traffic. The key to having the right information at the right time and keeping the data acquisition effort within budget, is to be selective and collect only the information relevant to the problems and opportunities identified in your study. Voluminous socio-economic statistics for the planning setting may have little value for NED analysis.

HINT. If there is no identifiable use for data, collecting it is counterproductive. Many studies provide a disproportionate amount of information on the planning setting simply because that information is readily available.

Information is needed for each problem/opportunity/objective/constraint. A typical, but not exhaustive list of items needed for deep-draft navigation is discussed below. While there is a lot of detail, I summarize it because the planner needs to have a good idea of what the various disciplines need to acquire to perform their work on time and within budget. The data collected will in some cases be used in forecasting and modeling, the results of which may lead to the need for more data in reformulation.

Definition of Problem Area



Channel

The channel is usually the major constraint to traffic. Various data are needed to define the baseline condition. Information is needed on the hydrodynamics of the waterbody that contains the Federal channel. Tide table information is readily available, but salinity and velocity data may need to be measured over a tidal cycle, lunar cycle, season or even longer depending on the nature of the environmental concerns. This coupled with the defining bathemetry is used for any numerical modeling to be able to predict changes between the without and with project conditions. Bed material data is needed for dredge cost estimates and designing of confined disposal areas. Core boring may be available from previous dredging studies.

Disposal Area

Benthic organisms need to be identified for any proposed open water disposal and this would require sampling. The existence of threatened or endangered species could impact dredged material placement operations and even considerations for channel enlargement. Published lists are available and critical habitats have been defined for a number, but not all, endangered species.

Ship Delays

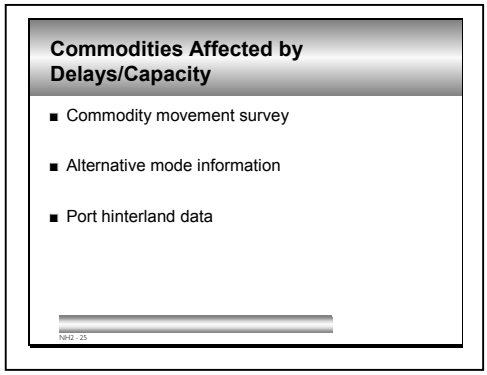
Most ship related parameters will be covered below. However, operating delays may be in pilot's log books and are essential information in quantifying the baseline condition. Many pilot's logs contain important information (often such as date and time of movement, dock facility visited, etc.) but often do not explicitly detail the nuances of when delays occur, at least due to waterway conditions. Often data in pilot's logs must be reconciled with a variety of sources which often exhibit inconsistent or incomplete data. Such sources include port authority or harbormaster records, secondary source records (Waterborne Commerce Statistics Center data - WCSC data, etc.), and tide and other climatic or physical data in addition to interviews with representatives of the maritime community to deduce the extent and nature of delays and similar constraints. Typically, for many studies no one source typically provides both the accuracy and detail often needed for detailed studies. Accordingly, the quantification of delays as they occur under actual conditions of operation can be a significant undertaking depending on the nature of vessel or waterway operations.

Lock

If a lock is involved, lock traffic information is needed on the traffic, lock performance times and ship waiting times. All of this information is collected by the Corps of Engineers and is contained in the Lock Performance Monitoring System database.

Commodity Information

Cargo information is used for an initial determination of the economic study area, and to provide the basis for commodity flow projections or forecasts. The information needed includes the size and composition of cargoes (annual tonnage by commodity or commodity categories), the origins and destinations of the cargoes (inland or hinterland, and external), and the inland transportation modes. Vessel information will help you identify the relevant traffic. Focusing on the commodities that produce benefits will save time and effort, even though the initial short list may need modification later. The desirable level of precision for both commodity analysis and transportation costs is county-level.



Actual Commerce

The purpose of most navigation projects is to lower transportation costs by better utilization of present vessels, or by use of larger and more vessels in order to take advantage of economies of scale. Predominantly, this involves existing commodity flows.

Potential Commerce

New or increased movements are usually viewed as opportunities by port interests. This is a very important point. Usually they are actual commerce at competing ports. Unlike the commodities associated with problems, which are finite in number, some potential commerce may be only in the mind of the beholder. In order to reasonably limit the baseline effort, it may be necessary to determine which prospective movements are serious candidates. The best assurance that new or larger movements actually can be realized is some evidence that the necessary port facilities will be provided. The best evidence will be the existence of port development plans and facility feasibility studies.

Commodities Affected by Delays/Capacity

Port Commerce Data

Historical statistics are readily available from the Corps' Waterborne Commerce of the U.S. A multiyear summary of all port commerce is the usual starting point, and should be displayed in the report. It will show the importance of different trades (domestic, foreign) and indicate growth trends of the commodity categories. An additional summary identifying the specific commodities associated with problems and opportunities to be addressed by the project is also needed. If specific channels are involved that are not separately authorized projects, statistics may not be published in Waterborne Commerce. The alternatives

are to obtain cargo information from terminal operators or carriers, or have the Corps Navigation Data Center extract the data from its computerized records. Use the Port and Dock Code Book to identify the relevant waterway segment or port facilities. It is desirable to have five or more years of comparative data, but that amount of information may be impractical if the data has to be obtained by interview or a search of NDC records. Some indication of growth trends should be shown, otherwise the problems(s) may be misstated.

For domestic movements that are mostly confined to Great Lakes navigation, the Maritime Administration annual publication is called Domestic Waterborne Trade of the United States. It uses Corps data to show origin-destination quantities for major commodity categories. Its level of detail may or may not be adequate for study purposes.

For overseas commerce, the best sources of data are the Bureau of Census publications TM/TA 380 and 780 (monthly and annual waterborne imports and exports, respectively).

Additional sources or alternatives to the references listed often include port control records and port authority and/or harbormaster records. Another source of foreign trade data (imports and exports) is PIERS (Port Import-Export Research Service/System) maintained by the Journal of Commerce for the ports to which the JOC extends coverage for data compilation. PIERS also often provides useful data regarding hinterland distribution, though it should be recognized related data is sometimes flawed, incomplete or not representative of actual circumstance relative to what is reported.

Determining Port Hinterlands

Port Hinterland Data

In addition to identifying the economic study area for commodity analysis and forecasting, baseline information should identify the extent to which the port's hinterland overlaps the hinterlands of other ports. That information is essential for determining the need for multiport analysis or for actually doing one if it is needed. Unfortunately, there may be no single source that identifies inland origins and destination conclusively. Theoretically, inland transportation costs should determine hinterland boundaries, but those boundaries are greatly skewed by the economics of transportation, and by the type and quality of services offered at competing ports. Potential single sources, after preliminary identification of relevant commerce as described elsewhere, are the terminal operators and steamship agents involved. They know who their customers are, and generally, who is using competing ports. However, they may be unwilling or unable to cooperate if they believe the information is sensitive, or if a lot of record retrieval is required. The alternatives or supplemental sources are vessel manifest data and inland transportation statistics.

The U.S. origins and destinations of port commerce, or "hinterlands", are commodity-specific for most liquid and dry bulk cargoes. Those commodity flows usually can be identified with reasonable accuracy and effort. The hinterlands for manufactured goods, especially containerized cargoes, are usually diverse and simplifying assumptions may be appropriate. If the project port is the only port that can or is serving these hinterlands, defining the study area is relatively easy. If that determination is conclusive, then multiport analysis is unnecessary.

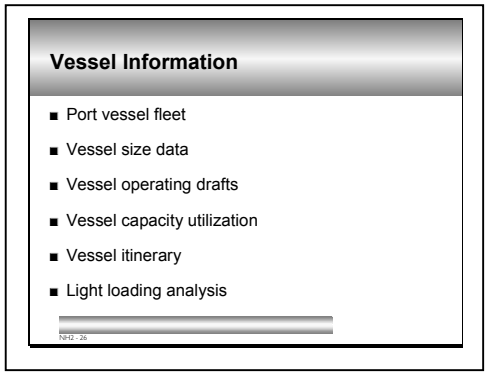
Preliminary Identification

There are two basic approaches to identifying cargo hinterlands. One is to trace overland movements to or from the port (and competing ports if appropriate). The other is to estimate overland transportation costs by the modes used and use the simplifying assumption that lowest cost determines port routing.

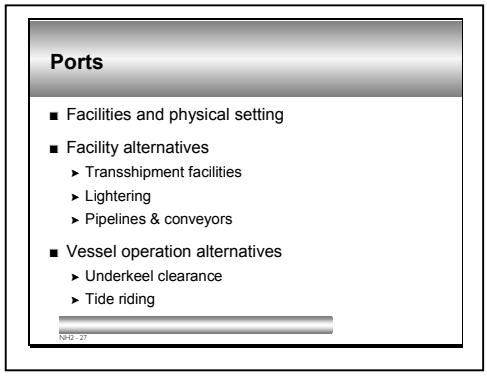
Final Identification

The desirable level of information for identifying domestic origins and destinations of relevant commodities is by country. Data on actual origins and destinations may show aberrations because many factors influence routing decisions. The basic simplifying assumption used in NED analysis is that costs determine transportation decisions. Actual overland transportation costs, or in their absence appropriate transportation cost algorithms, should be used for final identification of hinterlands. Ultimately those costs will be used for benefit calculations and multiport analysis (if needed). The combined hinterlands are the project study area. Subsequent analyses may modify the study area boundaries. The point is that final study area identification is likely to be one of the last steps in NED evaluation.

Port and Vessel Information



Vessel information is used in the analysis to determine future port fleet composition, and to identify how vessels operate at the project port. The information needed for fleet analysis includes the size distribution and capacity utilization of the present port fleet, and the limits on vessel sizes due to channel constraints at the project port and elsewhere on the vessel's itineraries. Generally the data that best identify capacity utilization and channel constraints are the actual drafts of the vessels, and their maximum loaded drafts.



Port information provides an honest look at opportunity constraints and helps define problems. It serves as a yardstick of what the local interests have done and can do.

Port Vessel Fleet Data

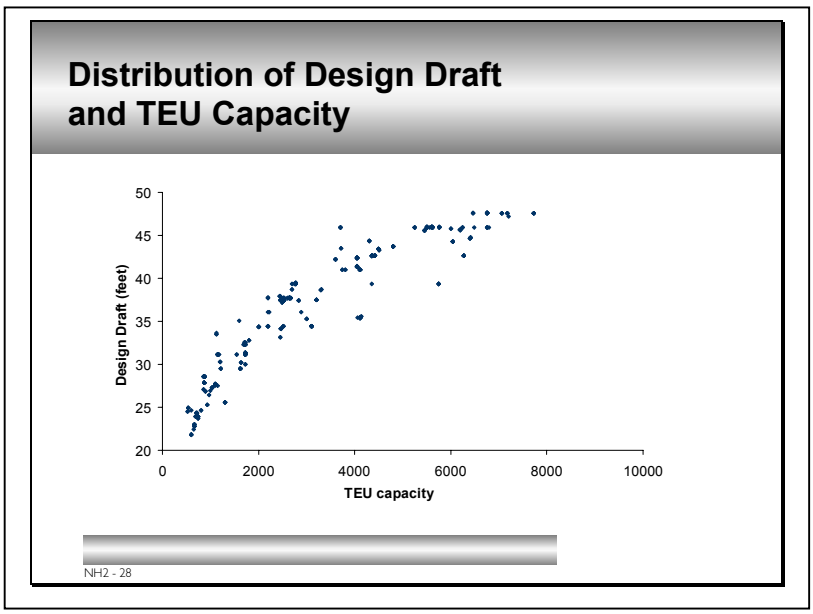
It is preferable to have a minimum of one year of record for all commercial vessel calls to identify fleet composition. Theoretically, sampling should suffice when the port under study has a large number of vessel movements. An alternative is to focus on the types and sizes of vessels that are or will be impacted by channel constraints, and obtain information on all of those vessels. However, the portion of the fleet not directly impacted in terms of waterway operating constraints is also of importance due to the share of tonnage throughput allocated to this segment of traffic relative to facility handling capacities, potential waterway congestion, and

reconciliation of fleet and cargo throughput forecasts. In addition, with computerized data (if available), sampling should only be applied when and to the extent that time and budgetary constraints mandate.

Vessel Size Data

The usual source for ship information are Lloyd's - Fairplay. IWR is a subscriber of ship characteristic data and that information is available to you through IWR. Primary sources of data also include Clarkson's Research Services. Jane's Research is also another source of vessel characteristic data, for both commercial cargo and military vessels, while the Waterborne Commerce Statistics Center (WCSC) of USACE publishes some information on vessels in domestic service or of U.S. registry.

Slide NH2-28 shows the variability containership design draft to carrying capacity. There is frequent practice in Corps feasibility reports to use the greatest design draft for a given capacity to justify channel deepening.



This is an example of the characteristics of the future "design" ship and addresses both expected operating drafts and the underkeel requirements.

Large Containership Depth Requirements

	Without Project	With Project
Vessel Class	4000 TEU	7500 TEU
Design Draft	43	48
Underkeel Clearance	4	5
Required Depth	47	53
Estimated Light Loading	3	3
Actual Required Depth	44	50

NH2 - 29

Vessel Capacity Utilization

It is possible to identify the actual amount and type of cargo on every vessel, but not only is it extremely difficult, it is seldom worth the effort. Generally the overall utilization of the vessels in a specific trade, based on total cargo tonnage versus total associated vessel deadweight, is an acceptable approximation. Similarly, for use in refining fleet forecasts, load factors for specific vessel size categories can be derived from the lightloading analysis.

For display and analysis, summarize the port fleet in categories that are one-foot increments of loaded draft. The total amount of deadweight in each category gives the fleet distribution that can be used to produce or apply fleet forecasts. The average deadweight in each category is the starting point for determining transportation costs and project benefits. The total amount of deadweight in all categories is needed in order to derive fleet capacity utilization.

Vessel Itinerary

Itineraries are needed when cost saving benefits are being claimed for traffic diversion or for use of faster ships. They form the basis for computing ship operating cost comparisons. Itineraries can be found from firms like Lloyd's. Other viable (and probably less expensive) sources for itineraries or routing information include the respective web sites of vessel operating companies, the Journal of Commerce (JOC web site version of ship cards) and other trade publications such as Containerization International, etc.

Vessel Operating Drafts

This is the most important data for a navigation study and thus, as you would expect, it is the biggest problem area. Not that the information isn't there - it is and in abundance. The problem is in correct representation. For example, ships often operate in trim. Therefore, the bow and stern drafts are recorded and the greater of the two should be used to determine underkeel practices for deciding channel depths. If there is a prevailing pattern in ship trim, ship loading factors need to be applied.

Light Loading Analysis

Light loading data is needed to verify the channel depth constriction problem and to compute benefits associated with allowing ships to more fully load or for channels to accommodate larger ships. Terminal and pilots records may contain arrival and departure drafts. For sure, this information is recorded by Customs.

Facilities and Physical Setting

Because most projects involve channel enlargement to accommodate more capacity per ship and usually larger ships as well, you have to see what constraints berthing areas may have on channel enlargement. Also, do the terminals have the throughput and storage capacity to accommodate the larger ships? Is there room for longer ships to turn around? If you deepen the channel does the berthing facility also need to be deepened? And you might shock the sponsor with this one - is there an option of moving a facility seaward instead of enlarging the channel? The Corps of Engineers Port Series is a map and statistical compilation of the port setting listing all the terminals, their handling capacity and a description of their berths including depths. If berthing depths are less than the authorized channel depths, you know there is a problem in the problem definition. That information would indicate that ships calling at that terminal do not now need the existing channel depth and thus, those that would call in the future would also be unlikely to benefit from proposed deepening.

Facility Alternatives

Are there or could there be facility alternatives to channel improvements such as transshipment facilities; lightering; or pipelines, conveyors or extremely long piers? The existence of lightering and transshipping demonstrate a need for channel improvement and their implementation is a poor substitute to channel enlargement.

Vessel Operation Alternatives

Reduced underkeel clearance is classified as a vessel operation alternative, but it really isn't. You can assume that whatever underkeel clearance they use now, they will use with a deepened channel. And that's how it should be treated in the with and without-project conditions. With and without-project margins for clearance should generally be consistent or the same unless differential conditions under with-project conditions logically allow otherwise. And example would be were a channel deepening exposed rock. The primary understanding is that the level of acceptable risk should remain approximately the same for with versus without-project conditions unless the bottom conditions or ship hydrodynamics change.

A realistic alternative is the use of tides. This is referred to as tide riding. It is only applicable to ports near enough to the sea that vessels can actually ride the tide in or out assuming there is a meaningful time range at the port. Whenever there is a predictable water depth greater than the official Corps of Engineers controlling or project depth, it is likely to be used by the deepest draft vessels. Use of tides will involve vessel delay costs, can involve shoreside terminal delay costs, and may involve additional costs related to vessel and terminal scheduling.

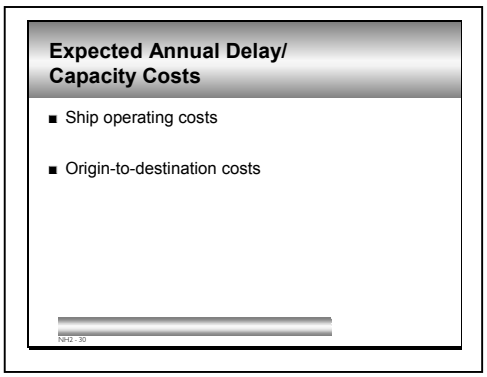
Port Institutions

An assessment of port-related institutions and their interaction may be needed to establish the most likely future with- and without-project conditions. To the extent that the institutions now have a visible or predictable impact that can limit realization of project benefits, they should be identified in NED baseline information. The major concern is land use.

Land Use. Port development usually has to compete for use of the waterfront, and it doesn't compete successfully when there is de facto economic zoning. The most efficient cargo handling is at ground level and almost any type of high-rise structure, regardless of purpose, can outbid facilities for a waterfront site. Local zoning may or may not reflect this. Coastal Zone management was intended to address it. Baseline information should identify which entities are involved in zoning, and the specific regulations or restrictions that are relevant.

Determination of Transportation Costs

Ship Operating Costs

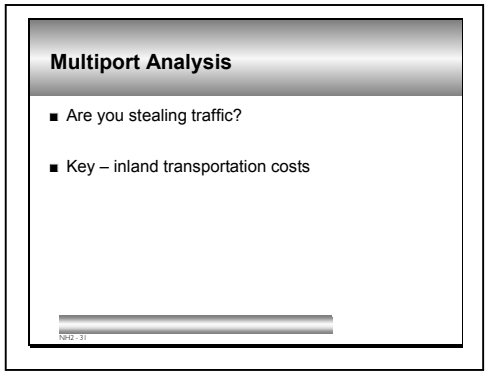


To determine the expected annual delay/capacity costs, you have to start with ship operating costs. There are three components: the replacement or financial costs, fuel, and fixed operating costs. (IWR is charged with producing vessel-operating costs).

Origin-to-Destination Costs

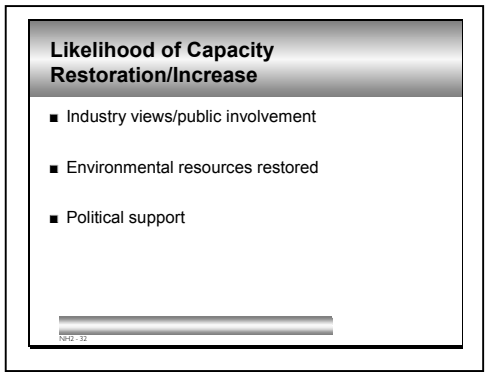
Analysis calls for the current transportation costs in NED evaluation, and those costs are to include the full origin-to-destination costs including necessary handling, transfer, storage, and other accessorial charges. For both theoretical and practical reasons it is necessary to interpret just what costs are NED costs, and whether all of those costs have to be counted in evaluation. The emphasis, of course, is on the transportation costs. Ideally, full origin-to-destination costs are required but where time and budgetary constraints limit efforts, origin-to-destination transportation costs that will be impacted or viably restructured/realigned due to waterway improvements are typically the critical components for analysis.

Inland transportation costs and the need for multi-port analysis. Rail and truck transportation costs are needed in order to complete the origin and destination costs if there are traffic shifts attributable to channel improvement. This implies a multi-port analysis. To minimize your effort, you should restrict this analysis to those movements of significant size. Regardless, this effort can be significant and it is generally specialized. For the navigation studies any combination of actual rates or cost estimates based thereon may be used.



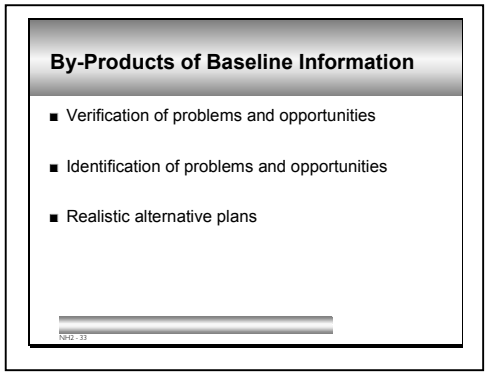
Computer models are available through IWR or you may wish to contract the analysis.

Likelihood of Capacity Restoration/Increase



Your publics are important, as in all water resources projects, in achieving the traffic restoration or increase through channel improvements. Obviously the local port authority is in favor, but what about the terminal owners/operators? Are they willing to improve the local service facilities necessary to achieve the benefits? You can assume that they are. Are there environmental impacts that need to be addressed before the project can proceed? There also needs to be political support. One more point about terminal owners/operators. Often, improvement costs to service facilities are relatively minor (such as deepening of quays) and are therefore readily embraced, but occasionally costs are significant and require extended financing and actions such as phased construction which can impact the stream of potential or realized benefits. Nonetheless, for expedience and due to limitations for time and budget such assumptions may, with reasonable judgment, be applied for reconnaissance studies. Respective to feasibility or detailed studies, interviews or investigations should always be conducted to determine both the nature or extent of improvements required, feasibility for the operator, and the costs, time, and process needed for placement and life-cycle maintenance/operation.

By-Products of Baseline Information



Once you have you baseline information, the iterative process continues. The data allows you to verify and modify, as necessary, your previously stated problems and opportunities. You now can look at realistic alternative plans.

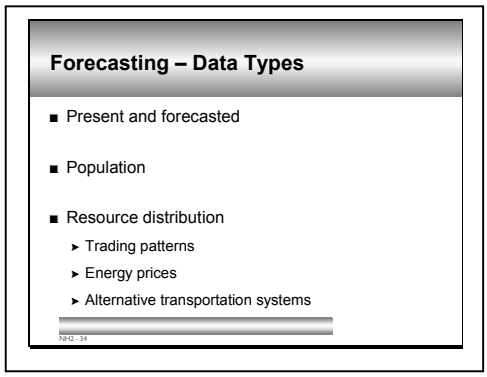
Gathering information about potential future conditions requires forecasts, which should be made for selected years over the period of analysis to indicate how changes in economic, social, environmental and other conditions are likely to impact problems and opportunities. Forecasting future conditions should be done in an iterative

manner, seeking input from Federal and non-Federal entities and other stakeholders, in order to help build consensus about future without project conditions and what outputs the proposed project will and should produce. Forecasting may be especially critical in the case of a plan recommended for the protection of a given resource, where an argument must be made that there will be a decline or degradation of the resource unless protection is provided.

Forecasts of the vessel fleet mix will also be discussed and the resulting impacts on formulation. This Module will review the computer models used in the determination of transportation costs and examples will be discussed that demonstrate experience and techniques in making use of these models on successful studies.

Forecasting

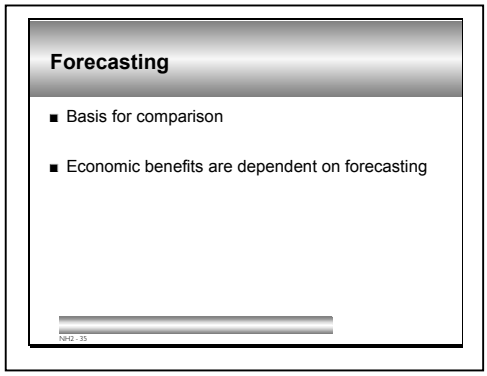
Types of Data Needed



The appropriate data is needed in order to forecast the without and with project conditions from the present through the economic life of the project (usually set at fifty years even though benefits are truncated at 20 years). For imported containerized commodities, niche products and bulks, population is a key parameter not only for the project and the port it serves but the so-called hinterlands for which the port is a gateway. This goes hand in hand with resource distribution. What are the present and future trading patterns and how are they influenced by energy prices, alternate transportation systems, rates and ship operating costs? What data feeds that analysis?

Population data is easy to deal with. It is a little harder to project the range of trading patterns but what is needed is the recent history of commodity movement including origin and destination. Ship fuel prices are readily available as are numbers representing ship operating costs, both at port and at sea, by ship type, size and flag. If commodity movements are expected to shift from other ports landside and, if applicable, inland waterway transportation data (cost or rates) are needed. And, unlucky you, this results in multi-port analysis.

Forecasting



Forecasting forms the basis for comparison. Economic benefits are dependent on forecasting. Port traffic and ship size and distribution need to be projected. This can be quite complicated and specialized and is often left to commercial firms that specialize in worldwide trading patterns. And while their models may be proprietary, the assumptions and support for their projections need to be clearly spelled out.

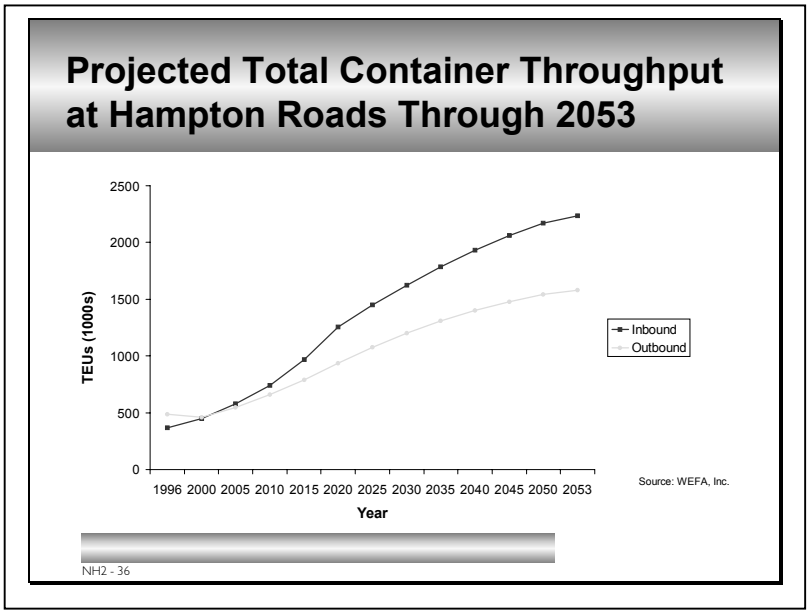
HINT. When employing outside projectionists, attribution

should be given to their product not only to let decision makers know that a reputable firm has supplied the information but to help achieve consistency in other decision documents that these firms are contracted to produce. The work and analysis should be reputable and withstand scrutiny relative to any source of information selected.

The economic feasibility of an alternative is tied directly to the forecast of future traffic. The choice of specific tools, data and assumptions about future conditions affecting demand for the port is often subjective. Forecasting is neither a science nor an art. It is a mixture of objective and subjective elements. You need to recognize the distinction between the objective and subjective components of forecasting and the sensitivity of the results to changes in the components.

We will talk about forecasting in terms of what needs to be forecast and its relationships to assumptions and project improvements. In order to further define the problem and to refine the opportunities, you need to know these elements.

This is an example of projected inbound and outbound container traffic for a channel deepening study.



Assumptions

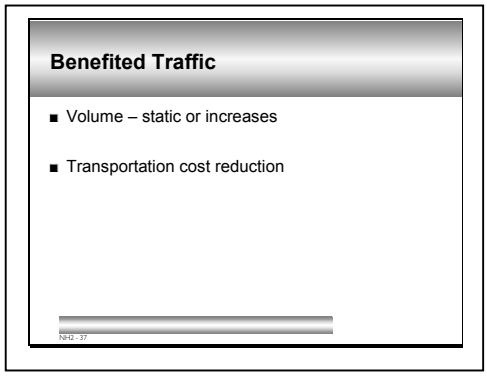
All forecasts of future demand are conditioned on assumptions about uncontrollable elements. Forecasting must be done because of the uncertainty relative to the uncontrollable determinants of demand. All forecasts are based on premises about major factors affecting demand. This requires you to make explicit or implicit assumptions about major factors affecting demand.

Failure to distinguish between different parameters and assumptions associated with different benefit categories (existing, diverted and induced traffic) can impair forecasts of traffic.

You have to avoid accepting certain assumptions without acknowledgment of the forecast to changes in the assumptions on which the forecast is based. It is better to include sensitivity analysis into the forecast process rather than conducting it as a residual at the end. This requires specification of forecast assumptions beforehand, rather than adjustments at the end.

So that you can reflect further on the reasonableness of project impacts, forecasts of volume of hinterland commodity flows should reflect not only current, diverted and induced traffic, for different commodities, but should also identify benefit category, vessel type and trade route associated with each projection.

Benefited Traffic



Projections of benefited traffic volumes comprise part of the basis of benefit estimation. The other element of benefit estimation is cost reduction. Benefits from the with-project conditions can be attributed to any change that reduces cargo costs. Traffic projection benefits should be specific to project impacts such as delay reduction, larger vessels, different vessel itineraries resulting for shorter voyages, and reduced inventory (this is a hard one).

Base year commodity flows affected by the project should be forecast by type of benefit category. The key is to assign base year commodity flows to different project impacts. Commodity projection adjustments to future base traffic result from the with-project condition, including interaction with fleet changes, capacity changes, and other competing projects. Timing for incorporation of existing, diverted and induced traffic projections should include all user-related investments or non-structural institutional changes necessary to stimulate or divert traffic. If uncertainty of timing exists, adjustments to future base traffic should be subjected to sensitivity analysis.

Slides NH2-38 and 39 are good examples of projected with and without condition forecast traffic and show a progressive change in fleet makeup.

Hampton Roads Import TEUs by Major Region and Vessel Size Group – Without Project Forecast

TEU Group	2000	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049	2053
North Europe												
0 to 999	1,020	1,255	2,463	2,992	3,597	4,145	4,626	5,049	5,413	5,721	5,975	6,175
1000 to 1999	21,952	25,257	9,851	11,967	14,390	16,580	18,504	20,194	21,651	22,883	23,899	24,698
2000 to 2999	29,018	34,022	24,629	29,917	35,974	41,449	46,261	50,485	54,129	57,208	59,747	61,745
3000 t0 3999	59,722	70,946	49,257	59,835	71,948	82,898	92,522	100,971	108,257	114,416	119,493	123,491
4000 to 4999	60,399	70,972	61,572	74,793	89,934	103,623	115,653	126,214	135,321	143,020	149,367	154,364
GT6000Mid	0	0	98,515	119,670	143,895	165,796	185,044	201,942	216,514	228,831	238,987	246,982
GT6000First	0	0	0	0	0	0	0	0	0	0	0	0
Regional Total	**172,110**	**202,452**	**246,286**	**299,174**	**359,738**	**414,491**	**462,611**	**504,854**	**541,285**	**572,078**	**597,467**	**617,454**

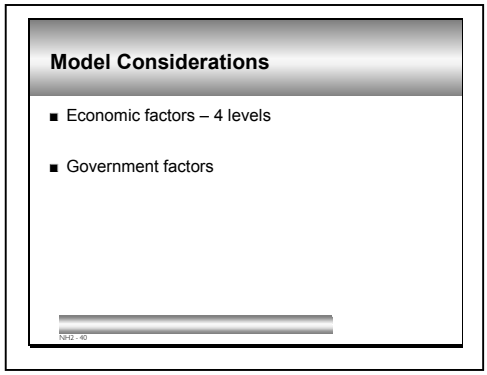
NH2 - 38

Hampton Roads Import TEUs by Major Region and Vessel Size Group – With Project Forecast

TEU Group	2000	2004	2009	2014	2019	2024	2029	2034	2039	2044	2049
North Europe											
0 to 999	1,020	1,253	2,459	2,987	3,592	4,142	4,624	5,047	5,412	5,720	5,974
1000 to 1999	21,952	25,213	9,836	11,948	14,370	16,568	18,496	20,188	21,648	22,881	23,897
2000 to 2999	29,018	33,964	24,590	29,870	35,924	41,420	46,240	50,471	54,119	57,201	59,743
3000 to 3999	59,722	70,824	49,180	59,741	71,849	82,839	92,481	100,942	108,238	114,403	119,485
4000 to 4999	60,399	70,850	61,475	74,676	89,811	103,549	115,601	126,178	135,297	143,004	149,357
GT6000Mid	0	0	49,180	59,741	71,849	82,839	92,481	100,942	108,238	114,403	119,485
GT6000First	0	0	49,180	59,741	71,849	82,839	92,481	100,942	108,238	114,403	119,485
Regional Total	**172.110**	**202.104**	**245.900**	**298.703**	**359.244**	**414.196**	**462.405**	**504.712**	**541.189**	**572.014**	**597.426**

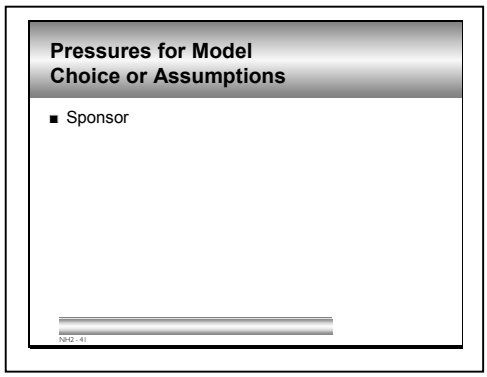
NH2 - 39

Model Requirements and Usage



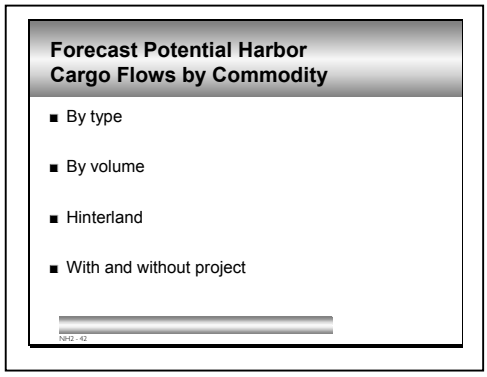
Forecasting models must consider the economic factors at the international, regional, market, and enterprise level while considering government factors pertaining to future laws, regulations, and fiscal or monetary policies that may influence activity related to the port hinterland such as tariffs and subsidies.

Where commodity flows are primarily heterogeneous, such as containerized goods, commodity projections will reflect historical time series data adjusted by macroeconomic projections for future growth of independent variables. On the other hand, homogeneous commodity flows of bulk materials will be more susceptible to user surveys to predict diverted or induced traffic to whatever growth might be expected.



There may be a lot of pressure especially due to the narrow range of interests and the fact that the sponsor is a cost-sharing partner. But you need to avoid combining different forecasting techniques so as not to bias the results from using different methodologies to obtain the most optimistic forecast. To do it right, given the time and money, projections of changes to traffic should be annualized across different forecasting methods to insure that the variables used are reasonable.

Forecast Potential Harbor Cargo Flows by Commodity



This process involves identifying both future commodity movements and hinterlands. Commodity projections begin with current and relevant historical baseline data. The objective is to identify the volume of benefited traffic. By far the easiest exercise, relatively speaking, involves a harbor that improvements would only apply to one commodity, especially if that were an import.

Without Project Conditions

This consists of existing commodity flows, diverted or induced traffic affected by lower transportation costs resulting from the project. Traffic forecasts are based upon aggregating past commodity trends ("bottom-up") or disaggregating future forecasts of commodities for multiple port or hinterlands to the specific project port or affected hinterland ("top-down"). The analyst must address growth rates conditioned on assumptions about major, uncontrollable factors affecting traffic demand. Growth rates should be commodity- and hinterland-specific and can be derived from trend analysis (bottom-up) if the past can be assumed to be representative of the future. (Note: Trend analysis in generally not an acceptable forecasting method.) Do the projections pass the "reasonable" test relative to the particular supply and demand characteristics of the hinterland?

Adjustments to the without condition forecast include diversions to other projects. Incorporating diversions into the baseline results in a series of commodity/hinterland projections. This forecast is an input to developing similar projections for the with project condition.

Again, I should point out that projecting is a specialized field and is often performed by contract. But with any such contract, the underlying assumptions and their associated risk need to be provided by the modeler. The need for "precision" in projections is dependent upon many considerations, the margins between costs and benefits and so forth. Often generalized regional forecasts which are readily available (commercially) can be combined with other available information about historical movements and site or facility-specific interviews regarding facility markets and capabilities and intentions for future conduct of business. Often reasonable forecasts can be assembled for most studies by USACE staff applying related prudent measures and practices. For large, costly, or controversial studies, or studies where justification or formulation are sensitive to, or significantly impacted by, relatively minor variations in projected throughput or service, it may be of critical importance to seek alternative commercial sources for forecasts and information in regard to prediction of factors or influences which impact project analysis. It should also be understood that the label of "expert" is subject to interpretation and circumstance. Often the most qualified experts for site-specific studies are not general consulting firms but industry-specific planners and program\engineering managers or more typically, the vessel and terminal operators themselves.

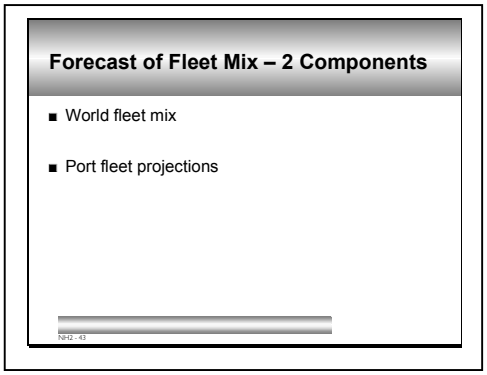
An alternative is IWR has recently received it's first long-term commodity forecast for U.S. waterborne trade from Standard and Poor's DRI for general use by the Corps. The forecast is an extension of DRI's World Sea Trade Service that IWR receives quarterly. The long-term extension has been added to the basic subscription, and will be received annually.

The forecast includes historic and forecasted imports and exports by metric tons for three types of service (liner, tanker and tramp). TEUs are also included. The data are disaggregated into six U.S. coastal regions, 19 partner regions, and 40 commodities, and include the years 1980 through 2050.

With Project Conditions

The with-project projections begin with examining how without-project projections would be affected by lower transportation costs. If you assume that there are no hinterland changes as a result of the project, diverted and induced traffic are unimportant. Multiport analysis is still required, however, to ascertain whether the existing project will affect competitive hinterlands.

Forecast of Fleet Mix



After you have predicted what will move through the port in the future, you have to predict how these commodities will move through. In other words, what subset of the world fleet will service these commodities? The extent to which the port fleet composition will change because of the project, will depend on the availability of larger and/or more efficient vessels and the ability of harbor users to employ them. Rudimentary fleet forecasts can be derived from basic extrapolation of existing fleet service patterns and information. With regard to commercial fleet forecasts, world-level forecasts (often benchmarked to deadweight capacity) of fleet structure(s) are available which must be disaggregated to the project level. This is perhaps one of the most difficult efforts for project analysis and forecasting to perform. Nonetheless, an acceptable or rudimentary forecast can be assembled with diligent efforts to gather data and perform interviews with vessel and facility operators, but as with commodity projections, for large, costly, and/or controversial projects, or projects where justification and/or formulation is sensitive to relatively minor changes in projected fleet activity or throughput, it may be advisable to seek support from industry forecast specialists.

World Fleet Forecasts

Fleet forecasts by industry experts are the best way to go. However, whoever does the work will have to disaggregate the world fleet to the project level. This will answer the important question, will there be enough benefit-producing vessels and where would these vessels most likely be employed.

A starting point, although dated, is the Corps of Engineers produced Fleet Forecasts for the United States to 2020 prepared by DRI and Temple, Barker and Sloane in 1990.

Port Fleet Projections

Historically most study specific forecasts have been port fleet projections that relied heavily on trend analysis to identify world trends and used expert opinions to arrive at the with- and without- project port fleets. The fallacy to this approach is that it may not account adequately for the distribution of benefit-generating vessels among competing ports.

Most fleet forecasts also use a limited number of vessel size ranges to simplify the analysis. A distribution of vessel sizes within each range will be needed to determine change in the overall fleet composition in the future time periods.

One Size Does Not Fit All

As a cautionary note, the actual distribution of vessel sizes at a port is unlikely to resemble the distribution of vessel sizes in the world fleet. The actual range will be limited on the upper end by channel size, and on the lower end by the higher cost of transportation in smaller vessel sizes. Within the actual range, the distribution of sizes will reflect a combination of factors more-or-less unique to each port. The actual size range for a port can be determined from statistics. The upper end can be estimated with reasonable accuracy based on channel depths, including the use of tides, and maximum light loading. The port's upper and lower size limits can be used to produce a size distribution useful for certain

purposes. You have to be alert to avoid double counting the most efficient ships at competing ports. To minimize this potential you can apply a proportional share of the world's fleet.

HINT: All to often in port studies the planner has used the largest size container ship in a given class. Some container ship companies design their ships with greater design drafts than others of the same carrying capacity.

Fleet Projecting Methods

The underlying presumption is that ship sizes will increase over time due to economies of scale. With that positive thought in mind, let's talk about ways to produce a fleet forecast.

Demand-supply analysis. Capital investments are generally made in anticipation of profit opportunities, hence shipbuilding for the world fleet has been subject to wild fluctuations. It is essential to match the trade forecasts with the appropriate universe of vessels. Most analyses assume vessels will be retired at the end of their economic life.

Trend Analysis. Fleet trend analysis uses the net result of actual additions and retirements, but requires judgment as to how long trends will continue and is only appropriate when there is a large enough population of vessels.

Consensus of Experts. The opinions of experts will be most useful for port fleet forecasts where a limited number of vessels are involved.

Disaggregating fleet forecasts. The difficulty of producing a valid forecast or projection is the reason why it is best to use a forecast prepared by experts. Available forecasts have to be related to the actual fleet at the project port. There are three basic ways to do that.

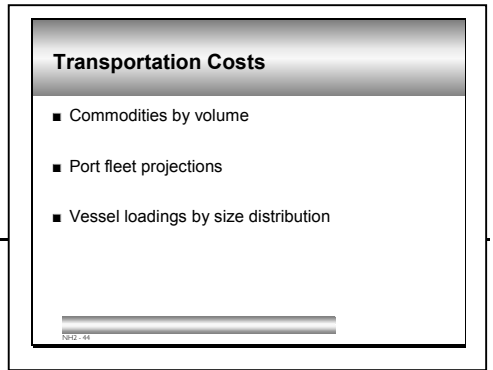
Integrated port fleets. This is an arithmetic exercise that merges the actual baseline fleet at the project port into the forecast fleets over time and is most appropriate for liner vessels that routinely call at a range of ports regardless or port channel depths.

Historical Share Port Fleets. It overlays the historical distribution of vessel sizes on the forecast fleets.

Optimized Share Port Fleets. It is a variation of historical share using calculated cost of transportation in various vessel sizes, and distributes port traffic among those sizes in proportion to relative efficiency up to the amount of available ships in those sizes.

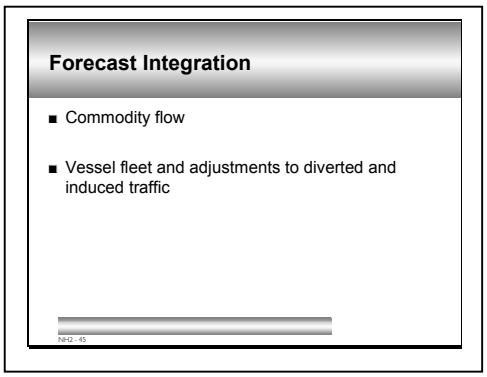
Port Fleet Projections. So what do they do on most studies when world fleet projections are relatively dated? Most Corps of Engineers studies have used the actual port fleet composition and projected change over time, or change because of the project, using some elements of the various forecasting methods. Projections that involved large numbers of vessels usually relied on the assumption that all replacements would be incrementally bigger. Projections for small fleets have relied heavily on specific vessel replacements, with- and without- project, identified by people at the port. What does this tell you? It tells me that you have a lot of latitude, and you will do all right as long as you thoroughly document what you have done and how, because this will drive the study.

Transportation Costs



Knowing the commodities by volume and the port fleet projections, you can identify the with- and without- project water transportation costs when you account for vessel loadings by size distribution. That coupled with landside transportation costs will allow you to compare effectiveness of alternatives.

Forecast Integration

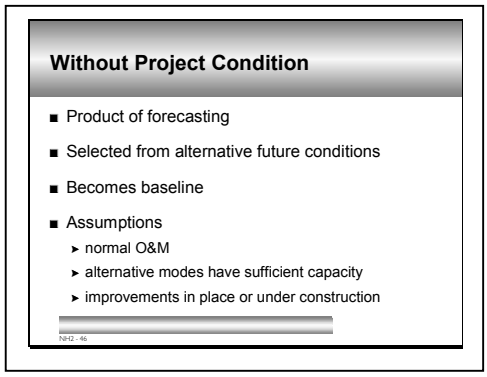


A primary characteristic of forecast integration and refinement is that the approach is often iterative, often similar to a "design spiral", to reasonably reconcile a given forecast with other input or forecasts and analytical parameters.

The technical forecasts of commodity flow, vessel fleet, and adjustments to diverted and induced traffic are usually done independently of each other. You will have to integrate the separate elements, based on similar time frames and forecast intervals. This can be especially subjective where the commodity projections are not linked to benefit categories affected by fleet forecasts. However, this is often the case due to study resource constraints. But do the best you can with the time and money available.

Benefit estimation assumes that the planner has explicitly linked the commodity projections to forecasts of benefit categories resulting from fleet projections, capacity projections and multiport analysis. Where multiple categories of benefits apply to broad groups of commodities, trade routes and vessels, the integration of the different forecasts will determine the relative feasibility of different alternatives.

Without Project Condition



The without project condition is a product of forecasting. It is selected from alternative future conditions and becomes the baseline. The assumptions are that it will include user charges and/or taxes if applicable, that normal O&M will be performed, that the alternative modes have sufficient capacity, and that only waterway investments currently (1) in place, (2) under construction, or (3) endeavors pending placement/construction or reasonably foreseeable within the planning horizon are in place over the period of analysis.

Review Questions

1. A port with a 35-foot channel anticipates no growth in commodity movements, but most ships now draw 49 feet of water. Name problems and opportunities.

2. The State of Maryland does not allow open water disposal in the Chesapeake Bay. Is that a constraint?

3. What is the hinterland for a crude oil port?

4. Name ship characteristic data needed in order to do economic analysis.

Section Summary and a Look Forward

This section has addressed the initial stages of plan formulation by discussing identification of problems and opportunities and using these to create objectives while being mindful of constraints. To that end, it has looked at the data needed, where to find it and discussed how it impacts the planning process.

This section has also discussed the role of forecasting, some on the basic techniques involved and their limitations. Finally the role of forecasting and the integration of commodity and fleet forecasts has been reviewed as it relates to defining the with and without project conditions. In the next section, we will discuss formulation.

References and Suggestions for Further Reading

Policy Guidance Letter, 97-10, dated 26 March 1997.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

National Economic Development Procedures Manual, Deep Draft Navigation. IWR, November 1991.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Selected Notes to the Instructor

Student Learning Objectives:

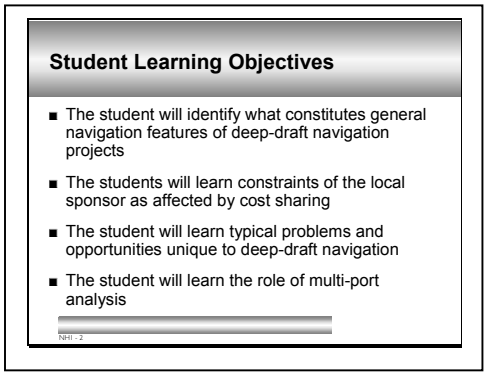
1. The student will understand how to identify problems and opportunities as they relate to navigation
2. The student will be able to determine the constraints to navigation improvements
3. The student will learn the parameters needed for inventory and their relation to time and budget
4. The student will learn why specific data is needed and the source of such data
5. The student will be able to determine whether multi-port analysis is applicable
6. The student will be exposed to forecasting needs and their impacts upon formulation
7. The student will learn how to use problem identification and forecast techniques to formulate plans for navigation harbors.

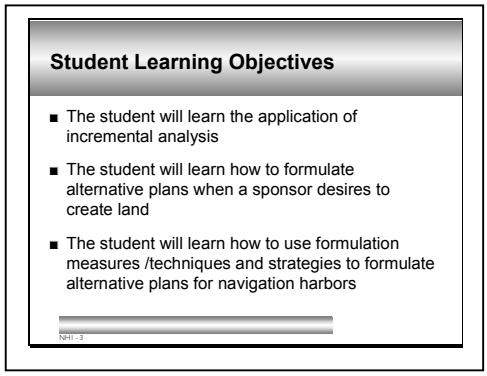
Instructor Notes and Exercises:

This Module will emphasize the first two steps of the planning process, problem identification and inventory and forecast. Major emphasis will be placed on the interaction of economics and technological advances as engines of change. This Module will cover the general economics of the navigation systems including the role of population and resource distribution, trading patterns, and alternative transportation systems, as they may relate to formulation. Multi-port analysis will also be discussed. Forecasts of the vessel fleet mix will also be discussed and the resulting impacts on formulation. This Module will review the computer models used in the determination of transportation costs and examples will be discussed that demonstrate experience and techniques in making use of these models on successful studies.

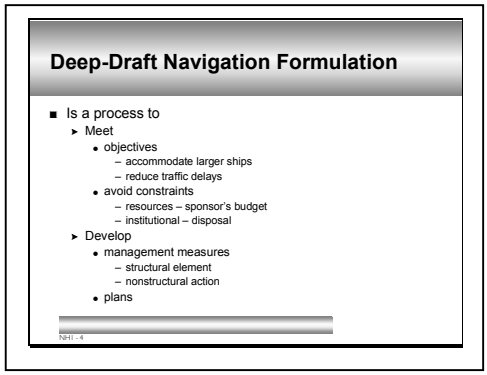
Slide NH2-31
You need to point out the difficulties and intricacies of multi-port analysis as such efforts are likely to become a more frequent requirement for deep-draft studies. Further, for deep-draft studies the application of rates versus costs for certain aspects of transportation has cautiously been applied generally only costs where not available, or where the rate in effect becomes a cost in the successive handling or chain of transport.

Module NH3: Formulation – Measures and Strategies





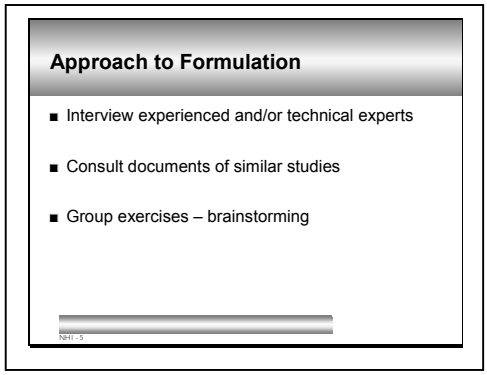
Navigation Harbor Formulation



By now you have collected a large database that has been generated describing possible future economic conditions within which the project could be implemented. This information has only limited reference to specific project alternatives, project implementation or economic evaluation. Deep-draft formulation is a process to meet objectives and usually revolve around accommodating larger ships in addition to reducing ship movement delays while avoiding constraints in order to develop management measures and plans. A note of caution is that many studies have also tended to focus on benefits attributable to larger vessels without the same or comparable analytical scrutiny devoted to benefit evaluation smaller or lesser classes of vessels that would benefit from improvements because it is believed such vessels do or should not drive formulation. Additionally, the focus of accommodation for larger or the largest of vessels is often emphasized because such considerations are the greatest concern of non-Federal sponsors. Depending on fleet service structure or frequency, this can impose skewing of the benefit structure to favor a threshold of plan formulation of greater or lesser specification(s) and costs than would otherwise be determined with a more thorough analysis. It should be emphasized that USACE study objectives for proper plan formulation include a comprehensive approach to determine (equitably and to the maximum extent possible subject to time and budgetary constraints), all applicable transportation cost efficiencies or benefits for waterway use and service associated with proposed waterway improvements.

Before addressing the development of management measures and plans one must know what some of the potential management measures are for harbor improvements.

Approach to Formulation



There are three good ways to approach addressing harbor improvements.

Brainstorming. Brainstorm both within the office and with interested parties.

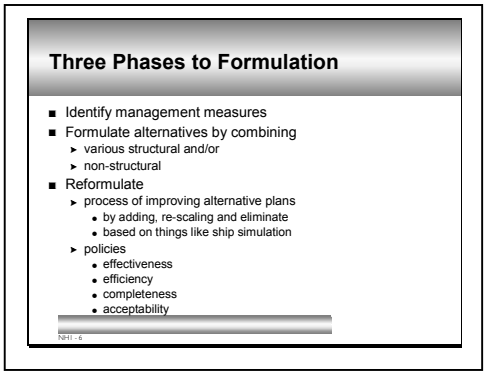
District Disciplines. Your district has been dealing with its Federal channels probably for the life of the district. Even if your district has not performed a harbor improvement study recently, you still have a wealth of talent and knowledge within the district to lean on. The operations people have been maintaining the channels and handling disposal so they are aware of potential problems and certainly must have ideas for opportunities. To a lesser degree, your hydraulics and hydrology staffs are acquainted with the waterbodies including those containing the Federal channels. Your real estate colleagues will know about access to disposal sites and pipeline relocations. And the list goes on.

Outside the Corps. Shippers, pilots, and port personnel are also good information sources. Resource agencies and environmental groups can provide information on sensitive habitats and critical environmental issues and concerns that might be encountered as formulation proceeds. Then there are other government groups that have to be consulted as part of the NEPA process. These groups will see environmental opportunities to augment beaches, mitigate habitat losses, create wetlands, protect cultural resources, etc. Municipalities may try to build on synergies such as by combining with other programs like Brownfields.

Don't Reinvent the Wheel. Harbor improvement studies are relatively universal. Their goal is to find ways to make traffic more efficient in a harbor. There really aren't many options. That doesn't mean it is necessarily easy to come up with a full array of management measures and plans. Therefore another good approach is to look at documents of similar studies. The key to this is to know what to look for, if information has no use it should not be displayed. Therefore look at the stated problems and opportunities and look at the various measures and plans. If you don't know what study(s) to look at, contact your division and the policy review folks in headquarters. The latter have reviewed them all!

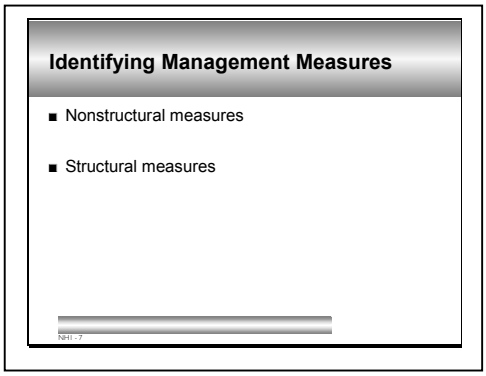
Interview. There are experienced and technical navigation experts in the district, division and headquarters – the Corps family. They can also be found at the port authority, among ship pilots, in consulting firms and inside the ivory towers on educational institutions.

Three Phases to Formulation

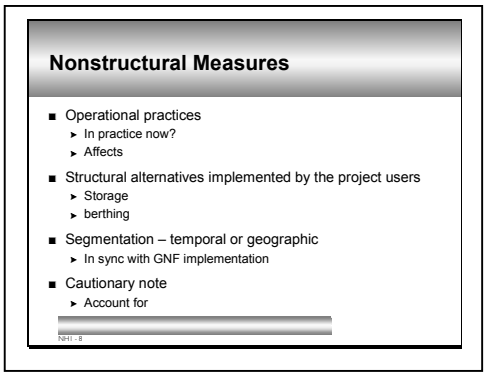


Identifying Management Measures

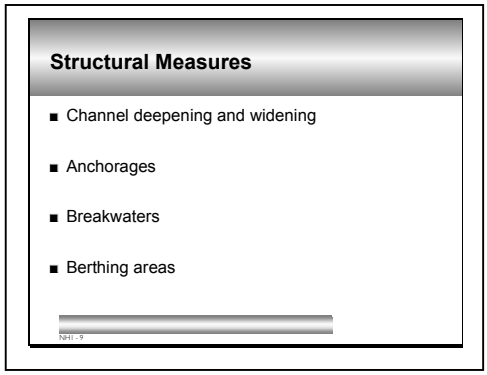
This is the first phase of deep-draft formulation.



The critical issues for nonstructural measures are how these factors might affect transportation costs and commodity flows associated with the project. But what are they? There is a need to include these in the mix but they are often neglected. All appropriate nonstructural measures should be included in each alternative, including the "do nothing" alternative. The potential oxymoron in that structural measures on the parts of the users are classified as non-structural measures. In some Corps of Engineer literature these efforts are called facility alternatives so we will continue the tradition here.



Structural measures are the general navigation features that the Corps and Coast Guard are responsible for and the accompanying local service facilities which are needed to achieve benefits afforded by the GNF.



Identifying Management Measures

This is the first phase of deep-draft formulation. There are two types of measures; structural and nonstructural.

Nonstructural Measures

The critical issues for nonstructural measures are how these factors might affect transportation costs and commodity flows associated with the project. The Principles and Guidelines (P&G) define nonstructural measures as follows: "Nonstructural measures are complete or partial alternatives to traditional structural measures. Nonstructural measures include modifications in public policy, management practice, regulatory policy, and pricing policy." (P&G (1.6.1(f)(1)). Defining nonstructural measures as those measures that are not structural does not tell the complete story. In fact, you may actually need heavy equipment to implement a nonstructural project, so do not let your understanding of these measures ride too much on the notion of construction activity. To define one as building things and the other as not does not capture all the nonstructural possibilities today. We will discuss some of the potential nonstructural measures. They fall into three specific areas: operational practices; facility alternatives implemented by the project users; and temporal or geographic segmentation associated with project implementation.

Operational practices. One measure used in a few of the major European ports and international canals, like Suez and Panama, is traffic management. In this case the channels are deep enough and wide enough but there would be traffic delays without some management control. It is operated just like air traffic control and is just as sophisticated. There could be policies imposed by pilots that result in one-way traffic for ships over a certain dimension. Pilots could also impose underkeel clearance restrictions to prevent groundings because groundings result in traffic delays.

Lightering can be a symptom of a problem and it can be a nonstructural measure. It allows ships that are loaded too deeply to come to berth to be partially unloaded onto smaller vessels. Obviously, this tends to raise the unit transportation cost. Ditto for tide riding. These operating practices should be identified and a determination as to their applicability in the baseline, and for each of the plans that are being evaluated. But first determine whether these practices are currently in use. If so, then care must be taken to determine the degree to which these practices are currently reflected in transportation costs.

Facility alternatives implemented by the project users. Structural alternatives implementable by project users would include such things as construction of special vessels, piers, and wharves. Piers can be extended out into deep water and transshipment facilities can be located adjacent to deeper water. Of the latter, offshore oil buoys with pipeline attachments are used for oil tankers. Although these measures constitute construction they are classified as nonstructural measures. Relocation of facilities should not be overlooked. This could include land creation or reconfiguration of existing ports.

In some cases, user implemented alternatives would simply be reflected in project costs as associated costs. In these instances you must consider the alternatives to the user, that is, facilities at competing projects. For example, the user may have alternative facilities with excess capacity or which better facilitate capacity expansion in response to increased traffic levels.

In other cases, user-implemented measures will affect the transportation costs at which traffic moves through the project. For example, utilizing a deeper channel typically requires deeper berths at the project, as well as deeper berths at overseas destinations. For some shippers, the lack of adequate overseas facilities may limit their need for greater depths at their berths, which would limit full utilization of the new channel depth. The ability of this shipper to benefit from the project is predicated on the willingness to deepen berths at project facilities. In either case, those aspects of the project that would be implemented by users must be specified for each plan. A determination must then be made as to which alternative implementation the user is most likely to take for each alternative. At this point you should identify any impacts on project scope and costs (including associated costs), modify the commodity flows and project fleet composition and compute new transportation costs.

Segmentation – temporal or geographic. Certain aspects of each project alternative could include phased construction or project segmentation. If so, you need to evaluate potential impact on alternative transport routings and costs over time. It is important to account for possible interrelationships between user implemented actions and project segmentation and phased construction. The basic information on project segmentation and its relation to project alternatives will cause further analysis.

Cautionary note. A closing cautionary remark on nonstructural measures, is that they are commonly neglected in plan formulation – they should be analyzed and included, as appropriate in all alternatives (including the no action alternative) being considered.

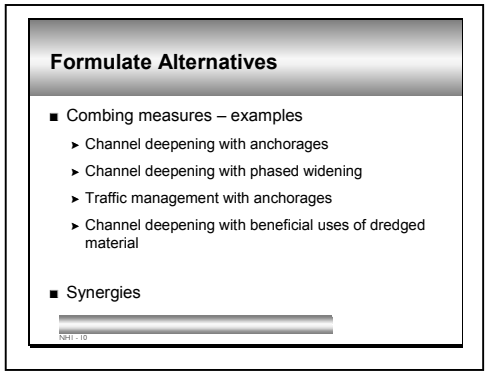
Structural Measures

Structural measures are the general navigation features that the Corps and Coast Guard are responsible for and the accompanying local service facilities which are needed to achieve benefits afforded by the GNF. They may also include relocations and removals.

If the objectives include accommodating larger ships, the channel and /or lock have to be enlarged. For the channel it might only involve the width of the channel, or just its approaches or bends. More likely, it is channel deepening that is associated with the problems and opportunities. However, if the improvement is to serve a bulk commodity, the ship may only need to travel laden in one direction. In that case a notched channel could be built such as at Hampton Roads.

If the objectives include reduction in delays, that could involve deepening to eliminate or reduce tide riding. But delays might be more related to channel configuration and appurtenances. Probably turning basins and anchorages are needed. Delays might be caused by inefficient wave climate control, which are normally a function of the approach channel depths and jetties.

Formulate Alternatives

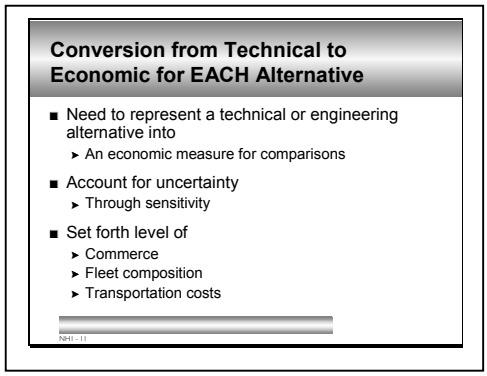


Now that you have identified a comprehensive list of measures to address some or all of the objectives, you need to start combining them to come up with a list of alternatives. Alternatives can differ in their timing as well as in their physical characteristics. They include present and future without plans usually thought of as what the project would be like without federally constructed improvements.

Accommodation of larger ships can be brought about by a combination of channel enlargement and tide riding. The latter is really only applicable, as stated earlier, to harbors within one tidal wave length of the ocean. But also it is not practical for liner service, which usually just involves container ships. This is because they are schedule driven and have a relatively high valued cargo. Bulk commodities, on the other hand, are just the opposite.

Knowing your future fleet distribution, you can combine phased width construction for one-way traffic as a management option when the widest ships encounter each other. In such case you have to account for any transportation cost delays.

A logical combination for any channel enlargement involves the disposition of the dredged material. While the magic phrase is the least costly disposal plan, we also want to consider beneficial use of the dredged material. Options are beach nourishment, wetland creation, restoration, mitigation, land creation and any other creative beneficial use. These are synergies. However, I have to point out that these applications of dredged material depend, in addition to cost increments (if they exist), on the type of material dredged. First, whether it is contaminated and then what type of rock or soil is it. For example, you are not going to nourish a public beach with non-sand material. And even if it is sand, it may need to be of a certain grain size distribution.



The purpose of explicitly structuring economic alternatives is to provide a basis for measuring incremental benefits and costs associated with each alternative. Economic alternatives have three parts: project costs of implementation (including future maintenance or stewardship obligations); future commodity flows; and relative transportation costs for each commodity flow. Each alternative should include the data, analysis and underlying assumptions.

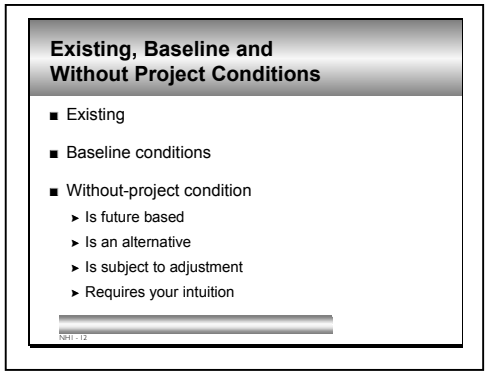
Due to uncertainties, there are several project-associated futures. For example, actions by competing ports may be difficult to associate with specific project alternatives. These can be dealt with through sensitivity analysis. The goal is that the alternative analysis provide sufficient information to explicitly set forth the level of commerce, expected fleet composition and costs by transport alternative for each technical alternative that is under consideration.

It appears that baseline and without project conditions are interchangeable terms. This may be because there are no rules on factors that differentiate the two. Further, as analysis leads to better information the baseline/without-project condition is adjusted. To arrive at the specifics that the without condition will represent, you will have to use your best intuition about the future. However, you will be guided not only by commodity movements and fleet compositions, but by resolved issues, and critical issues. For example, if some actions do not affect commodity flow levels or relative transportation costs, these should be considered resolved issues and incorporated into the without-project condition. More simply stated, one alternative involves no structural changes, just nonstructural if applicable. This probably becomes the future without project condition. The commodity movements and their transportation costs are going to be based on the project port fleet that would evolve given no structural improvement.

Baseline condition – A scenario from which project impacts can be measured, i.e. a point of reference. The baseline may coincide with the without-project condition.
Existing condition - A description of the project setting based on present conditions; it simply describes "what is" at the time the analysis is undertaken.

Without-project condition – The set of future conditions most likely to prevail in the absence of the proposed project. It does not describe conditions as they exist at the time of the study, but describes the conditions that are expected to prevail over the planning horizon in the absence of a project.

With-project conditions - The set of future conditions the analyst believes most likely to prevail for each project implementation over the planning horizon. These conditions may vary for each project alternative.



Existing, Baseline and Without Project Conditions. The without-project condition, as we have noted, is one of the alternatives. But before we define it, you first must clearly delineate between the existing and baseline conditions. The baseline condition represents a scenario from which other impacts are to be measured – a point of reference. The with- and without-project conditions represent futures that can be associated with-project implementation; one where no project is implemented and the other when it is. Usually we use baseline and without project interchangeably. And there are no rules on factors that differentiate the two. Further, as analysis leads to better information the baseline/without-project condition is adjusted. To arrive at the specifics that the without condition will represent, you will have to use your best intuition about the future. However, you will be guided not only by commodity movements and fleet compositions, but also by resolved issues, and critical issues. For example, if some actions do not affect commodity flow levels or relative transportation costs, these should be considered resolved issues and incorporated into the without-project condition. Those left will help identify factors critical in reaching the recommended course of action.

A difficult aspect of specifying the without-project condition revolves around what is termed critical issues. During the data collection phase, information will be obtained from shippers and carriers that provides a basis for determining the likelihood that certain actions will be implemented relative to each project alternative.

Without Project Condition

- Includes nonstructural components
- Excludes structural components
- Controls
  - Future port fleet
  - Commodity movements
  - And thus transportation costs

NH1 - 13

The without condition can also be identified on the basis of disaggregation of commodity flows into commodity groups, trade route and benefit category. Conceptually, generating the without project condition commodity flows is a linear decision that begins with the baseline traffic, then proceeds through transportation costs, resulting in estimated project commerce for each study time interval conditional on some project alternative. How the fleet changes to various conditions will also provide information that will assist in defining the without-project condition. But we are getting ahead of ourselves.

Lets look back at it one more time, but this time more simply stated. One alternative involves no structural changes, just nonstructural if applicable. This probably becomes the future without project condition. The commodity movements and their transportation costs are going to be based on the project port fleet that would evolve given no structural improvement.

Merging Costs and Benefits

In the previous module we talked about how to go about determining the transportation costs. Now we have to determine the cost to implement the various alternatives. Not only do we have to put them in the proper category, we also have to annualize them so we can compare alternatives with different timing components. Economic costs need to be evaluated and presented. As we arrive at a common point of comparison, we can then look at adding increments, changing scale and deleting components that are ineffective, inefficient or unacceptable. And don't forget, there is an interrelationship between transportation costs and a given alternative.

The terminology presents a problem similar to the structural/nonstructural situation. It is confusing at least with respect to NED and associated costs. There are different uses for costs, that is, between analysis and accounting (which includes cost sharing). The former is for plan formulation and the latter is for presentation and cost sharing.

Costs

- Terminology confusing
- Construction costs
- Real Estate costs
- Transportation costs

NH1 - 14

Equally as important as understanding that expenditures for construction typically flow over or during the period of construction is also stating the basic reason why IDC is assessed - IDC is assessed to account for the time value of money. In relative context to IDC and phased construction, it may also be informative to explain the context of assessing (where it applies) benefits during construction (BDC) which, where applicable, often helps to offset IDC. Sometimes, efforts to balance or net minimize IDC and/or net maximize BDC play a significant role in determination of the order or progression of project phasing, formulation, or justification.

NED Project Costs

- Construction costs
  - project features
    - Role of ship simulation models
  - dredging
    - advanced maintenance
    - over-depth
    - disposal
  - Operations and Maintenance costs
    - life-cycle

NH1 - 15

NED Project Costs, Cont.

- Interest during construction
  - Affects formulation of timing of alternatives vary
- Real estate
  - lands
  - easements
  - rights of way
  - relocations
  - disposal areas (differentiate from LERR)
- Associated costs – see next slide

NH1 - 16

The major problem related project associated costs is the frequent assumption that certain types of associated costs are self-liquidating. These costs are typically related to project throughput, either explicitly or implicitly. The basis for this assumption is that certain associated costs can be provided at constant per unit average costs and are accounted for in other aspects of the benefit-cost analysis. For example, increased storage area for additional coal could be provided at the same per unit cost as existing storage area. If this were the case, the cost associated with increased storage area would be reflected in the transportation costing analysis. The cost would be self-liquidating and would not need to be specifically reflected in economic costs (costs for justification).

You have to do two things. One, you have identify associated costs fully and account for them in some manner in the analysis. That is, they should be reflected in economic costs (not project implementation costs) or in comparative transportation costs. There is little general guidance on the best manner to account for associated costs.

Associated Costs – What Are They and Who Pays

- Frequently overlooked because
  - often not paid by Federal or non-Federal partner
  - public or private non-federal expenditure
  - incurred by project users
- Associated with the general navigation feature
  - to achieve the estimated benefits
  - or traffic levels for each project alternative
- Represent
  - fixed costs of doing business,
  - fixed costs of project implementation, or
  - variable costs of the transportation process

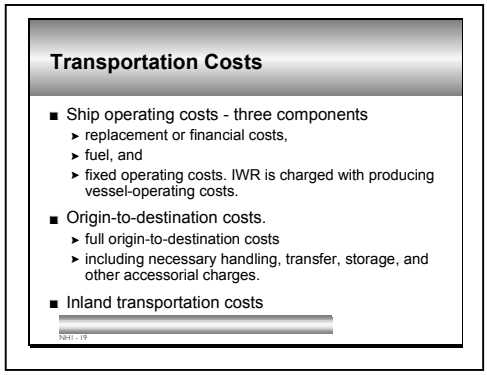
NH1 - 17

Associated Costs – Transportation or Implementation?

- Required to implement a project alternative
  - at the estimated benefit or
  - traffic levels
- Related to project throughput

NH1 - 18

For both theoretical and practical reasons it is necessary to interpret just what costs are costs, and whether all of those costs have to be counted in evaluation. For most things it is obvious, but not necessarily the project associated charges.



The directive that associated costs are to be analyzed is mandated by guidance. As far as accounting for such costs within comparative transportation costs, often existing tariff structures (if available) for usage of some existing or similarly planned port facilities provide a reasonable benchmark for recovery of a specified level of capital and operations costs that can often be adjusted to account for marginal associated costs required in support of waterway improvements. When appropriate tariffs or cost schedules are not available to reasonably estimate unit allocation of costs, then life-cycle costs of implementation, operation and maintenance need to be estimated or applied with costs accounted for on an annualized basis. Often, feasibility studies conducted by the non-Federal sponsor or private entities to determine the investment viability of significant capital expenditures are available to lend some insight as to the value or magnitude of such costs. Other alternatives include development of cost estimates from aggregate cost surveys such as assembled by/for construction estimation, etc. Also, the analyst must be careful to analyze the nature of such costs on a life-cycle basis under with versus without-project conditions. An additional consideration concerning the assumption that if a sponsor undertakes an associated cost expenditure that it is self-liquidating is that sometimes the criteria for what a sponsor assumes is self-liquidating may not be considered self-liquidating under NED criteria. Such circumstances may prevail because of subsidies or external general funding provided a port authority for improvements or differential financial costs due to differing assumptions, time periods and interest/discount rates assessed for recovery of costs. Accordingly, all potential associated costs should be identified and at least reviewed to determine applicability to a given project analysis.

Costs

Now as you start to make general navigational feature improvements and decide when you would make them based on availability of commodities and fleet, you can determine the unit transportation costs. Because cost terminology is confusing the analysis might be incomplete. What do I mean? Follow me and see for yourself.

NED Project Costs

The first step in completing the feasibility analysis is the generation of a complete cost stream associated with each alternative over the period of analysis. Various types of costs must be assessed: project implementation or construction costs; interest during construction; operations and maintenance costs (usually dredging); aids to navigation; project associated features; and land, easements, rights-of-way and relocations.

Construction Costs

The major costs for deep-draft projects are the Federal and non-Federal construction costs. This distinction is needed for accounting, and is important for determining the NED costs of the project. If resources are committed to project implementation, they should be reflected as NED or economic costs.

The costs include project features or general navigation features. We are talking about channel deepening, disposal containment areas, breakwaters, jetties, anchorages, etc.

HINT: Project construction costs almost always include dredging (for channel enlargement). However, in the construction category you have to account for advanced maintenance and overdepth dredging costs if applicable, even though these are for initial channel depths (and sometimes widths) beyond the project alternative's dimensions.

HINT: As you have identified your fleet distribution for the present and future, you will study various channel depth options. Traditionally, maximizing benefits centers around channel depths. The variable to channel depth is the channel width. If the slope is relatively flat, it will result in a disproportionate amount of dredging just to reach the desired depth. Even if the slope is not an issue, optimizing channel width is still a necessity. Various engineering manuals provide the channel width to correspond to one- and two-way traffic in terms of a multiple of the ship beam. To economize the cost of construction, you can see if there is a narrower ship channel option. You do this through ship simulation.

The problem that I have seen is that the ship simulator test operator may be more academically attuned in his/her model than the planning process. To the point, simulate only the largest vessels you are designing for. Unless vessels of similar size but built for different purpose (i.e. crude oil carrier versus finished product carrier) have demonstrated different handling characteristics, don't use both because it is their cross section that drives the model. These model studies tend to be expensive and hard to schedule, so beware.

Actually the concerns about modeling can be extended to economic or other models as well. Experience indicates that when modeling efforts go awry or become too costly or time consuming, it is often as much due to a breakdown in communication regarding needs and constraints (and subsequent scoping) for studies on the part of the planner or client (of the modeler) as it is desire for enhanced work on the part of the modeler. Many planners have underlying expectations that modelers or models are supposed to provide "the answers". A planner has an obligation to inquire and learn (at least generally) how applied models work, what the limitations are, the nature and sensitivity of assumptions, and to understand that decisions concerning formulation still rest largely with the intellect of individuals managing and working on the study often outside the modeling realm. When scoped properly, models are merely a means to obtain information with which to make a better-informed decision about study or project needs and formulation than would often otherwise be possible (without modeling efforts). Generally, when planners have sufficient understanding to properly help scope such efforts, modeling in most circumstances (whether for vessel simulation, etc.) returns good value to the decision-making process for time and funds expended.

<u>Operations and maintenance costs</u>. Operations and maintenance costs are the on-going claims on resources over the project life. The majority of these costs will have to do with channel dredging and disposal. Usually a modeling effort is performed to determine whether the channel deepening will induce a change in the rate of shoaling. It has happened so I will warn you in advance. If your model results predict less maintenance dredging than you are currently experiencing, there is something fishy. You should expect either no change or an increase. No change in shoaling rate means you could assume your

normal maintenance dredging cycle and costs unless channel deepening requires the channel to extend further seaward.

Interest during construction. Interest during construction reflects the fact that project construction costs are not incurred in one lump sum, but as a flow over the construction period. It is frequently computed on the assumption that expenditures are incurred at a constant rate over the construction period. If details show that construction expenditures would not be constant, compute your interest accordingly, especially if the project will be constructed in phases. This would affect formulation if the timing between alternatives were a factor.

Project associated costs (local service facilities). Here is where a lot of potential problems could arise. Which are implementation costs and which are transportation costs? Project associated costs are frequently overlooked because often they are not paid for by Federal or non-Federal partner, but by the users. Local service facility (associated) costs are any public or private non-federal expenditure that is required along with the general navigation feature in order to achieve the estimated benefits or traffic levels for each project alternative. Project users incur them as part of the transportation or logistics process. They represent (1) fixed costs of doing business, (2) fixed costs of project implementation, or (3) variable costs of the transportation process. Examples are facility enhancements necessary to accommodate larger vessels or larger loads per vessel such as bigger cranes, deeper berths, and piers, or expanded storage areas. They are often referred to as local service facilities.

The issue is the manner in which project associated costs are addressed in the analysis. Certain types of analysis, for example, pipeline relocations, are typically included as project implementation costs. In most cases, these costs are unrelated to project throughput, but are required to implement a project alternative at the estimated benefit or traffic levels. The major problem related to project associated costs is the frequent assumption that certain types of project associated costs are self-liquidating. These costs are typically related to project throughput, either explicitly or implicitly.

The basis for this assumption is that certain associated costs can be provided at constant per unit average costs and are accounted for in other aspects of the benefit-cost analysis. For example, increased storage area for additional coal could be provided at the same per unit cost as existing storage area. If this were the case, the associated cost of increased storage area would be reflected in the transportation costing analysis. The cost would be self-liquidating and would not need to be specifically reflected in project implementation costs.

HINT: You have to identify associated costs fully and you have to account for them in some manner in the analysis. That is, they should be reflected in project implementation costs or in comparative transportation costs. There is little general guidance on the best manner to account for associated costs.

Lands, Easements, Rights-of-way and Relocations. Real estate is another broad category (and includes certain project associated costs if applicable). You need to account for lands, easements, rights-of-way, and relocations. Because of the crediting issue involved, the non-Federal sponsor will be interested in this and it may even affect the sponsor's level of participation in terms of the size of the project.

Transportation Costs

To compute benefits you have to first calculate transportation costs for each scenario. Knowing the commodities by volume and the port fleet projections, you can identify the with- and without-project

water transportation costs when you account for vessel loadings by size distribution. That coupled with landside transportation costs will allow you to compare effectiveness of alternatives.

Ship Operating Costs

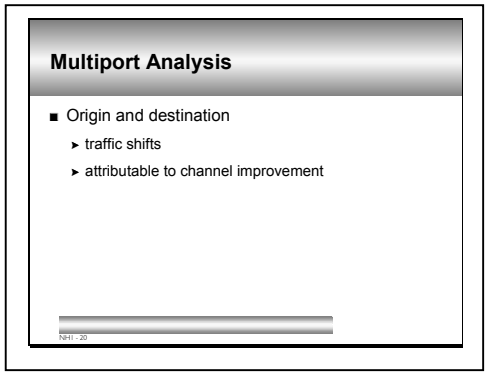
To determine the expected annual delay/capacity costs, you have to start with ship operating costs. There are three components: the replacement or financial costs, fuel, and fixed operating costs. IWR is charged with producing vessel-operating costs.

Origin-to-Destination Costs

Analysis calls for the current transportation costs in NED evaluation, and those costs are to include the full origin-to-destination costs including necessary handling, transfer, storage, and other accessorial charges. For both theoretical and practical reasons it is necessary to interpret just what costs are costs, and whether all of those costs have to be counted in evaluation. The emphasis, of course, is on the transportation costs.

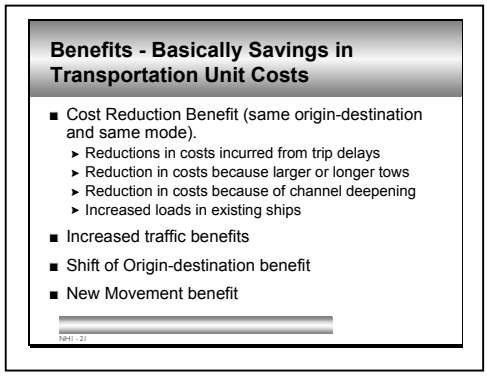
Inland Transportation Costs and the Need for Multiport Analysis

Rail and truck transportation costs are needed in order to complete the origin and destination costs if there are traffic shifts attributable to channel improvement. This implies a multiport analysis. To minimize your effort, you should restrict this analysis to those movements of significant size. Regardless, this effort can be significant and it is generally specialized.



NED Benefits

Project benefits are presented in the form of transportation cost savings and fall under two categories.



1. Cost reduction benefits. Cost reduction benefits result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern and harbor in all project conditions. Cost reduction benefits will generally take one of three forms depending on the project formulation.

    a. Enhanced maneuverability and delay reduction. Things that apply here are, for example, expanded turning basins or increases to the number of passing lanes to decrease channel transit time for all vessels. Some or all of the large ships using tides will no longer be tide dependent. Benefits attributed to enhanced vessel

maneuverability or delay reduction are usually computed as timesavings multiplied by some per unit cost.

b. Increased loads for existing vessels. For any given operating draft, a larger size vessel carries a larger load than a smaller one. It may provide lower transportation costs even though it is not fully loaded. As a result, there is an incentive to use oversize vessels for any given channel depth. That portion of the fleet which does not change in response to project implementation is likely to include some oversize vessels that can load more fully because of channel deepening.

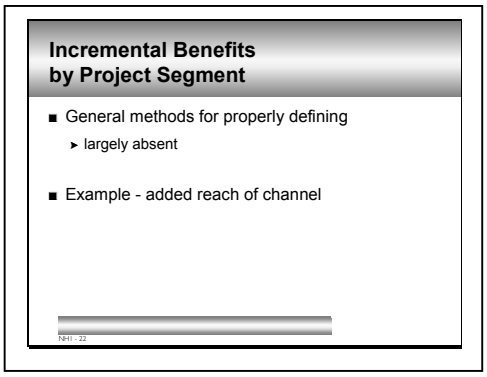
   Stated less formally, the above conditions simply divide traffic into two classes; those movements that do not benefit from the project and those movements that do. The first condition indicates that movements on ships that are not constrained by the existing project will not benefit from any proposed project. As a result, the movement has the same estimated transportation costs in both the with- and without-project conditions. The latter indicates that movements which are constrained by the existing project may benefit from some proposed alternatives. The difference in transportation costs between the two conditions, when multiplied by the vessel load represents the total transportation cost savings for the movement. This difference would be computed for all movements which satisfy the second condition, then summed to obtain total savings for the year of comparison.

c. Larger vessels. Depending on the characteristics of the proposed projects, carriers may have an incentive to use larger, draft-constrained ships with a resulting increase in average load per vessel. This will be reflected as a shift in the fleet forecast between the baseline and with-project alternative fleets. The conceptual distinction between benefits derived from loading vessels more fully, and benefits derived from the use of larger vessels, is that the latter reflects change in fleet composition between alternatives, while the former reflects better utilization of that portion of the fleet which does not change in response to various project alternatives.

2. Increased Traffic Benefits. In addition to the decreased transportation costs for existing movements, the proposed project may also increase the level of traffic as a result of decreased transportation costs. It is important to note that this traffic does not represent growth over time, but difference in traffic levels between alternative futures at any point in time.

While we don't want to get into the details of evaluation, I should point out that in the case of induced movements, benefits should conceptually be based on changes of net income to the commodity producer or user. This is not easily estimated so these benefits are often estimated as one-half of the difference in the maximum and minimum transportation costs for each alternative, unless you have better or more detailed information.

Incremental Benefits by Project Segment



It should also be explained that sometimes no initial segment or interior channel may be justified by itself without synergistic grouping with other features and segments or increments (some of which may be non-successive in physical layout) and associated user activities. It does often require experience and insight to logically and objectively delineate where one increment analytically "stops" and another begins. This brings forth the concept of separable and non-separable benefits/costs. A simple and common example is the placement of transit channel improvements without commensurate turning or maneuvering area improvements and vice-versa. What could the nature of the benefits relative to costs be under such varying circumstances?

When a proposed project can be divided into segments, the economic criteria for project justification require that each project segment be either independently or conditionally justified. Appropriate general methods for properly defining project segments are largely absent. In most instances project segments will be defined by you based on physical and cost differences that can be observed and appear to be significant. There should be some obvious characteristic that differentiates the segments. For deep draft navigation, a typical example is an added reach of channel.

Review Questions

1. A port with a 35-foot channel anticipates no growth in commodity movements, but most ships now draw 49 feet of water. What is the opportunity for transportation cost savings?

2. The State of Maryland does not allow open water disposal in the Chesapeake Bay. Is that a constraint?

3. What effect does increasing an alternative depth beyond 45 feet?

4. If you anticipate no induced traffic to the port, should you need to do multi-port analysis.

5. Who is responsible for confined dredged material disposal areas?

Section Summary and a Look Forward

This section has addressed the initial stages of plan formulation by discussing identification of problems and opportunities and using these to create objectives while being mindful of constraints.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

National Economic Development Procedures Manual, Deep Draft Navigation. IWR, November 1991.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Selected Notes to the Instructor

Student Learning Objectives:

1. The student will identify what constitutes general navigation features of deep-draft navigation projects
2. The students will learn constraints of the local sponsor as affected by cost sharing
3. The student will learn typical problems and opportunities unique to deep-draft navigation
4. The student will learn the role of multi-port analysis
5. The student will learn the application of incremental analysis
6. The student will learn how to formulate alternative plans when a sponsor desires to create land
7. The student will learn how to use formulation measures/techniques and strategies to formulate alternative plans for navigation harbors.

Instructor Notes and Exercises:

This Module will emphasize the third step of the planning process, formulation. It will review the measures that could be combined to formulate alternative plans for navigational improvements, including disposal options. Plan formulation strategies will be discussed. Cost variables will be covered with an emphasis on generating an understanding of the variables that can influence cost and therefore optimization. The differentiation of general navigation features from other features will be discussed. The impacts of real estate, OMRR&R, land development and other significant factors in developing formulation strategies will be discussed.

Slide NH3-4
You want to point out that by now the planners would have collected a large database that has been generated describing possible future economic conditions within which the project could be implemented. This information has only limited reference to specific project alternatives, project implementation or economic evaluation. Deep-draft formulation is a process to meet objectives that usually but should not always revolve around accommodating larger ships and reducing ship movement delays while avoiding constraints in order to develop management measures and plans. Point out that the class has already discussed objectives and constraints so now is the time to talk about the development of management measures and plans. But first tell them what some of the potential management measures are for harbor improvements.

Slide NH3-5
Only some of the districts have harbors and studies of these are sporadic. So how do you approach addressing harbor improvements? There are three good ways. (1) Brainstorm both within the office and with interested parties; (2) Don't Reinvent the Wheel, use previous studies or their relevant parts; and (3) Interview. There are experienced and technical navigation experts in the district, division and

headquarters – the Corps family. They can also be found at the port authority, among ship pilots, in consulting firms and inside the ivory towers on educational institutions.

Slide NH3-6
Exercise NH3.1
What we want the class to do is to produce a comprehensive list of as many navigation improvement measures as possible. Divide the class by gender, district, experience or any other way to add a little fun to the exercise. Choose a person to start. They name a navigation measure and you write it down. The next person does the same. As the list grows it gets harder. When people come up blank or you reject their idea they sit down. The last person standing wins a candy bar if you plan ahead and buy one. The point is to generate a list. If everyone gets stumped and there is no last person standing then let the last group that was standing try again. Hopefully they came up with two basic types – structural and non-structural.

Slide NH3-10
At this point in the process you have identified a comprehensive list of measures to address some or all of the objectives, you need to start combining them to come up with a list of alternatives. Alternatives can differ in their timing as well as in their physical characteristics. They include present and future without plans usually thought of as what the project would be like without federally constructed improvements. Try to incorporate synergies to create a win-win for a "larger community".

You could ask the class for examples.

Slide NH3-12
A word of clarification. The class may need to understand that even when issues are non-critical, they are not necessarily resolved, simply determined to be non-critical to considerations for a given study. The reality is that many studies will have minor issues that are never fully resolved satisfactorily to all parties involved, in part because not everyone is agreeable to compromise. The objective is that resolution be achieved for critical issues (i.e., non-criticality by default does not necessarily render resolution to all interests) to the extent that project disposition (justification and/or formulation) is reasonably or properly determined.

It wouldn't hurt to remind the class of definitions for the three plus that of the with project condition.

Slide NH3-13
This is really a prototype for all alternatives.

Slide NH3-14
As you go through the various categories below, be sure to point out what parameters affect costs and their impact on alternatives. One distinction that is often applied for costs is "economic" (for analysis) versus "accounting" costs.

Slides NH3-15 & 16
The first step in completing the feasibility analysis is the generation of a complete cost stream associated with each alternative over the period of analysis. Discuss each of the bullets above using the text as your guide. One of the keys as noted in the HINT below is that the planner has to be very careful of what modelers want to do for them – often it is way too much which costs too much and takes too long.

Slide NH3-17
The first thing to try to get across is what they are. After discussing who is responsible and what it is for, then we have to see where it fits in formulation, which the next slide should help.

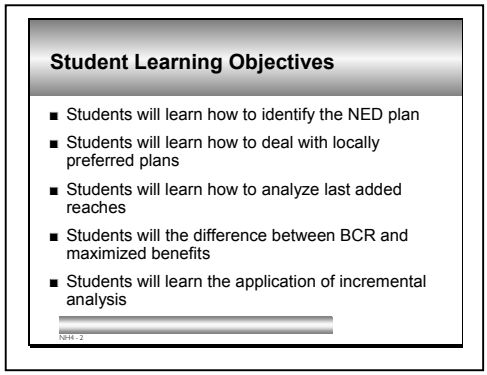
Slide NH3-18
This would be the place to discuss accounting for removals mentioned in Module 1 of this chapter.

Slide NH3-22
Point out that this was very cleverly applied in the recent New York/New Jersey study. The first interior channel was economically justified and other reaches were added on the basis of their independent justification. These separable elements would never have been justified on their own.

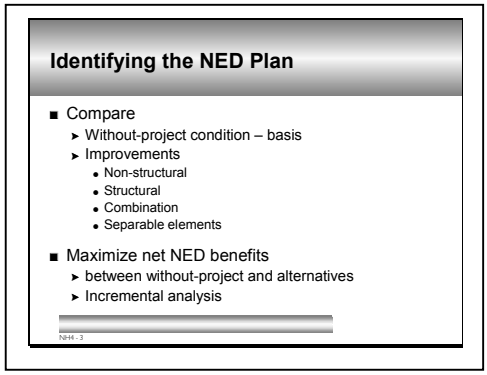
Slide NH3-22
Exercise NH3.1
1. State situation – ask for problems & opportunities.

2. Table from current port study – what is missing?

Module NH4: Reformulation – Optimization, Incremental Analysis and Selection of the NED Plan



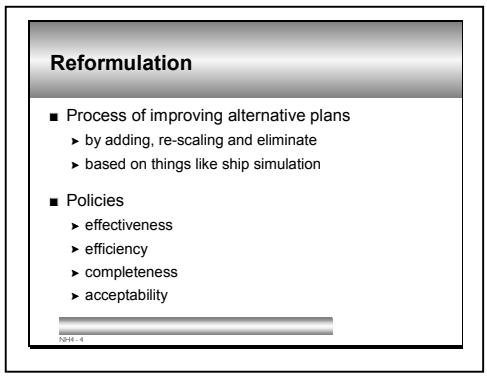
Identifying the NED Plan



The one plan that you are required to detail is the NED plan. This is the plan that maximizes not just any benefits, but NED benefits. It is not necessarily the plan with the highest benefit ratio. As you start tabularizing your alternatives in a benefit-cost comparison, you will keep adding increments, usually depth, until the increments in benefits start to be eclipsed by the increments of cost. When dealing with depths you try to find that high point on the curve for one-foot increments. The table showing "River A- River B Waterway Economic Analysis of Project Deepening is from a draft report where I have changed the names of the project and ports. It is a preliminary table used to narrow down the choices of evaluation in terms of project depths. The table does not include channel dredging maintenance costs nor does it include associated costs. Both could have an impact on the NED plan. We can tell from the table that it is a crude oil import port. We don't know from the table what the future project fleet distribution might be. If we did we could comment on the logic of taking the investigation to even deeper project depths. We can tell from the table that deeper depth apparently really start extending seaward, but perhaps the next increment may drop off or may hit rock. Things to think about. Our data inventory would have helped in this regard.

We can use the same table to discuss last added reach (see the rows that have the numbers highlighted in yellow). This can be viewed under progressive development or more analytically under incremental analysis. Remember from module NH1, progressive development includes situations where the last small increment of a channel serves a non-public owner. The last property owner served may be "at the end" in terms of length, depth, or width, necessitating some project investment in his service alone. This is treated as a multiple-owner situation unless a disproportionate incremental investment is required. So what does disproportionate mean? There is no written definition.

Reformulation



It is probably not clear where you draw the line between formulation and reformulation in terms of actual analysis. For classification or lecture purposes, after you have combined whatever measures and created a number of alternatives, the iterative part starts. You are going to be adding bits and pieces, re-scaling and eliminating. While you are headed in the direction of maximizing benefits you need to be measuring these alternatives and their metamorphoses against the parameters of effectiveness, efficiency, completeness and acceptability.

Let us put these parameters in the context of navigation improvement through example. Deepening certainly is effective for light loaded ships but not for ships whose drafts are already accommodated. Do enlarging turning basins increase efficiency now that most ships have bow thrusters? Is a deepening project considered to be complete the local service facilities are not built? Is it acceptable to mitigate in an area outside of the port?

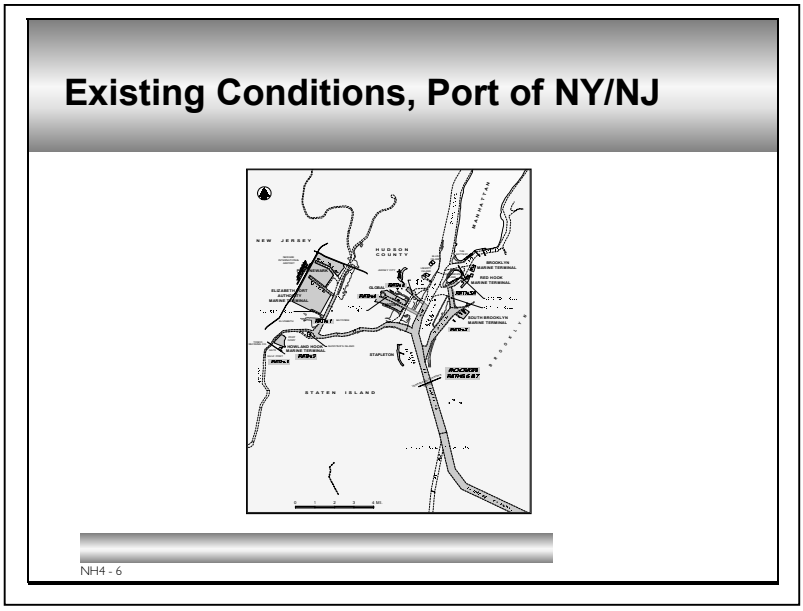
With-Project Conditions. These are the conditions you believe most likely to prevail for each project implementation. Probably the most important parameter is the commodity flows. Do they divert to or from the project port? Is traffic induced? To answer these questions one normally would disaggregate the commodities to see what factors have the largest impact on a given commodity and better determine the commodity beneficiaries.

Example of NED Identification

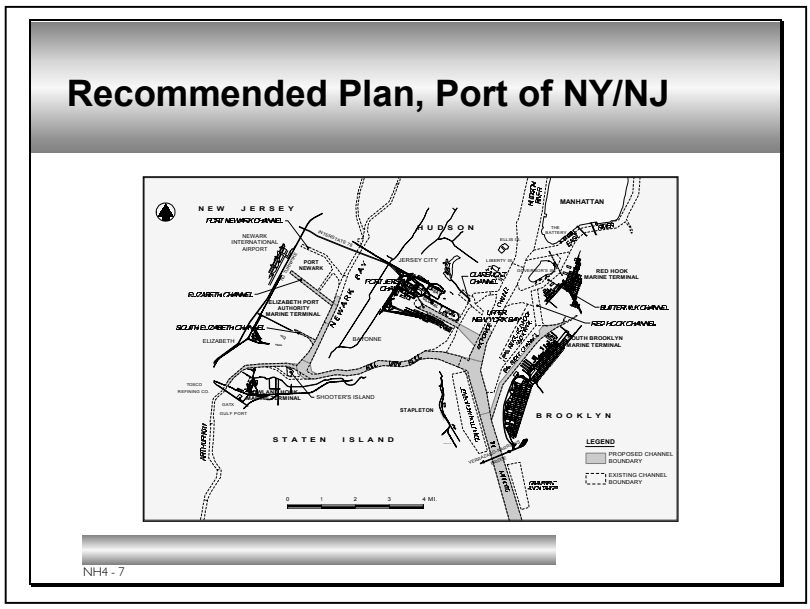
Example of NED Identification

RIVER A - RIVER B WATERWAY ECONOMIC ANALYSIS OF PROJECT DEEPENING						
BENEFITS	43	45	48	50	53	55
Downstream Port Benefits						
Crude Petroleum Imports	$6,546,410	$8,130,533	$12,309,970	$13,526,683	$15,641,626	$18,999,767
Petroleum Product Imports	$789,997	$1,013,283	$1,594,143	$1,904,115	$2,255,707	$2,398,070
Petroleum Product Exports	$544,536	$699,101	$1,100,316	$1,314,392	$1,544,687	$1,642,282
Downstream Port Total	$7,880,943	$9,842,917	$15,004,430	$16,745,190	$19,442,021	$23,040,120
Upstream Port Benefits						
Crude Petroleum Imports	$11,192,741	$13,905,184	$21,048,641	$23,182,977	$26,816,688	$29,047,523
Petroleum Product Imports	$2,673,782	$3,429,983	$5,396,346	$6,448,183	$7,580,793	$8,067,929
Petroleum Product Exports	$1,034,112	$1,327,696	$2,090,369	$2,497,512	$2,929,141	$3,114,431
Upstream Port Total	$14,900,635	$18,662,863	$28,535,356	$32,128,672	$37,326,622	$40,229,883
Upstream & Downstream Ports' Deep-Draft Benefits						
Crude Petroleum Imports	$17,739,151	$22,035,717	$33,358,611	$36,709,661	$42,458,315	$48,047,291
Petroleum Product Imports	$3,463,779	$4,443,266	$6,990,489	$8,352,298	$9,836,500	$10,465,999
Petroleum Product Exports	$1,578,648	$2,026,797	$3,190,686	$3,811,904	$4,473,829	$4,756,713
Total	$22,781,578	$28,505,780	$43,539,786	$48,873,862	$56,768,643	$63,270,003
COSTS						
First Cost Deepening Total River A & River B Waterway						
River A & River B Existing Width	$134,295,000	$191,843,000	$297,787,000	$373,275,000	$496,691,000	$575,436,000
River A & River B 500-ft Width	$212,630,000	$261,446,000	$345,360,000	$435,015,000	$565,561,000	$651,100,000
Average Annual Cost for River A & River B Waterway						
River A & River B Existing Width	$8,969,424	$12,812,996	$19,888,886	$24,930,652	$33,173,479	$38,432,776
River A & River B 500-ft Width	$14,201,338	$17,461,708	$23,066,238	$29,054,203	$37,773,235	$43,486,297
Benefit-to-Cost Ratios (Upstream & Downstream Ports' Benefits; River A & River B Cost)						
River A & River B Existing Width	2.54	2.22	2.19	1.96	1.71	1.65
River A & River B 500-ft Width	1.60	1.63	1.89	1.68	1.50	1.45
Net Excess Benefits (Upstream & Downstream Ports' Benefits; River A & River B Cost)						
River A & River B Existing Width	$13,812,153	$15,692,784	**$23,650,900**	**$23,943,211**	**$23,595,164**	**$24,837,226**
River A & River B 500-ft Width	$8,580,240	$11,044,071	**$20,473,548**	$19,819,660	$18,995,408	$19,783,706
Benefit-to-Cost Ratios (Upstream Port's Benefits; River A & River B Cost)						
River A & River B Existing Width	1.66	1.46	1.43	1.29	1.13	1.05
River A & River B 500-ft Width	1.05	1.07	1.24	1.11	0.99	0.93
Net Excess Benefits (Upstream Port's Benefits; River A & River B Cost)						
River A & River B Existing Width	$5,931,211	$5,849,867	**$8,646,470**	$7,198,020	$4,153,143	$1,797,107
River A & River B 500-ft Width	$699,297	$1,201,154	**$5,469,119**	$3,074,469	-$446,613	-$3,256,414

Existing Conditions, Port of NY/NJ



Recommended Plan, Port of NY/NJ



Locally Preferred Plan – 2 Possibilities

Locally Preferred Plan – 2 Possibilities

- May deviate from the National Economic Development Plan
- If requested by the non-Federal sponsor
- If approved by ASA(CW)
- Conditions

NH4 - 8

Locally Preferred Plan – 2 Possibilities

- Conditions (continued from previous slide)
  - Larger than the NED plan
    - a larger than NED plan may not be recommended
    - incremental cost is entirely a non-Federal responsibility
    - Special case - NED Plan exception
      - » Chief can't recommend
      - » ASA(CW) grants
      - » costs for the granted exception will be shared on the same percentage basis as the NED plan
  - Recommended plans less costly than the NED plan
    - will normally be granted an exception to NED plan selection,
    - and cost shared on the same percentage basis as the NED plan

NH4 - 9

Comparison of Plans Where LPP > NED

Comparison of Plans Where LPP>NED

	No Action	NED Plan	Locally Preferred Plan
Plan Description	No Action – without Project Condition	Deepens channels to 43 feet	Deepens channels to 45 feet
National Economic Development (NED)			
Project Cost	$0	$10,000,000	$15,000,000
Annual Cost	$0	$ 1,000,000	$ 1,500,000
Total Annual Benefits	$0	$ 2,000,000	$ 2,400,000
Annual Net Benefits	$0	$ 1,000,000	$ 900,000
Benefit to Cost Ratio	N/A	2.0	1.6

NH4 - 10

Included in the comparison of plans are the evaluation of meeting planning objectives, the fleet or traffic you are desiring to accommodate, and evaluating responsiveness to evaluation criteria of completeness, effectiveness and efficiency. Intuitively you would assume that the no action plan would fail all categories. But the NED plan may not rank highest in this comparison.

For various reasons, the local sponsor wants a project with depths greater than those of the NED plan. This is no problem so long as the sponsor is willing and able to pay for the differential. Under special cases, recommending the NED plan can be waived. Check with the Division and Headquarters for case by case guidance. For now, just know that it can be done. I would say, though, that this has far greater potential in environmental, flood, or multi-purpose projects.

Comparison of Plans Where LPP < NED

Comparison of Plans Where LPP<NED

	No Action	NED Plan	Locally Preferred Plan
Plan Description	No Action – without Project Condition	Deepens channels to 48 feet	Deepens channels to 45 feet
National Economic Development (NED)			
Project Cost	$0	$20,000,000	$15,000,000
Annual Cost	$0	$ 2,000,000	$ 1,500,000
Total Annual Benefits	$0	$ 4,000,000	$ 2,400,000
Annual Net Benefits	$0	$ 2,000,000	$ 900,000
Benefit to Cost Ratio	N/A	2.0	1.6

NH4 - 11

Local Sponsor Share of Construction, in Percent

In the above tables, if the non Federal sponsor identifies a constraint to maximum physical project size such as a financial constraint due to limited resources the requirement to formulate larger scale plans in an effort to identify the NED plan is suspended. The cost-sharing table gives an example of why this case may occur.

Local Sponsor Share of Construction, in Percent

Project depth	20 feet or less	20 to 45 feet	Greater than 45 feet
General navigation feature**	10/10*	25/10*	50/10*
Mitigation	10/10*	25/10*	50/10*
Aids to navigation	0	0	0
Service facilities	100	100	100
LERR	100	100	100

* The second number, 10%, is the amount of total cost of general navigation features that the local sponsor must pay over a period not to exceed 30 years. This amount may be offset by the value of LERR.

NH4 - 12

Review Questions

1. Is the plan with the highest benefit cost ratio the NED plan?
2. Is the only exception to the NED plan a less costly plan?

3. What is a way to analyze the last added reach?

Section Summary and a Look Forward

This module has looked at comparison of plans from the aspect of maximizing net benefits and the continuation of this process until the incremental benefits begin to decrease. It has also addressed the conditions for deviating from the NED plan as well as how to look at the last added reach. Combined with the previous 3 modules, the planner should have a good grasp on formulating for harbor navigation studies.

References and Suggestions for Further Reading

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

National Economic Development Procedures Manual, Deep Draft Navigation. IWR, November 1991.

Yoe, Charles and Kenneth Orth. Planning Manual. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Yoe, C. *National Economic Development Procedures Manual – National Economic Development Costs*. IWR Report 93-R-12, June 1993.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will learn how to identify the NED plan
2. Students will learn how to deal with locally preferred plans
3. Students will learn how to analyze last added reaches
4. Students will the difference between BCR and maximized benefits
5. Students will learn the application of incremental analysis

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Instructor Notes and Exercises:

Module NH4 covers optimization and selection of the NED Plan. At the end of this module, the student should have a good grasp of incremental analysis and the policies for the last added reach of channel as well as need for the bracketing of the NED Plan. Exceptions to the NED selection criteria will be discussed as well the impacts of locally preferred plans on the selection process.

Slide NH4-3
Exercise NH4.1
As the fourth and final module, we want to spend some practical time with the class by looking at comparisons. We have already reviewed what goes into the without-project condition and the various items that generally constitute improvements so now we want to direct their attention to determining what makes for maximizing NED benefits through example from a draft report. The idea of the table below is to look at the costs and benefits for two ports (the upstream port and the downstream port) that are within 5 miles of each other on a river and its tributary. Explain the proximity of the two ports and although two rivers are involved, one port is just up river from the other. Have them tell you the nature of the commodities affected by the project and guess at what the hinterland might be. Explain that the columns represent alternative project depths and the rows give the associated costs and benefits. Then ask them to take a couple of minutes to look at the table and tell you what is missing. It is the both the life cycle or dredging maintenance costs and associated costs.

Using the same table, you now want them to spend about 5 more minutes and then tell you what the NED plan is forgetting the missing O&M and associated costs. Engage them in a discussion of whether they have actually found the maximum benefits based upon the table. Maybe it is greater than 55 feet. Discuss that if the design drafts of the future fleet are 53 feet or less that the NED plan would not be over 55 feet. Try to trap them and see if they fall for the BCR as the indicator of the NED plan. This should make for a lively discussion.

Lets play with the table some more. Point out that it also combines looking at channel depths with one width increase.

Staying with the table, talk to them about incremental analysis by looking at increments of both depth and width and that we keep going until the incremental cost exceeds the incremental benefits thus bracketing

the NED plan. Then get back to a discussion about the decrease in net benefits when going from 50 to 53 feet and the subsequent increase from 53 feet to 55 feet. Ask why the table only addresses one width increase. Could it be for 2-way traffic?

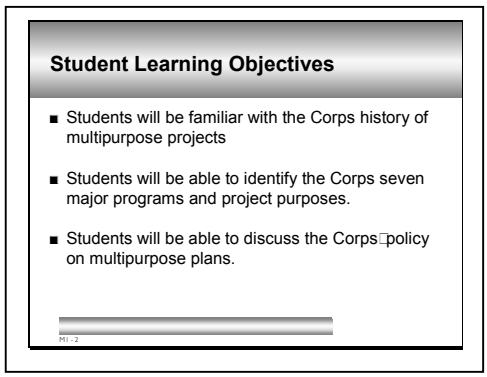
Have the class do one last exercise with the table – discuss the last added reach. See if they remember what we talked about in the first module. The Upstream Port is the last added reach in this case. Does the analysis provided by the table allow you to determine whether you can add it and if so to what depth? Focus on the rows with the yellow numbers in the table. The table is flawed in that it uses the total project costs to the Upstream Port and compares that to the benefits of the port ignoring the benefits at the Downstream Port. For the last added reach you normally should use the incremental costs for the last reach compared to the incremental benefits. Show slide (Figures 2 & 25) from the New York/New Jersey as an example of this. Enough already?

Slide NH4-9
After reading and elaborating on the self-explanatory slide, use the following slide to give an example of the first situation. If the sponsor is willing to pay the differential, that would be the recommended plan with the appropriate project cooperation agreement.

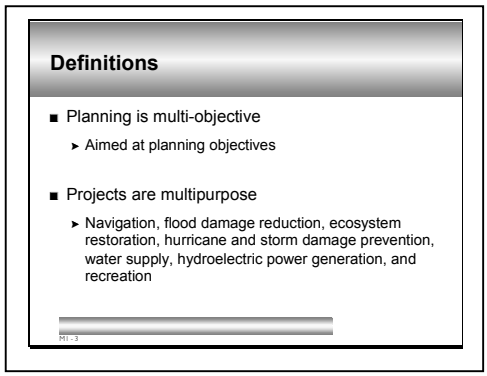
Slide NH4-12
The above two slides show the situation where the local sponsor wants a smaller scale plan the NED plan. The cost sharing should be discussed because of its potential affect on the sponsor's choice. Note that the sponsor's preference for a smaller scale plan should not affect identification of the NED plan.

Chapter 8 – Multipurpose Projects

Module M1: Additional Project Purposes – Policies and Constraints



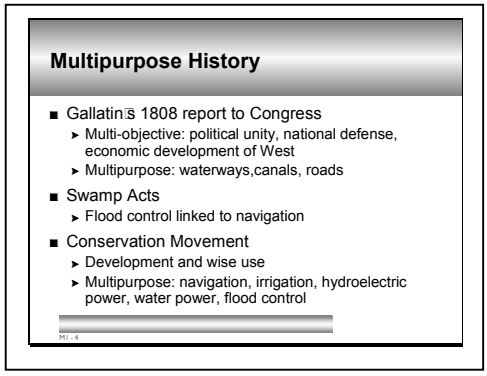
Definitions



We need to begin with some language issues. This is a topic with some very messy language history. Multi-objective and multipurpose are words thrown around as anything from synonyms to antonyms in the planning jargon. That cannot be. For purposes of this course we offer the following definitions. Planning is multi-objective. Projects are multipurpose. A good planning study always has several planning objectives. The planning process aims to meet as many of these objectives as completely as possible. Hence, planning is by its nature multi-objective because it considers multiple objectives.

The multiple objectives of the planning process are met by projects. Those projects may have a single purpose or they may have multiple purposes. The "purpose" of a project, in the larger agency sense, is to accomplish one or more of the Corps' missions. The Corps has seven mission areas: navigation, flood damage reduction, ecosystem restoration, hurricane and storm damage prevention, water supply, hydroelectric power generation, and recreation. Thus, these are the most common purposes of a Corps project.

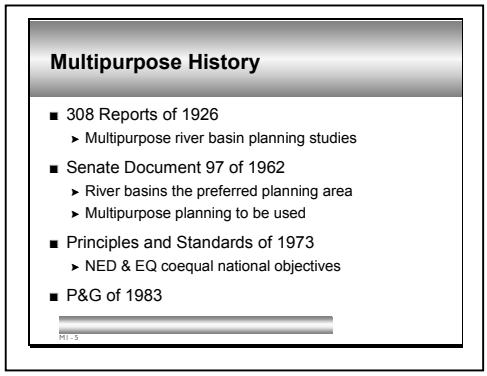
How Long Has This Been Going On?



Treasury Secretary Albert Gallatin was asked by Congress in 1807 to make a thorough investigation of waterways, canals, and roads. In 1808, apologizing for the "lateness" of his report he presented a foresighted summary that helped guide development of the early Nation's transportation system on land and by water. His study was multi-objective. It considered ways to unite the Nation politically, provide for the nation's defense and advance the economic development of the West, which at the time was west of the Ohio River. Pursuing these objectives he identified projects that made use of waterways, canals and roads to achieve these objectives. Multi-objective planning and multipurpose projects in the U.S. are nearly 200 years old!

As noted in the flood damage reduction modules, the Swamp Acts of 1849 and 1850 enabled the government to begin some flood damage reduction so long as it was linked to navigation. Multipurpose projects were the rule for Federal Flood Control Activities in the US from its very beginnings.

The Conservation Movement was an elite reformist movement that favored government action to "preserve" natural resources. It emerged in the 19th century in reaction to rising industrialism and large cities. The future of the world's energy resources was a particular concern at the time. Development and wise use of our natural resources was the clarion call of this movement. It may strike us as an odd conservation philosophy but fashioned during Theodore Roosevelt's years, it guided water resources in a multipurpose fashion up into the 1960s when the modern environmental movement replaced it.



The 308 Reports authorized in 1925 and completed in 1927 were the Nation's first complete and comprehensive river basin studies. These were clear precursors to the system view of the current watershed approach to planning.

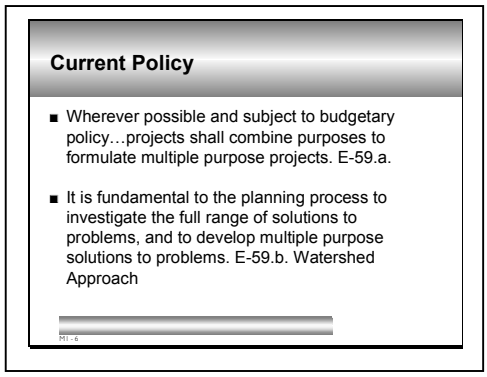
Senate Document 97 is the better known name of President Kennedy's 1962 "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources." It is significant for many reasons. It required multi-objective planning to address development, preservation of resources, and well being of people. River basins were identified as the preferred planning areas and multipurpose planning was prescribed for use. This period is as close to a "golden age" of multipurpose water resources planning as this Nation has had. It was characterized by the planning and construction of many large multipurpose reservoirs throughout the country.

The Principles and Standards (P&S) of 1973 refined the objectives of water resources planning. Of interest to us is the fact that National Economic Development (NED) and Environmental Quality (EQ) were considered coequal national objectives. Planners had to develop an EQ plan as well as a NED plan. Many of the formulation and evaluation issues confronting planners today were analyzed, debated and discussed in the early 1970s.

NED and EQ remained coequal objectives. The Carter years began with the then famous water resource project hit list that kicked off what amounted to two decades of interesting times for the Corps. In 1983 President Reagan resolved some of the issues of that era with the Principles and Guidelines (P&G), which established NED consistent with protecting the Nation's environment as the only Federal objective in water planning.

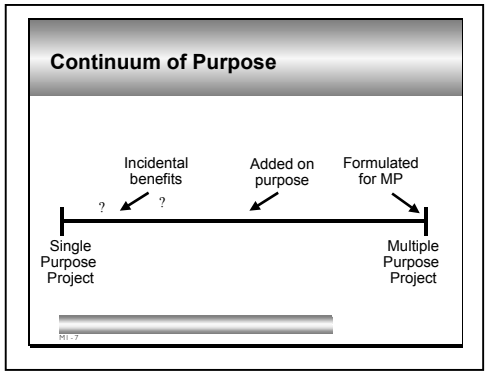
The current orientation toward multi-objective planning and multipurpose projects may seem new to the short planning lifetimes of many Corps planners but it is more a return to old roots than a new initiative. Highly motivated planners may find it useful to review some of the historical documents and professional literature of the last half of the 20th century for the planning and formulation lessons they hold.

Current policy is found in many places. The figure quotes ER 1105-2-100 paragraph E-59.a. and b.



Project Purposes

The figure demonstrates a simple but important point. There can clearly be single purpose projects that do one thing and one thing only. Likewise, there clearly are multipurpose projects that serve several purposes. Very few projects are truly single purpose. They may only serve other purposes by accident or incidentally, but that is almost inevitable. Somewhere between these two unmistakable extremes is a primarily single purpose project that incidentally serves or disservices another project purpose. The presence of benefits or costs incidental to the primary purpose of the project does not make a project multipurpose. A project is multipurpose when it is formulated, designed and constructed to serve more than one purpose. The key is to formulate measures for each purpose. In this case, the contribution to their purposes is not incidental and that project purpose must bear its fair share of the project's costs.



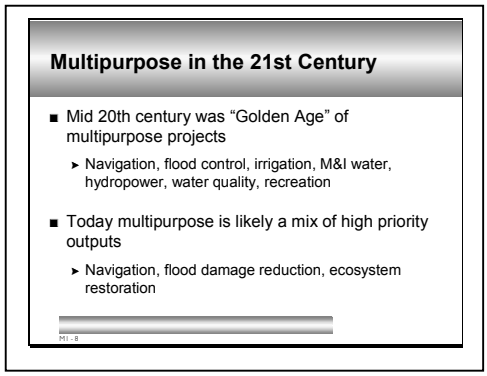
"Project purpose" means a type or kind of project, the purpose for which it is undertaken. For example, flood damage reduction is a project purpose, as is navigation. The term does not necessarily imply an exclusive use of a particular kind. Water stored for hydropower also provides recreational opportunities even if that was not the reason for the water's storage. Neither does a single purpose project imply one category of economic benefits accruing to the project. Corps projects are formulated for specific project purposes, i.e. to produce specific outputs. This does not necessarily mean the project will produce only those outputs for which the project was formulated. There can be incidental benefits to any single

purpose project. A project formulated only for navigation (project purpose) could also have flood damage reduction benefits and recreation and navigation benefits.

Often, but not always, a multipurpose project has separable elements. A separable element is any part of a project which has separately assigned benefits and costs that can be implemented as a separate action. This separate action may be a separate project or a phased component of a project. In other cases a common element of a project may serve multiple purposes. For example, a navigation channel can support commercial fisheries and recreational navigation, as could a breakwater that protects a mixed-use harbor. In addition, recreation for a structural flood damage reduction project is supposed to be something that cannot stand on its own, hence it is by requirement not a separable element. Consequently, planners must recognize that multipurpose projects can come in different forms. Perhaps the most authoritative, if not the most useful, definition of a multipurpose project is that a project is multipurpose if its costs are allocated to more than one purpose.

It is not always easy to discern the difference between incidental and separable purposes. A jogging trail on top of a levee might seem like incidental recreation. It would not be, however, if there are separable features for this recreation purpose that are not required for the single purpose flood damage reduction project. For example, the separable features might be limited to signs. If the path is improved in any way that would be separable, as would the addition of benches, warm-up stations, and comfort stations. The interest in the lands could be intensified from easement to fee to accommodate the trail. To help you think about these concepts consider a project as a recipe. If any ingredients (signs, benches, etc.) have to be added to accommodate a purpose the purpose is a separable one. But if people just decide that running on top of the levee is a good idea and no extra ingredients are added to the flood damage reduction recipe the benefits would be incidental.

In the 1960s a multipurpose project may have included a navigation pool, hydropower, flood damage reduction storage, irrigation water and recreation features. The age of large multipurpose dams has passed. With it has passed this complex mix of purposes at a single project. A more realistic multipurpose project today would be a local flood damage reduction project with ecosystem restoration features, or a navigation project with ecosystem restoration, or an ecosystem restoration project with flood damage reduction. There might be an occasional recreation purpose to accompany a project. And although the number of purposes of a project may be smaller and the mix of purposes less diverse the principles of multipurpose planning remain unchanged.



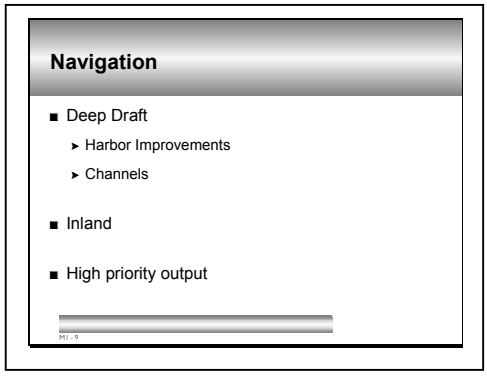
The mix of project purposes could be any from the Corps' seven missions or purposes. Currently, recreation, water supply and hydropower are formulated only in connection with a high priority primary purpose of flood damage reduction, hurricane and storm damage reduction, navigation or ecosystem restoration. That is, the Corps does not currently recommend single purpose water supply, hydropower or recreation projects.

Realistically, it is likely that a multipurpose project will reflect the budgetary priorities of the President and Congress. At the current time flood damage reduction, navigation and ecosystem restoration are considered the high priority outputs of the Corps' program. That does not mean that other purposes are unimportant, it simply means they receive less priority in the allocation of the Nation's scarce budgetary

resources. It suggests, as we've indicated above, that the most likely multipurpose projects will be a mix of these three purposes. Having said that, however, there is always the chance that the opportunity will arise to include one of the Corps other project purposes in the formulation of a plan. Consequently, we briefly consider each of the Corps' missions.

The Corps' Missions

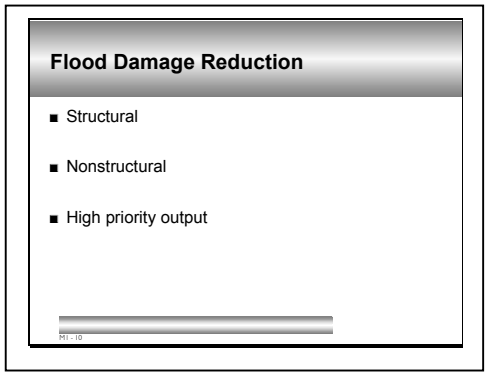
Navigation



The Corps' missions are distinguished by the fact that it has been determined that there is a Federal interest in being involved in these activities. The Federal interest in navigation derives from the Commerce Clause of the Constitution, and is limited to the navigable waters of the United States. Federal navigation improvements must be in the public interest and must be open to the use of all on equal terms. As a matter of law and policy, a distinction is made between general navigation features, and other features or facilities serving navigation. The Corps participates financially in general navigation features and Special Navigation Programs only (see ER 1105-2-100); all other features and facilities (e.g., piers) are non-Federal responsibilities. These general navigation features are measures used to formulate plans. Navigation is divided into deep draft (channels and harbors) and inland navigation (channels, locks, and dams)

General navigation features include channels, jetties or breakwaters; locks and dams; basins or water areas for vessel maneuvering, turning, passing, mooring or anchoring incidental to transit of the channels and locks. They also include dredged material disposal areas (except those for the inland navigation system, the Atlantic Intracoastal Waterway and the Gulf Intracoastal Waterway), and sediment basins. These are eligible for development as general navigation features of harbor or waterway projects. Special Navigation Programs include removal of wrecks and obstructions; snagging and clearing for navigation; drift and debris removal; bridge replacement or modification; and mitigation of project-induced damage.

Flood Damage Reduction



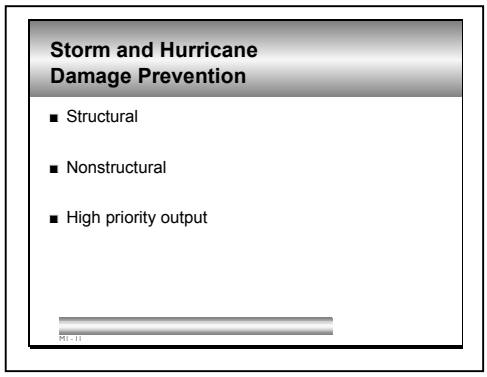
The Flood Control Act of 1936 established the policy that flood damage reduction on navigable waters or their tributaries is in the interest of the general public welfare, and is therefore a proper activity of the Federal Government. It provided that the Federal Government, cooperating with state and local entities, may improve streams or participate in improvements "for flood damage reduction purposes, if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are

otherwise adversely affected." The 1936 Act, as amended, and more recently the Water Resources Development Act of 1986 and other acts, specify the details of the program and the nature of the Federal government's participation.

Typically, the Corps will consider structural or nonstructural measures for reducing flood damages. Structural measures include dams with reservoirs, dry dams, channels, levees, walls, diversion channels, ice-control structures, and bridge modifications.

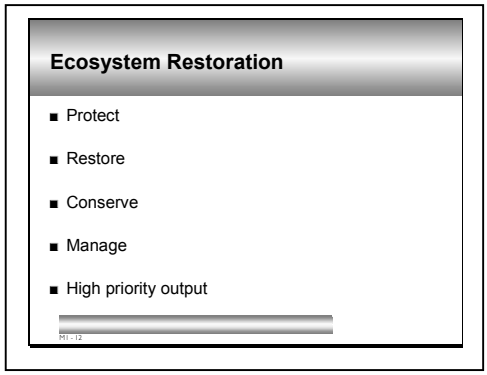
Section 73 of the 1974 Water Resources Development Act requires consideration of nonstructural alternatives in flood damage reduction studies. They can be considered independently or in combination with structural measures. Nonstructural measures reduce flood damages without significantly altering the nature or extent of flooding. They do this by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard. Examples are flood proofing, relocation of structures, flood warning/preparedness systems, and regulation of flood plain uses. These are among the measures used to formulate for the purpose of flood damage reduction.

Storm and Hurricane Damage Prevention



Congress has authorized Federal participation in shore protection projects to prevent or reduce damages caused by wind and tidal generated waves and currents along the Nation's ocean coasts and Great Lakes shores. The improvements are usually structural and nonstructural measures as with flood damage reduction. Structural measures include such features as beachfill, groins, seawalls, revetment, breakwaters, and bulkheads. Nonstructural measures include such features as property acquisition, may also be appropriate.

Ecosystem Restoration



Numerous Federal laws and executive orders establish the Federal interest in protecting, restoring, conserving and managing environmental resources. These provisions include compliance requirements, they emphasize protecting environmental quality, and they endorse Federal efforts to advance environmental goals. A number of these laws and orders say that full consideration should be given to the opportunities projects afford to ecological resources. Recent water resources authorizations have enhanced the Corps' opportunities to specifically address objectives related to the restoration of ecological resources and ecosystem management. Specific authorities for new individual studies and projects to restore ecological resources have also been provided in legislation. Examples include:

Federal Water Project Recreation Act of 1965, as amended; Water Resource Development Acts of 1986, 1988, 1990, 1992, 1996 and 1999; Coastal Wetlands Planning, Protection and Restoration Act of 1990 (Title III of P.L.101-646).

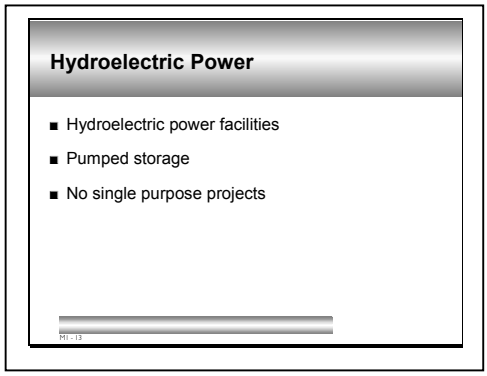
The Corps ecosystem restoration policy is described in more detail in ER 1165-2-501 and EP 1165-2-502. Ecosystem restoration focuses on projects that restore ecosystems and ecological resources. This does not include restoration of cultural and historic resources, aesthetic resources, or clean up of hazardous and toxic wastes.

The authorities through which the Corps can participate in ecosystem restoration, protection studies, and project implementation include:

1) Congressionally authorized studies, pursued under General Investigations (i.e., new start reconnaissance and feasibility studies) for single-purpose ecosystem restoration or multipurpose projects that include ecosystem restoration as a purpose.
2) Programmatic authorities such as:
    a. Section 1135, Project Modifications for Improvement of the Environment Water Resources Development Act, WRDA of 1986, as amended;
    b. Section 206, Aquatic Ecosystem Restoration WRDA of 1996, as amended;
    c. Section 204, Beneficial Uses of Dredged Material, WRDA of 1992, as amended;
    d. Dredging of contaminated sediments under Section 312, WRDA of 1990, as amended; and
    e. Flood Mitigation and Riverine Restoration Program Section 212 of WRDA of 1999.
3) Additional opportunities for ecosystem restoration and protection may also be pursued through existing project authorities for the management of operating projects; e.g., through water control changes or as part of natural resources management.

The typical measures used for ecosystem restoration do not lend themselves easily to enumeration. Some that have been implemented are wetlands creation using dredged material, placement of woody debris in streams and the creation of pools and riffles to improve fish habitat, oxbow restorations on river systems, habitat creation for critical species, more intensive management of existing habitats, revetment and closure dike removal and lowering to increase channel width and to restore historical channel configuration. Changes in regulated flow regimes for scour or to emulate historical flows and in the case of Kissimmee River restoration of the whole river,

Hydroelectric Power



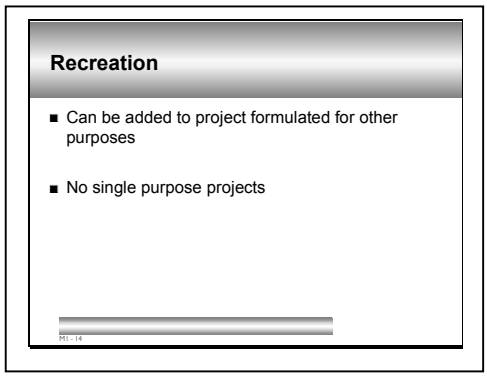
Hydroelectric power development may be considered during planning for multipurpose projects involving dams and lakes and may be recommended if non-Federal development would be impractical. The Corps does not construct single purpose hydroelectric power projects. No single purpose hydropower studies may be initiated for new sites unless specifically directed and funded by the Congress. Non-

Federal sponsors must agree to share the cost of the feasibility study with the explicit understanding that any resultant project will be financed by non-Federal funds.

Existing Corps projects without hydroelectric power facilities may have them added, either through Congressionally authorized Federal development, or preferably through Federal Energy Regulatory Commission (FERC) licensed non-Federal development.

Pumped storage may be investigated where non-Federal development would be impractical. Pumped storage facilities can be either integral or adjoining. Integral facilities frequently consist of a conventional powerhouse with reversible units, i.e. the same turbines alternately generate power and pump water. Adjoining facilities usually consist of an upper or lower reservoir and powerhouse and intake separate from the multipurpose project dam and conventional powerhouse, if any. Adjoining facilities may be the only practical way to add pumped storage to an existing project.

Recreation

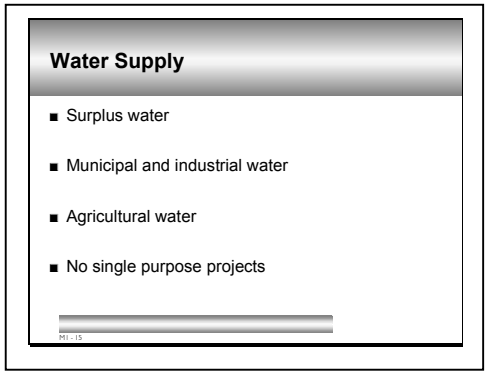


The legislative basis for Federal participation in recreation development is found in the Flood Control Act of 1944, as amended, the Federal Water Project Recreation Act of 1965 (Public Law 89-72), and the Water Resources Development Act of 1986 (Public Law 99-662). These give broad authority to include recreation as a project purpose. Recreation is currently a low priority output so the Corps cannot formulate single purpose recreation plans unless a sponsor is willing to pay 100 percent of the associated implementation costs.

Recreation can, however, be added to a project formulated for other purposes. When that happens the cost sharing requirement is just 50 percent. The Corps can also plan for and implement projects serving other purposes that may have incidental recreation benefits. Incidental benefits comprise less than 50% of total benefits, or less than 50% of the average annual project costs. For multipurpose projects recreation may be included as a primary purpose if there is a non-Federal sponsor.

Measures providing outputs or services generally considered vendible are non-Federal responsibilities. Marina facilities and telephone services are examples. Any improvement or service not closely and directly related to enjoyment of the natural resource itself is a non-Federal responsibility, even if it is not generally considered vendible. Examples of these include tennis courts and accommodations for viewing sporting or cultural events taking place on or near a lake.

Water Supply



The Flood Control Act of 1944 and the Water Supply Act of 1958, as amended, among other pieces of legislation, define the Federal interest in water supply. The current policy was defined by Congress in Section 932 of the WRDA of 1986. This policy is based on recognition that states and non-Federal entities have the primary responsibility in the development and management of their water supplies. The policy also recognizes a significant but declining Federal interest in the long-range management of water supplies and assigns the financial burden of supply to users. The Corps may, however, participate in developing water supplies in connection with water resource improvements for construction, operation, maintenance, and modification of Federal navigation, flood damage reduction, or multipurpose projects when certain conditions of non-Federal participation are met. Existing legislation gives the Corps authority to use its reservoirs for surplus water, for municipal and industrial (M&I) water supply and for agricultural water supply. The Corps is also authorized to provide emergency water and assist states and local interest in their water supply planning process.

In order to include M&I as a project purpose in a multipurpose project, benefits from water supply can not exceed the following limits depending on the type of project: 1) The project has justified, separable storage for flood damage reduction or navigation or agricultural water supply. In this case the sum of benefits for these purposes must be at least ten percent of total NED benefits. If M&I water supply exceeds 90% of total benefits the project is considered single purpose water supply and thus not eligible for Federal participation. 2) The project has no separable storage for flood damage reduction or navigation or agricultural water supply. In this case the sum of benefits for these purposes must be at least twenty percent of total NED benefits. If M&I water supply exceeds 80% of total benefits the project is considered single purpose water supply and thus not eligible for Federal participation.

The Corps cannot conduct single purpose water supply studies, except for analysis of existing data under Section 22 of the Water Resources Development Act of 1974. This constraint does not apply to single purpose water supply modifications to previously constructed projects having flood damage reduction or navigation purposes. Also, the Corps may conduct reimbursable single purpose water supply studies for non-Federal interests under provisions of the Intergovernmental Cooperation Act of 1968.

Review Questions

1. Distinguish between multi-objective planning and multipurpose projects.
2. Give one example of multi-objective planning from the Corps' past.
3. What planning objectives were identified by Senate Document 97?
4. When was the golden age of multipurpose reservoir projects?

5. What are the Corps' high priority outputs/purposes?

6. Can you formulate a water supply project? A hydropower project? A recreation project?

Section Summary and a Look Forward

Language usage is very messy at times. To make matters worse, it is not used consistently across time. The words as used here are defined for use here, be forewarned that other people may use the words differently. Planning is multi-objective. Projects can be multipurpose. Watersheds have historically been a natural focus for water resources planning and are becoming so again. Each of the Corps' current business programs has a rich, complex, and unique legislative history.

With this background on project purposes in mind it is important to understand that planners formulate for specific project purposes in multipurpose planning. That is the subject of the next module.

References and Suggestions for Further Reading

Corps Policy and Guidance

The best source of Corps Guidance on the topics of this chapter is the Planning Guidance Notebook, ER 1105-2-100. Current Corps guidance on multipurpose issues can be found by searching on "multipurpose, multipurpose, multiple-purpose and multipurpose" at: http://www.usace.army.mil/search.html#Search. Most of the historical discussion of multipurpose projects developed around multipurpose reservoirs where some purposes were reimbursable and others were not. That limits their utility to current formulation situations but they are still a valuable source of information.

For an excellent history of water resources in the U.S. read Beatrice Holmes. The two best sources are:

Holmes, B.H., *A History of Federal Water Resources Programs, 1800-1960.* No further information available.

Holmes, B.H., *History of Federal Water Resources Programs and Policies, 1961-70.* U.S. Department of Agriculture, Economics, statistics and Cooperative Service, Miscellaneous Publication No. 1379. 1979.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will be familiar with the Corps history of multipurpose projects
2. Students will be able to identify the Corps seven major programs and project purposes
3. Students will be able to discuss the Corps' policy on multipurpose plans

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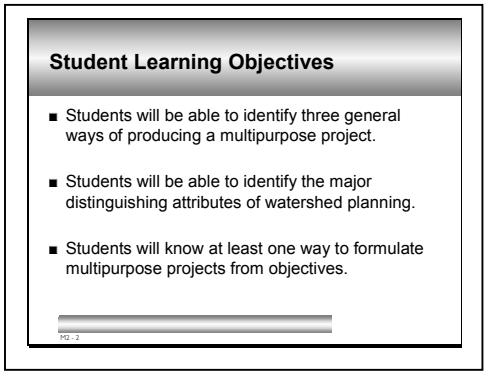
Instructor Notes and Exercises:

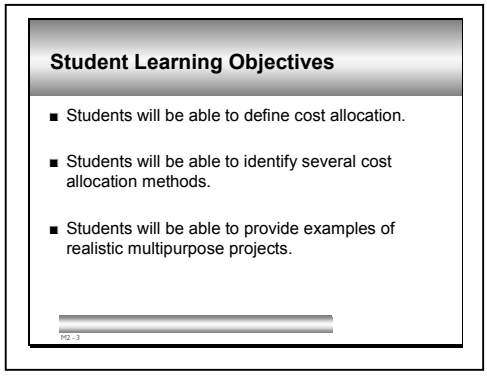
This section needs to be a flexible one. It can be expanded or contracted depending on whether and how much the purposes were covered earlier in the course. The key is these are not new ideas, so no one should get too excited. There is much to be learned from the past, a great deal of thought and work has already been done on these topics. Let students know they can profitably learn a great deal about the topic by searching out and reviewing some of the earlier materials. There is a great deal of "authority" material here. Normally this is very dry, if necessary. Go over it lightly unless there is a program that requires special attention.

Slide M1-1
Exercise M1.1 Language
You might begin by asking students to distinguish these two concepts for you. They will have slides with definitions in their books so if you begin this way do so before they turn to the module. Ask them what the difference between multi-objective and multipurpose projects is. Maybe there is one they do not understand. If not, ask if planning is multipurpose. The point here is to clarify the language then to use it consistently. Do this before displaying the second slide.

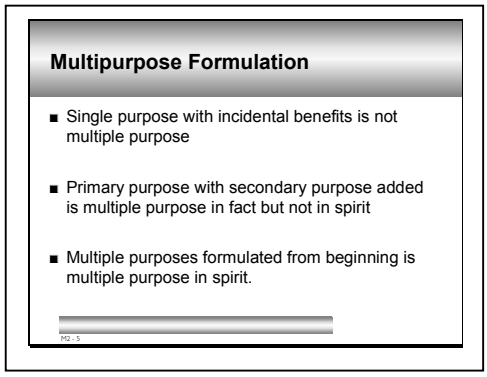
Slide M1-4
Exercise M1.2 What Do You Know?
Ask, "When did this emphasis on multipurpose projects begin?" If you are lucky students will think it a recent phenomenon. Ask if anyone has been involved in a multipurpose project. Have them say a little about it and their experience if they were. The purpose of this exercise is to make sure people understand a little bit of the history of multipurpose projects.

Module M2: Multipurpose Formulation

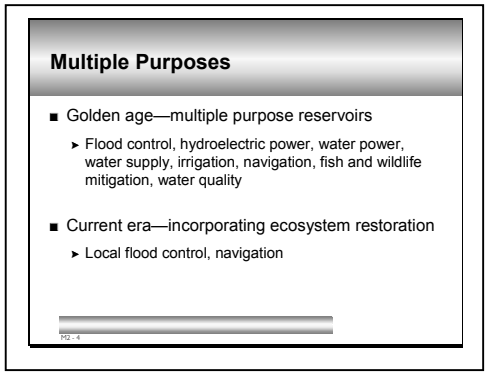




The golden age of multipurpose reservoir projects has passed. Multipurpose project formulation in the current era most likely means incorporating ecosystem restoration purposes into a flood damage reduction or navigation project. Recreation is a reasonably common third purpose. As multipurpose projects are experiencing a revival in water resources planning it is important and timely to consider the challenges of formulating a multipurpose project.



A single purpose project that incidentally provides more than one benefit category is not a multipurpose project. Some multipurpose projects evolve from single purpose projects to which a second purpose is added. Although these projects may be multipurpose in fact and in cost sharing, they are not multipurpose in spirit. A true multipurpose project does not add a second purpose to a primary purpose in an opportunistic or afterthought manner. Planners formulate multipurpose projects from the very beginning of the formulation process.



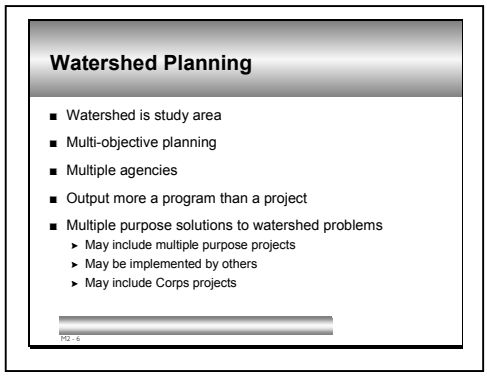
Problems and opportunities are identified and planning objectives and constraints are established. When these objectives can be met by multiple purposes, formulation strategies should incorporate these purposes from the very beginning.

One of the most effective formulation strategies is to formulate to meet each planning objective. Suppose we are considering a project that could include flood damage reduction, ecosystem restoration and recreation. Further suppose one objective is to increase the quantity and quality of riverine terrestrial

native habitats. To formulate a multipurpose project the team would identify as many flood damage reduction measures that could increase the quantity or quality of native habitat as possible. These measures would vary with the situation but it could easily include levees set back from river banks to preserve riverside terrestrial habitat, evacuation of the flood plain, land use controls, channel improvements and so on. Then the team would identify ecosystem restoration measures that would meet this objective. These could include land management, habitat creation, water holes, plantings, duck boxes and so on. The recreation measures that could be identified might include an interpretative nature trail, wildlife viewing stations, and greenways. Formulation proceeds from the identification of measures to the assembly of the measures into coherent combinations that constitute true multipurpose plans. Multipurpose plans can result from the familiar project planning initiatives or they could result from the Corps' watershed planning initiatives.

Watershed Planning

Watershed planning considers the entire river basin rather than focusing on a specific locale or reach of the river. This is a major distinction between it and project planning. With this broader view of problem solving through planning, watershed planning has a system focus much as the comprehensive river basin studies of the Corps' past did. It seems only reasonable that watershed planning with its more comprehensive view of a watershed and its problems should lead to multipurpose projects more often than not. Whether it does or not will depend on the circumstances of each unique study. But clearly, the formulation process should always be multipurpose in nature and even single purpose projects will emerge from a formulation process that was multipurpose in nature.



The 308 Reports mentioned in the previous module were essentially watershed studies. Pragmatically these reviews recommended a series of projects that served a variety of purposes. Some projects were multipurpose some were single purpose. All were conceived in a multipurpose environment. The reports in essence were more like a program than a typical project plan. Watershed planning is envisioned in the same way today.

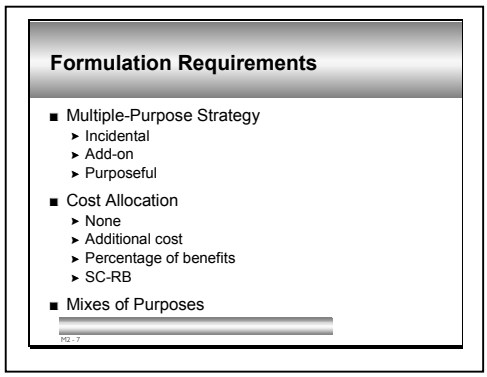
The Corps of Engineers is limited in what it can do by the authorities provided it by Congress and the budgetary priorities of the Administration. The Corps has the authority to engage in watershed planning and unconstrained multipurpose plan formulation for a watershed. A comprehensive plan for the watershed would undoubtedly include some purposes and initiatives that are beyond the Corps' authority to implement. Thus it is envisioned that implementation of the watershed plan would be the responsibility of another entity. Some of the recommendations of the watershed plan would be implemented without Corps participation. The plan may also identify components of the watershed plan that the Corps and sponsor may pursue under Corps' authorization.

Watershed planning is always multi-objective and these objectives invariably relate to multiple problems and opportunities. A full range of multipurpose solutions to the watershed's problems should always be investigated. Solutions to these multiple problems that achieve the multiple objectives should be multipurpose at least from a programmatic perspective and preferably at the project level as well when such projects can take advantage of significant savings and synergy by virtue of their integration.

Watershed planning is likely to involve more stakeholders than project planning. This presents a formulation challenge to planners who must coordinate with and involve more agencies, non-government organizations and other interest groups. This means a more complex web of conflicts, compromises, trade-offs, legal mandates and constraints that must be taken into account.

Multipurpose Formulation Requirements

Multipurpose formulation requires a formulation strategy and cost allocation considerations. Multipurpose projects emerge in one of three ways. Each has its place in the Corps' plan formulation process but the third of these is the generally preferred way to formulate multipurpose projects. In the first, benefits associated with another purpose are incidental to the project's performance. An example might be where good environmental design of a navigation or flood damage reduction project results in some ecosystem improvements. This may be most appropriate when the features required to realize these incidental benefits are very limited and the results of their inclusion is important to sustainability of to meeting policy requirements.



A second example of an emergent multipurpose plan might be where a purpose is added to a formulated plan. In this case the secondary purpose is an addition (a last added element in the jargon of the Corps) with benefits sufficient to support its separable costs. This type of plan makes the most sense when the single purpose project is economically justified, accounts for the preponderance of the benefits, and the evaluation required to allocate the joint costs are not worth the effort. An example of this situation might be a nonstructural flood damage reduction and restoration project with one sponsor.

The third, and ideal source of a multipurpose plan occurs when a multipurpose plan is formulated from the outset and costs are allocated among the purposes. Two "requirement themes" run in parallel with these three approaches. First, there is the manner of the multipurpose formulation. This evolves from incidental consequences through add-on to purposeful incorporation. Another theme can be found in the cost allocation. This evolves from none through last added separable costs to full cost allocation in the three ways multiple purposes emerge from Corps projects.

The Corps high priority outputs include flood damage reduction, hurricanes and storm damage reduction (H&SDR), navigation and ecosystem restoration. A multipurpose plan can include any mix of these purposes. Currently, recreation, water supply and hydropower purposes are formulated or recommended as project purposes only in conjunction with one or more of the high priority outputs. These and other purposes may, however, be included in a multipurpose watershed plan that does not require implementation by the Corps.

Cost Allocation Methods

Cost allocation is a complex and arcane topic for most planners so it deserves some discussion. Cost allocation is the process of apportioning the total financial costs of a project among the purposes served by the project. This apportioning is made necessary by the fact that different project purposes have different cost shares associated with them. That is the sponsor may pay x percent of the costs associated with purpose A and y percent of the costs associated with purpose B. Cost allocation is the process of figuring out how much of the cost is associated with purpose A and how much is associated with purpose B. This is necessary because x and y are different percentages.

Cost Allocation

- The process of apportioning the total financial costs of a project among the purposes served by the project.
- Made necessary by different cost shares for different project purposes.

M2 - 8

Several cost allocation methods have been used historically by the Corps. The separable costs - remaining benefits (SC-RB) method of cost allocation is recommended for use with multipurpose projects. Described at length in the next module, it relies on a thorough and rigorous plan formulation process. Not only should that process consider alternative multipurpose projects it must also consider variants of each multipurpose project that proceeds to the final rounds of comparison prior to plan selection, as well as a series of single purpose project, in order to generate information required for the SC-RB method.

Cost Allocation Methods

- Separable Costs-Remaining Benefits (SC-RB)
  - Recommended Green Book 1958 & Section IX of ER 1105-2-100
- Alternative Justifiable Expenditure Method
  - EM 1160-2-101, 1 Jan 58
- Use of Facilities Methods
  - EM 1160-2-101, 1 Jan 58
- Incremental Costs
  - Recreation
- Percent of Benefits
  - Commercial and recreation navigation

M2 - 9

The application of the SC-RB method relies on cost estimates of the multipurpose project with each purpose excluded. For example, suppose you formulate a plan with flood damage reduction, ecosystem restoration, and water supply purposes in a watershed. The SC-RB method requires a cost estimate for that plan with no flood damage reduction, that same plan with no ecosystem restoration, and that same plan with no water supply. To estimate the costs of these plans the plans themselves must be formulated.

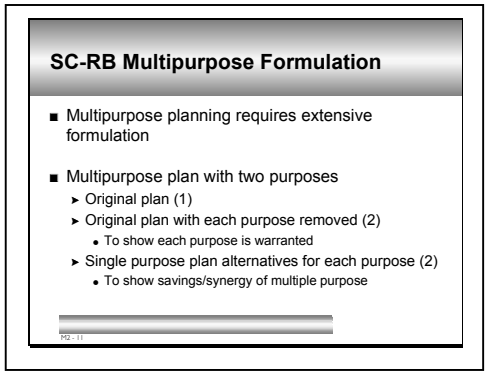
SC-RB Formulation Requirements

- SC-RB relies on rigorous formulation process
- Multiple purpose projects
- MP projects with each purpose removed
- Single purpose alternative projects

M2 - 10

If that is not burden enough, the method also requires formulation of the most likely alternative single purpose plan. In other words, if the flood damage reduction benefits provided by the multipurpose project were to be provided by a single purpose flood damage reduction plan, what would that plan cost? Once again, to answer that question the plan must be formulated.

Conceivably a multipurpose project with two purposes could involve as many as a total of five different plans; the original plan (1), the plan with each purpose removed (2), and single purpose plans for each purpose (2) if they are different. A plan with three purposes could involve seven plans. And these examples exclude the fact that alternative multipurpose plans will likely be formulated.

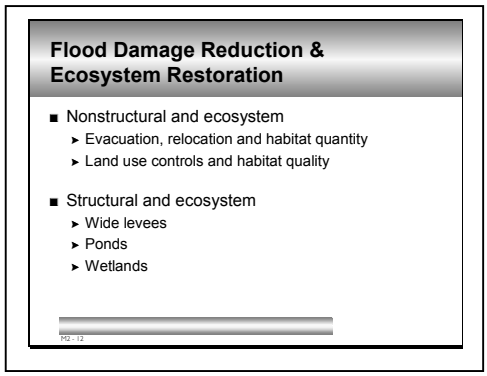


Planners need to be aware that multipurpose plan formulation involves a great deal more than identifying a plan. There needs to be some assurance that the multipurpose plan is better than a series of single purpose plans and that each added purpose is indeed warranted. Currently this means each project purpose must be economically justified. That, however, is a policy that may continue to evolve and change.

In the paragraphs that follow some of the more likely multipurpose projects combinations are discussed. The examples are representative rather than exhaustive.

Flood Damage Reduction and Ecosystem Restoration

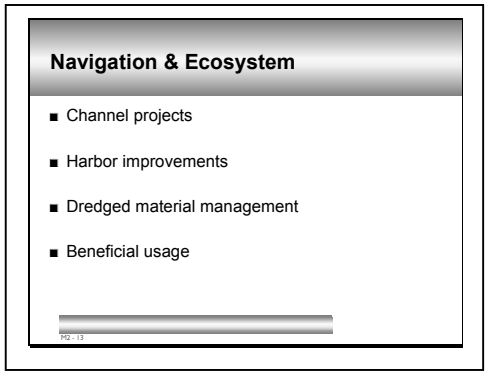
The most promising multipurpose projects involving these purposes are likely to involve the reuse of flood plain land made available to ecosystem restoration through nonstructural measures. Flood damage reduction measures that raze or relocate houses or otherwise permanently evacuate a flood plain effectively provide new resources for ecosystem restoration. Likewise measures that affect land use to preclude, minimize or control development densities can be effective compliments to ecosystem restoration plans.



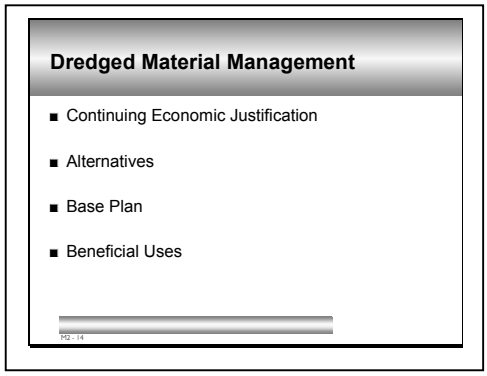
More environmentally friendly designs of structural projects provide opportunities to incorporate ecosystem restoration values in projects. Lands acquired for flood damage reduction purposes can be managed for fish and wildlife to achieve ecosystem benefits. Wider levee tops make for easier access to adjoining areas and easier animal passage and other habitat values. Ponds and wetlands can represent more environmentally sustainable flood damage reduction options.

Ecosystem restoration has been added to flood damage reduction projects when the flood damage benefits are substantial. And it is equally feasible to add flood damage reduction to an ecosystem restoration project. Recreation features are also compatible with flood damage reduction and ecosystem restoration purposes and can be formulated from the outset.

Navigation and Ecosystem Restoration



Dredge Material Management Plan



The requirements for the formulation of dredged material management plans have been rather carefully specified. The components of such a plan have been identified in Policy Guidance Letter No. 40 as follows.

Continuing Economic Justification

The first step is to confirm that continued maintenance of a project is justified or that new investments are justified. Continued economic justification must also be demonstrated when any other significant increase in maintenance cost, for example the provision of a new confined disposal facility or use of a more distant ocean disposal site, is needed. If projects or increments of projects are not justified for continued or new maintenance, the management plan shall provide for appropriate adjustments in the maintenance program, which could include deferral of dredging, maintenance to lesser project dimensions, or the orderly curtailment of maintenance.

Alternatives

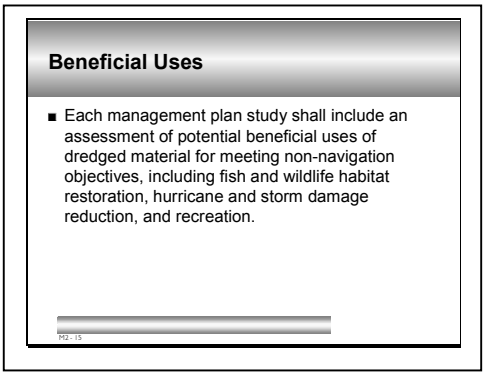
Management plans shall consider the full range of measures for dredged material management, including measures to reduce dredging requirements, management of existing disposal sites to extend their life, and various combinations of new disposal sites involving different disposal methods, disposal area locations, and periods of use.

Base Plan

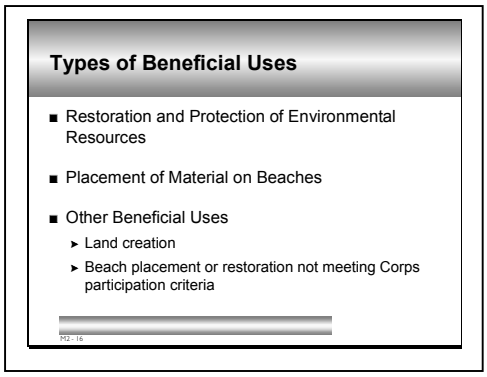
The Federal interest in continued operation and maintenance of an existing Federal project for its navigation purpose is defined by the least cost plan for dredged material management that is consistent with sound engineering practice and meets the environmental standards established by Section 404 of the Clean Water Act of 1972 or Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended. Therefore, each management plan must establish this base plan using the procedures in 33 CFR Parts 335, 336, 337 and 333.

Beneficial Uses

Each management plan study shall include an assessment of potential beneficial uses of dredged material for meeting non-navigation objectives, including fish and wildlife habitat restoration, hurricane and storm damage reduction, and recreation. Where a beneficial use is part of the base plan for navigation purposes, it shall be treated as a general navigation operation and maintenance component.



Costs for beneficial uses that are consistent with and part of the base plan are operation and maintenance costs and the costs of studies pursuant to these beneficial uses are Federal cost, recoverable from the Harbor Maintenance Trust Fund. However, study costs for beneficial uses which are not part of base plan, beyond those reconnaissance level studies needed to identify these potential uses as part of management plan studies, are either a non-Federal responsibility or are a shared Federal and non-Federal responsibility depending on the type of beneficial use, as follows:



1. Restoration and Protection of Environmental Resources. The incremental costs above the base plan for the use of dredged material to restore and protect environmental resources, pursuant to Section 1135 of the WRDA 86 as amended, and/or Section 204 of the WRDA 92 (Note: Section 204 was modified by Section 207 of WRDA 96) must be shared on a 75% Federal and 25% non-Federal basis with a qualified non-Federal sponsor. Incremental costs for planning, design and implementation for environmental restoration and protection are not navigation operation and maintenance costs and the Federal portion of such costs are not recoverable from the Harbor Maintenance Trust Fund. If a potential restoration beneficial use project exceeds the cost limitations of section 1135 or section 204, it may be pursued as a cost shared feasibility study leading to specific authorization.

2. Placement of Material on Beaches. The Corps will participate in the additional costs of placing clean sand or other suitable material, dredged by the Corps during construction or maintenance of Federal navigation projects, onto adjacent beaches or near shore waters, if the added cost of placement is justified primarily by the benefits associated with hurricane and storm damage protection provided by such beach or beaches and the beach involved is open to the public with public access. Under the authority of Section 145 of the 76, WRDA as amended by Section 933 of WRDA 86, and Section 207 of WRDA 92, the cost sharing for the placement of the sand is 50 percent Federal and 50 percent non-Federal. The non-Federal sponsor must provide 50 percent of the incremental study costs at the time of construction.

3. Other Beneficial Uses. Other potential beneficial uses include placement of dredged material for land creation or land enhancement for development purposes, placement of dredged material on beaches not meeting the criteria for Corps participation, and environmental enhancement projects not meeting the criteria for Corps participation. In these cases all incremental study costs and implementation costs above the cost required for the base plan must be paid by non-Federal interests.

Studies for beneficial uses involving increments of costs over the base plan shall be pursued using the programmatic funding of the Section 1135 (Construction, General) or Section 33 (Operation and Maintenance, General), as applicable. Programmatic funding under the section 204 authority was not appropriated for Fiscal Year 93 but will be requested for Fiscal Year 94. If a potential restoration beneficial use project exceeds the cost limitations of section 1135 or section 204, it may be pursued as a cost shared feasibility study leading to specific authorization.

Environmental Consistency

Management plan studies shall address the requirements of all applicable environmental statues for all disposal options considered including the requirements of the National Environmental Policy Act, Section 404 of the Clean Water Act, Section 103 of the Marine Protection, Research and Sanctuaries Act, and the Coastal Zone Management Act.

Review Questions

1. What is the best way to formulate a multipurpose project?

2. What distinguishes watershed planning from project planning?

3. Define cost allocation.

4. What is the Corps' recommended cost allocation technique?

5. What will the most likely multipurpose project look like in the future and how does that differ from the multipurpose projects of the past?

Section Summary and a Look Forward

The multipurpose projects of the future are a far cry from the multipurpose reservoirs of the past. It is more likely that ecosystem restoration and recreation measures will be added to a flood damage reduction or navigation project than that a multipurpose plan will be formulated for all these purposes from scratch. And that is a trend that should be reversed. The best multipurpose plans, now as during the golden age of these projects, are formulated for multiple purposes from the beginning of the planning process.

Well-formulated multipurpose plans require cost allocation. There are several ways to allocate costs. The SC-RB method of cost allocation places a substantial burden on planners to formulate plans to ensure that a multipurpose plan is better than a single purpose plan and that each purpose is economically justified. Cost allocation using the SC-RB method is demonstrated in the module that follows.

References and Suggestions for Further Reading

Watershed planning is a new enough concept that new works are being produced all the time but we have been unable to find one or two that helps define the concept in a way that is useful to Corps planners. Consequently, the search goes on for this material.

Most of the good materials on cost allocation are dated and may be a little hard to find.

A nice annotated bibliography was prepared by the Division of Navigation Development and Technical Library of the TVA. It contains several examples and articles related to the evolution of thinking on cost allocation. Copies may be available from agency libraries. The effort put into the search should be tempered by the fact that the articles, although very good in some cases, are also dated and may be hard to find. The bibliography is "Benefit-Cost Analysis of Water Resource Projects: A Selected Annotated Bibliography," prepared by the Tennessee Valley Authority, Knoxville, Tennessee, October 1967.

Two good sources of general background on cost allocation are classic texts for water resource economists and engineers. The first reference is Chapter 23 Cost Allocation in *Economics of Water Resources Planning* by L. Douglas James and Robert R. Lee, McGraw-Hill, New York, 1971. The second reference is scattered locations throughout *Principles of Engineering Economy* by Eugene L. Grant, w. Grant Ireson, and Richard S. Leavenworth, John Wiley & Sons, New York, 1976.

The government documents of most value are also dated. A good starting point for a description of the SC-RB method is "Proposed Practices for Economic Analysis of River Basin Projects," a Report to the Inter-Agency Committee on Water Resources by the Subcommittee on Evaluation Standards, revised in May 1958.

For those with access to a good set of old Corps guidance Cost Allocation for Multipurpose Projects Allocation of Cost is found in EM 1160-2-101 1 January 1958. More recently Section IX - Multipurpose Projects of ER 1105-2-100 is a good source of information.

Selected Notes to the Instructor

Student Learning Objectives:

1. Students will be able to identify three general ways of producing a multipurpose project.
2. Students will be able to identify the major distinguishing attributes of watershed planning.
3. Students will know at least one way to formulate multipurpose projects from objectives.
4. Students will be able to define cost allocation.
5. Students will be able to identify several cost allocation methods.
6. Students will be able to provide examples of realistic multipurpose projects.

Instructor Notes and Exercises:

Formulation of multipurpose projects is the key lesson here. If students know nothing else they should understand that projects could become multipurpose in one of three ways. Some are incidentally multipurpose. That is not the same as accidentally multipurpose. It means that by conscious design a project is modified in a minor way to enable it to produce benefits to a purpose incidental to the project's sole primary purpose. Projects can become multipurpose as an afterthought. Once a single purpose project has been completed is it sometimes possible to make it multipurpose by adding some features to the existing project design. If the benefits of these last added features exceed their costs that is sufficient. Acknowledge these sources of multipurpose plans and recognize their legitimacy. But emphasize that the best multipurpose plans are neither incidental nor afterthoughts. They are purposefully formulated as such from the outset.

Once people understand what a multipurpose project is and where it comes from, you discuss examples at the end of the modules, it is important to introduce the idea of cost allocation. You are not going to teach the techniques here but you want the idea to be clear. Note in the text that although the SC-RB receives the emphasis in this class there are other ways to do cost allocation. Be sure terminology is clear. People often confuse cost allocation, cost apportionment and cost sharing. We cost allocate because of different cost shares.

Slide M2-3
Exercise M2.1 The Spirit of Multipurpose Project Formulation
It is important for students to understand that multipurpose is a way of thinking. Begin by drawing a dam and reservoir in cross section on a flipchart or board. Ask people how the storage can be used. You are fishing for things like navigation, hydropower, water supply (get them to distinguish irrigation and M&I water), low flow augmentation (if there are any dinosaurs in the class), flood storage, recreation and anything else that might come up.

As students identify purposes draw horizontal slices of the storage and mark them for the purposes identified. Pose the question, "How do you think planners decided which of these would be included and which excluded?" You are looking for students to make the connection among problems, opportunities,

planning objectives and the formulation process. The key point is this was not a haphazard process. It was not a situation where a dam was built for one purpose and someone later decided to add a couple of feet for fish and wildlife mitigation! It was a purposeful process. People were thinking about these purposes from the beginning. And the system of reservoirs that may have existed in the watershed made the formulation all the more purposeful.

You want students to see that although the nature of a multipurpose project has changed the spirit in which they are formulated has not changed. Suppose a project like the text example that follows. You will want to lead the class through this example. The goal is to incorporate multiple pruposes into your formulation strategies.

Imagine a project where we are considering flood damage reduction, ecosystem restoration and recreation as potential purposes in the project. Suppose two planning objectives are as follows. 1.) To increase the quantity and quality of riverine terrestrial native habitats. 2.) To reduce flood damages to the residential community.

To help people understand the spirit of multipurpose plan formulation, write the three purposes on the broad in three columns. Pose the first objective. Ask for flood damage reduction measures that could meet this objective. List those the group identifies in the flood damage reduction column. Then ask for ecosystem restoration measures that achieve this objective. Do the same for recreation measures. Then repeat the process including a new list with three columns for each objective, for the second objective. Once you have these two sets of lists suggest that now you can begin o assemble these ideas, these measures into plans that will meet the two objectives to varying extents while serving the three purposes.

Stress that the three project purposes, although made up for the example, are not pulled from the sky. They emerge form the problem identification and planning objectives tasks of the planning process. Conclude with the strong message that this is how you formulate multipurpose plans from the outset. And that is how it should be done.

Slide M2-8 & 9
Exercise M2.2 Real Multipurpose Projects
This is not an easy concept for many people to get. Before proceeding to a discussion of some policies it is important to make sure people have the right mental model for this. It is time to go back to the class. Ask if anyone has even worked on a project with more than one kind of benefit. Ask what kinds of benefits. Ask their relative magnitudes. We want a picture of what the project produced. Now probe to find out if these benefits were incidental or not. Ask for examples of incidental benefits from their experience or things done by their District.

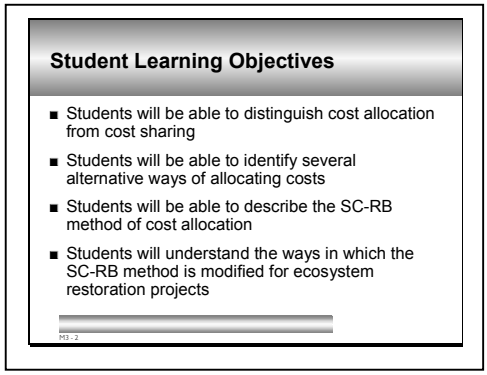
If no one has had any experience then it is time to get creative. Tell students you want to make sure the concepts are coming across. Give everyone a few minutes to think of an example of how a project they are now working on might include benefits incidental to another purpose. Then ask for these examples.

Ask who has worked on a project where they had to do cost allocation. This is a good opportunity to make sure that cost allocation is being properly understood as well. As before, draw people into the discussion. What were the purposes? Who did the cost allocation? What method was used? Did anyone understand it at all? Did USCAE get involved? At what point? Questions in this vein will help you define the situations.

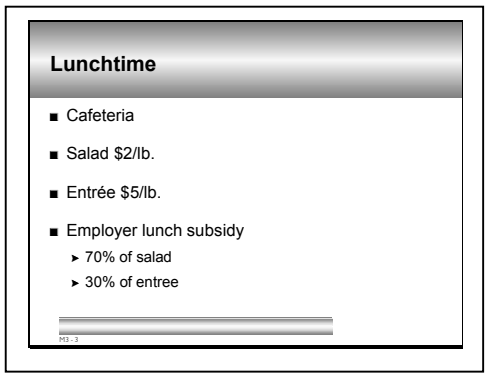
Finally, ask for examples of how flood damage reduction and ecosystem restoration could be combined. Tell them to use their experience. Keep notes on good examples for use in future offerings of the course. If they have no experience tell them to use their imagination. The point here is to cover as much of the

dry policy stuff that flows with class discussion. Do not be afraid to run long on the discussion at cost to the slides and lecture.

Module M3: Cost Allocation

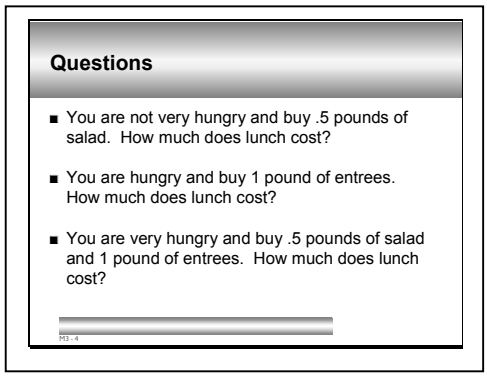


The Cost of a Meal



It's lunchtime. You're hungry and headed to lunch. Your employer offers a flexible benefits package and you chose the lunch subsidy as one of your perks. Under the lunch subsidy your employer will pay 70 percent of any salad costs for a lunch purchased in the company cafeteria. They will pay 30 percent of any entree costs. Apparently, the different costs reflect a policy decision to encourage healthy eating.

Entrees sell for $5/pound in one of those load'em up and weigh'em buffets. Salads sell for $2/lb. Potatoes are sometimes offered in salads and sometimes with entrees. They are also offered on their own at times.



Question 1: You are not very hungry and buy .5 pounds of salad. How much does lunch cost?
Answer 1: 5 x $2 = $1
Point 1: The purpose of this meal was to "eat healthy." This is like a single purpose project. Point out that different sized meals have different prices.

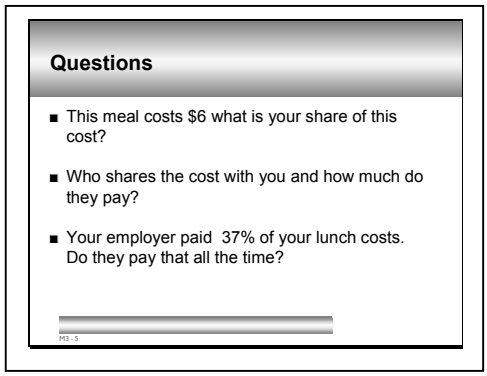
Question 2: You are hungry and buy 1 pound of entrée. How much does lunch cost?
Answer 2: 1 x $5 = $5
Point 2: The purpose of this meal was to "fuel up." It is like a single purpose project, with a different purpose.

Question 3: You are very hungry and buy .5 pounds of salad and 1 pound of entrees. How much does lunch cost?
Answer 3: .5 x $2 + 1 x $5 = $6
Point 3: The purposes of this meal were to fuel up while eating healthy. This is like a multipurpose project.

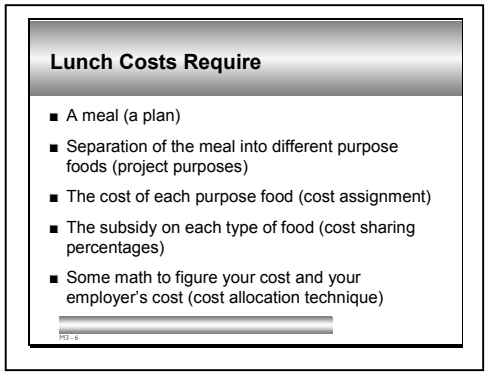
Question 4: The meal cost $6 but what is your share of the cost?
Answer 4: 30% x $1 + 70% x $5 = $3.80
Point 4: Your cost is of utmost importance to you.

Question 5: Who shares the cost with you and how much do they pay?
Answer 5: Your employer pays $2.20.
Point 5: Your employer cares about this value.

Question 6: Your employer paid 37% of your lunch costs. Do they pay that percentage all the time?
Answer 6: No, the percentage share as well as the absolute amount paid depends on a few things. How much you eat, what you eat, and what your share of the cost is for each food.
Point 6: Your share is not a simple percentage, it must be calculated new for each meal.



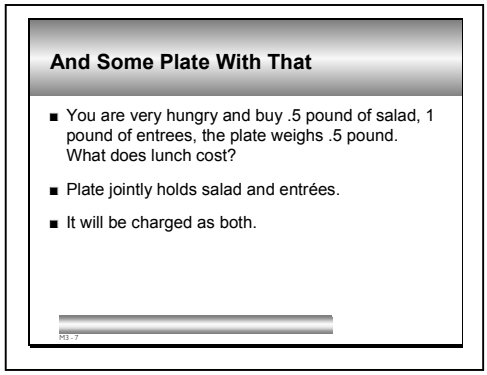
So far, to figure out your lunch costs we need the following things. The parallel concept for a multipurpose project is introduced in parenthesis after each item to begin to introduce the notion of cost allocation and cost sharing.



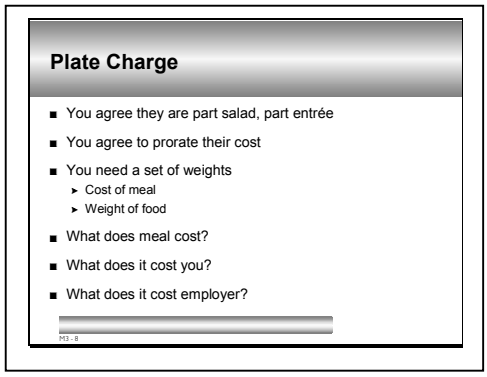
1. A meal (a plan)
2. Separation of the meal into different purpose foods (project purposes)
3. The cost of each purpose food (cost assignment)
4. The subsidy on each type of food (cost sharing percentages)
5. Some math to figure your cost and your employer's cost (a cost allocation technique)

So far so good. Now let's consider another lunch when the cafeteria introduces a new pricing strategy. Until now meals were weighed and charged in virtually weightless Styrofoam containers. Durable china plates are now used for all meals and the meal is weighed with the plate.

Question 7: You are very hungry and buy .5 pound of salad, 1 pound of entrees, and the plate weighs .5 pounds. The cashier rings up the salad and entrees with no problem. Then he starts to ring up the plate's weight on the entrée key. You stop him and argue the plate is not an entrée item and you do not want to pay $5 per pound for it. If you have to pay for the plate you'd prefer to pay $2 per pound. The cashier, a part owner, wants your business but does not want to lose money and all of his costs have been going up. He explains to you that he must pay for the plates too and many of them are broken. He also points out that the plate is holding your entrée as well as your salad and if you were eating only the entrée there would be no argument. You both agree the plate is part of the salad food and part of the entrée food. To reflect this you decide to prorate the cost of the plate over those two food categories. But how will you do that?



The owner suggests you use the value of the meal less the plate as the basis for developing weights to prorate the plate cost. As you spent $5 on entrée and $1 on salad he suggests the plate be charged at 1/6 the salad price plus 5/6 the entrée price or about $4.50 per pound. (1/6 x $2) + (5/6 x $5) = $4.50 per pound.



You do not like this idea so much and suggest that the price should be based on relative weights of food. With .5 pounds of salad and 1 pound of food the price would be (1/3 x 2) + (2/3 x 5) = $4.00 per pound of plate.

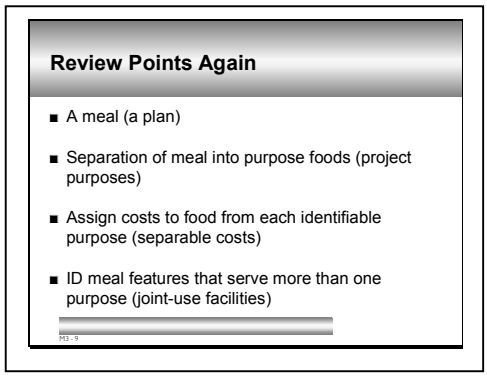
Assume the owner agrees to your method. What does lunch cost you?

Answer 3: .5 x $2 + 1 x $5 + .5 x $4 = $8

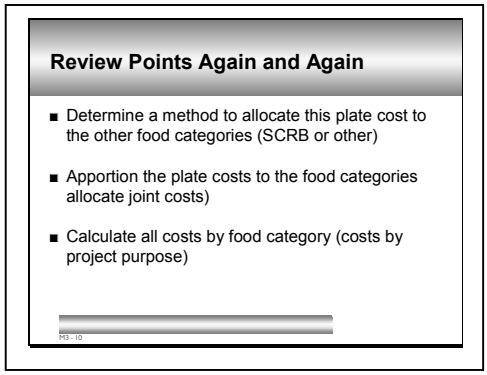
Point 7: There are several different ways to prorate the cost of common elements to the different food categories. These are just two of them. The final choice depends on criteria such as debating skills, fairness, store policy, and the like.

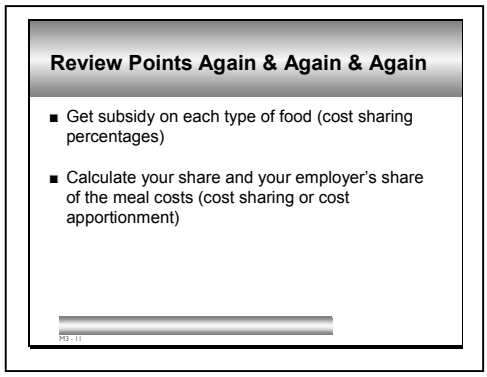
Review Points

In addition to the points made before they started charging for plates, repeated here for convenience, there are some new features to this problem. There is a slight change in orientation as our example gets more involved. New concepts are introduced here. To figure out your lunch costs we need the following things. Once again the Corps' parallel concept is indicated in parenthesis.



1. A meal (a plan)
2. Separation of meal into purpose foods (project purposes)
3. Identification of meal features that serve more than one purpose (joint-use facilities)
4. Assign costs to food from each identifiable purpose (separable costs)
5. Determine a method to allocate the plate cost to the other food categories (SC-RB or other method)
6. Apportion the plate costs to the food categories (allocate joint costs)
7. Sum all costs by food category (costs by project purpose)
8. Get subsidy on each type of food (cost sharing percentages)
9. Calculate your share and your employer's share of the meal costs (cost sharing or cost apportionment)





People Care About Costs

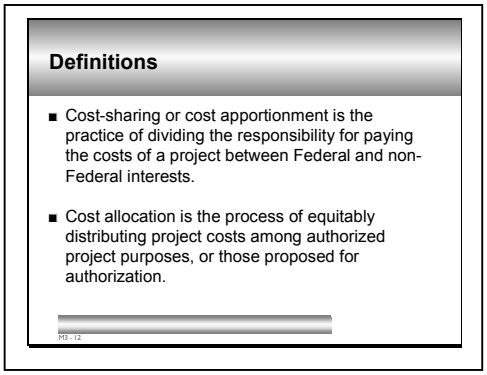
People care about costs. It does not matter how large or how small the costs are. It does not matter if the cost is an explicit cost that causes someone to expend money, time or other resources or an implicit cost that forgoes the opportunity to have gained or saved money, time or other resources. If there are costs associated with an action, someone is going to care about that action. That someone is the person responsible for bearing the costs. And usually that someone will prefer their costs to be as low as possible. This is especially true as the costs increase in magnitude.

In the Corps' past the costs of some project purposes were borne entirely by the Federal government while some project purpose costs were reimbursable. Projects with non-reimbursable project purposes were of little concern to local sponsors of these Federal projects. But a reservoir that provided flood protection, navigation and hydropower was a different matter. Once lands had been acquired flood control and navigation outputs came at no cost to the local sponsor. Hydropower was reimbursable, however. How was one to decide how much the local sponsor was to pay for the dam itself? The massive concrete structure was needed to create the navigation pool. It was needed to create the flood storage. It was also needed to create the head required for power production. The dam was a joint-use facility.

Clearly there were costs that could be easily identified with the project purposes. The lock was for navigation. The generators were for hydropower. The costs of a dam were big and people care about costs. With this background in mind lets consider some terminology.

Language Is Messy

Different people use different words to mean the same thing. Cost assignment and cost allocation are sometimes interchanged. Cost sharing and cost apportionment are often used as synonyms. Oddly, cost apportionment and cost allocation are also used interchangeably. Clearly the same words cannot mean such different things. That is the other problem, sometimes different words are used to mean the same thing. We cannot hope to clarify and unify the way the language is used by the Corps. We can however clarify how the language is used here. And it is used as described in the definitions that follow.



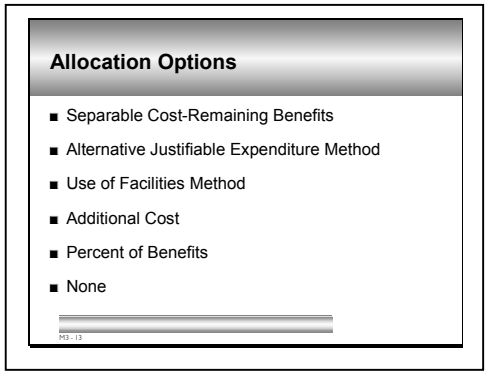
No one seems to be sure if we are talking about multipurpose projects, multipurpose projects or multipurpose projects. So the terms are used interchangeably. We do have some agreement that these are not multiple-purpose projects, however, and that is progress.

Cost-sharing or **cost apportionment** is the practice of dividing the responsibility for paying the costs of a project between Federal and non-Federal interests.

When a project serves more than one purpose, cost sharing can get a little complicated. The first step required in determining cost shares is to allocate or assign the costs of the project to the different purposes served. **Cost allocation** is the process of equitably distributing project costs among the project purposes served. Once costs have been allocated, those costs can be shared according to the existing cost-sharing responsibilities.

Now that we have explored the intuition of these notions of allocating and sharing costs in our meal example we need to apply these concepts to a multipurpose project. The key ideas are quite the same. There is a project cost. Some costs of the project are easily attributed to a specific purpose and some are like the plate in that they support salad and the entrée. In fact the salad and the entrée are incomplete without the plate in this instance. It is the plate-like costs of the project that present the challenge.

Allocation Options



In our simple meal example two ways to allocate the costs of the plate were identified. One was by value the other was by weight. There could have been many other ways to do this as well. When the multipurpose dams were being built the costs involved were large and a lot of people cared about these costs. In an effort to develop an approach that assured that all purposes shared equitably in the savings of multipurpose construction several techniques were proposed and used over the years.

The guiding principles that emerged came to be: 1) that no purpose would have costs allocated to it that exceeded its benefits; 2) that each purpose had to have benefits at least equal to its separable costs; and,

within these maximum (benefits) and minimum (separable costs) limits there would be proportional sharing of the savings that resulted from multipurpose development. It is worth noting that it is the cost savings that are being allocated. Cost allocation is a brain-cramping concept to apply in practice. The emphasis is on cost concepts and it is easy to lose sight of the fact that the technique is intended to fairly share the savings of doing more than one thing together. In the context of our meal example this means a change in emphasis. It means that by putting our salad and entrée on the same plate we saved the money that would have been spent with a second plate. Thus, in cost allocation we were really looking for a way to share that saving rather than for a way to split the cost of the plate. This requires a slightly more complex method.

The methods used historically included the Separable Cost-Remaining Benefit (SC-RB) method, the Alternative Justifiable Expenditure Method and the Use of Facilities Method. The SC-RB method was identified as the preferred method in the previously mentioned Green Book. That decision has been affirmed several times since the original decision. The SC-RB was chosen in part because it maximizes the direct allocation of costs and minimizes the joint costs to be allocated. That has been considered the fairest way to share the savings. One must bear in mind that these techniques were developed for multipurpose reservoirs with some purposes that were reimbursable and some that were not. This no longer fits the current situation quite so accurately and although the SC-RB method is perfectly applicable to some situations there are simpler techniques for other situations.

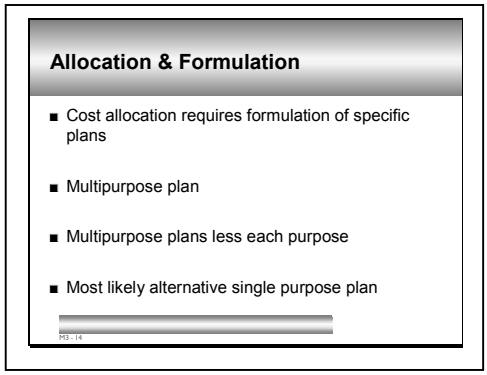
Although these techniques have no official names in policy, one of these we will call the last added or additional cost approach, another we will call the percentage of benefits approach, and the last one requires no cost allocation. The formulation module indicated that multipurpose plans result in one of three ways: incidentally, add-on and purposeful formulation. The last added or additional cost method of cost allocation is best suited for plans that result from the add-on approach to formulation.

Consider a structural flood damage reduction project with a "Federal interest" (i.e., a benefit-cost ratio > 1) formulated for the single purpose of flood damage reduction. Once the NED plan is identified, then recreation, the second purpose, can be added to the project. All costs assigned to recreation, the last added purpose, are in addition to the NED plan costs. These additional costs e.g. the added interest in land, perhaps an upgrade from easement to fee simple, maybe a little more land for parking or access, and the recreation facilities themselves. There is no formal policy guidance on this approach, it is used because it makes sense. Were recreation a primary purpose for which one formulated there may be an argument for using the SC-RB method to share the savings. As an add-on purpose the additional cost approach to cost allocation is reasonable. Costs allocated in this fashion are then apportioned and shared according to current policy.

The remaining benefits approach is used when there are no separable costs. In some situations all features of a project are common to the same purposes. For example, a navigation project comprising an entrance channel and a protective breakwater will serve both commercial fisheries navigation and recreational navigation. All features of this project are both joint-use and joint. There are no separable costs. Both navigation purposes benefit from the project's features. With no separable costs there is no option to use the SC-RB method. In these cases costs are allocated on the basis of the proportion of benefits. If 42 percent of the benefits are to recreation and 58 percent are to commercial fisheries the costs are allocated in the same proportion, 42 percent recreation and 58 percent navigation. As with the additional cost method, this allocation technique is based more on common sense and practical experience than on formal guidance.

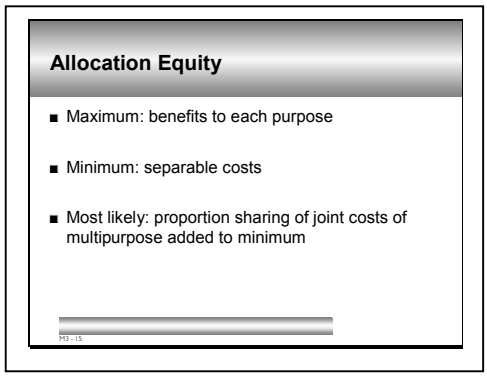
When there are benefits to a second purpose, there are no additional costs whatsoever, and the project has been formulated for one purpose the incidental benefits are free and no costs are allocated to the purpose that benefits in this way.

Allocation and Formulation



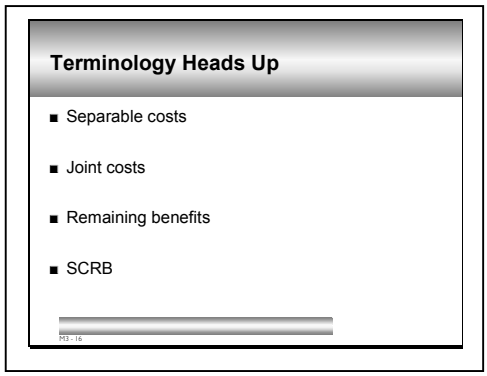
Plans can be formulated for multiple purposes. When these projects entail separable costs the cost allocation method for multipurpose projects can dictate to some extent the plans you formulate. Some methods used to allocate costs, such as the SC-RB, dictate that certain kinds of plans be formulated and their costs evaluated. This is important to know as early in the multipurpose project formulation step as possible. The formulation of additional plans may be necessary to produce the kinds of information that are discussed below.

Allocation Equity



The SC-RB method requires a lot of information, but if a good formulation process has been followed it should be reasonably available. In effect, separable costs are calculated from a series of project cost estimates, each representing the multipurpose project with one purpose omitted. For a two-purpose project it is a series of two other projects that must be formulated. Flood damage reduction with ecosystem restoration may not look the same as flood damage reduction without the ecosystem restoration. The most likely alternative project that will provide the same benefits for each purpose must also be formulated and its cost estimated.

Terminology

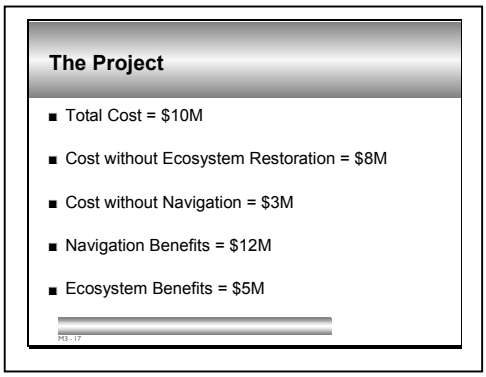


First, we have to be able to identify the costs that are called **joint costs.** Second, we need a set of weights for prorating the joint costs to the various purposes of the project. The weights used by the Corps are the lesser of the separable costs or the remaining benefits of a project purpose. It is now time for a water resource example.

Two Purposes

Most applications of the SC-RB method were done for multipurpose reservoirs. That is not our interest here. If a simpler cost allocation technique can be used, use it. To illustrate the SC-RB method consider a navigation project with some ecosystem restoration features.

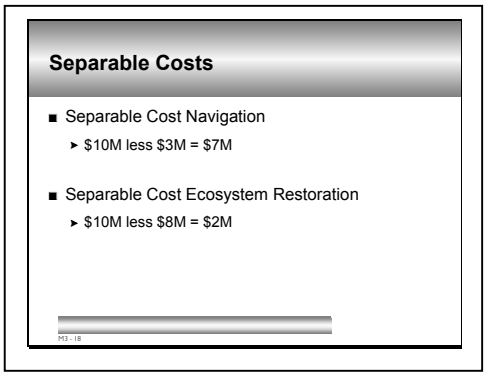
The Project



The project's average annual costs are $10 million. All used in this example are average annual values. If there is no ecosystem restoration the project would cost $8 million. If there is no navigation the project would cost $3. Navigation benefits are $12 million and ecosystem restoration benefits are $5 million. There is one cost sharing policy for navigation and a different cost sharing policy for ecosystem restoration. The SC-RB method uses average annual benefits and costs calculated in the usual manner. What we want to know is how much is this project going to cost the Corps and how much is it going to cost the non-Federal partner? It is important to try to see this problem as similar to our simple meal cost above. There is salad and entrée but we do not see the plate yet. We need first to look for the plate costs but they are going by a new name now, joint costs. It is time for some new terminology.

Separable costs are the costs incurred specifically to add a purpose to a project. These costs are normally estimated during plan formulation to evaluate the economic feasibility of including the purpose in a multipurpose project. The separable cost is the minimum cost that will allocated to a project purpose. This is the cost of the salad and the cost of the entrée before considering the cost of the plate. The separable cost for navigation is the total project cost less the costs of the project with no navigation purpose. The separable cost for ecosystem restoration is the total cost of the project less the costs of the project with no ecosystem restoration. With a simple two-purpose facility these alternative costs are just the costs of a single purpose project. With three or more purposes these are the costs of projects that may or may not have been formulated during the normal course of the planning process.

Separable Costs



In the example separable costs of navigation = $10 million - $3 million = $7 million. The separable costs of ecosystem restoration = $10 million - $8 million = $2 million. So separable costs for any purpose X are determined by subtracting from the cost of the multipurpose project the cost of the most economical alternative project to obtain the same benefits for the other purposes with purpose X omitted. Thus the separable costs of navigation are the total project costs less the cost of the project with no navigation. If that gives you a headache, you're normal. Take your time and read it about 100 times. It gradually becomes clear.

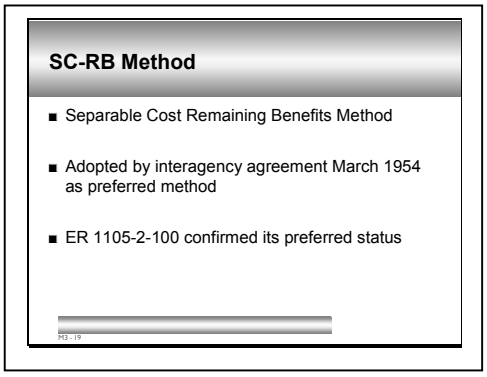
Joint costs (or plate costs) are what is left over. Joint costs are the difference between total project costs and the sum of all separable costs. In this example, joint costs are the costs that are not specifically attributable to either navigation or ecosystem restoration. They are calculated to be $10 million - ($7 million + $2 million) = $1 million.

We do not know whether to charge the navigation or ecosystem restoration price for these joint costs. These are analogously, our plate costs. Bear in mind the analogy is not an exact one so do not lose sight of the goal, we're trying to find out who pays how much. The joint costs or savings were initially hidden from view so calculating joint costs is the second major task of the Separable Benefits and Remaining Cost method. The first task was calculating separable costs of each project purpose.

The next task is figuring out how much of these costs are prorated to navigation and how much are prorated to ecosystem restoration. To prorate the costs we need a set of weights to decide what percentage of the $1 million joint costs should be considered navigation and what percentage could be considered ecosystem restoration. There are many ways one could imagine doing this, some of them have been mentioned earlier. The method used to determine these weights is the SC-RB method.

SC-RB Method

The separable costs-remaining benefits method (SC-RB) of cost allocation was adopted by interagency agreement in March 1954 as the preferred method for allocating costs of Federal multipurpose water resource projects. Current Executive guidelines endorse its continued use.



The method is actually quite simple. Its purpose is to prorate the joint costs to the various project purposes. This is done by using project benefits. The amount of project benefits used to allocate joint costs is limited by the cost of providing equivalent outputs from the most likely economically feasible alternative source in the project area. The weights used are these limited purpose specific benefits minus their separable costs. The resulting benefits used are called the remaining benefits. This concept was judged equitable some time ago and that judgment has been confirmed by its continued use.

The calculation of remaining benefits begins with the original benefit estimates, $12 million for navigation and $5 million for ecosystem restoration. For convenience we assume ecosystem restoration benefits can be quantified. We will relax that assumption later. This step is one of the more difficult to understand. Rather than using these benefit estimates as the starting point the SC-RB method limits the amount of benefits to be used to the least costly alternative for producing the project purpose benefits in an alternative project. Hence, the weights are not 12/17 and 5/17. Joint costs distributed in this fashion could in some circumstances lead to a project purpose with costs in excess of the cost of providing a single purpose project that would achieve the same benefits. To avoid a situation like this the SC-RB method was adopted.

SC-RB Example

Suppose the navigation benefits could be produced by an $8 million project and the ecosystem restoration by a $3 million project. Thus, the same benefits could be produced by two single purpose projects with a total cost of $11 million. Combining the two purposes saves us $1 million and that saving is being shared when joint costs are allocated.

SC-RB Example

	Navigation	Ecosystem Restoration	Total
Average Annual Benefits	12	5	17
Alternative Cost	8	3	11
Limited Benefits	8	3	11
Joint Costs	1	1	1
Separable Costs	7	2	9
Remaining Benefits	1	1	3
Weight	50%	50%	100%
Allocated joint cost	0.50	0.50	1
Total allocation	7.50	2.50	10

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Remaining benefits are the limited benefits less the separable costs of that purpose. Limited benefits are the lesser of project purpose benefits or the cost of an alternative single purpose project. Navigation remaining benefits are $8 million - $7 million = $1 million. Ecosystem restoration remaining benefits are $3 million - $2 million = $1 million.

The table shows the remaining benefits calculation. Fifty percent of the joint costs are apportioned to navigation and 50 percent to ecosystem restoration. This method assures that the total cost allocated to each purpose will not be more than their benefits or less than their separable costs. For example, navigation costs at $7.5 million exceed the $7 million in separable costs but remain less than the $8 million in remaining benefits.

The bottom line is that $7.5 million of the $10 million project cost is allocated to navigation and $2.5 million is allocated to ecosystem restoration. These costs now must be cost shared.

Cost Sharing

Cost sharing is essentially analogous finding out what you pay and what your employer pays for lunch. Except you're the Federal government and the employer is the non-Federal government. In this example we have assumed for convenience the harbor improvement is less than 20 feet below MLW so the non-Federal navigation cost is 10 percent. This value would have to be calculated as usual. Likewise we have assumed an ecosystem restoration share of 35 percent calculated as usual. And yes, we realize this is a mighty expensive project for such a shallow draft channel!

Cost Sharing

	Navigation	Ecosystem Restoration	Total
Allocated	7.5M	2.5M	10M
Federal	6.75M	1.63M	8.38M
Non-Federal	0.75M	0.87M	1.62M
Total	7.50M	2.50M	10M

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Flood damage reduction and Ecosystem Restoration

It goes without saying that the SC-RB method is identical if say we had flood damage reduction as a purpose instead of navigation. What if we had flood damage reduction and ecosystem restoration? Current guidance (EC 1105-2-219) says to use the SC-RB method for that too. Sounds reasonable until we get to the benefit part of the SC-RB because explicit estimation of ecosystem restoration benefits in terms of dollars is not usually part of the evaluation process. Thus, you are not likely to have the luxury of the benefit estimate presented above. In that case we have to amend the SC-RB method.

A More Realistic Ecosystem Restoration Example

The method proceeds in essentially the same fashion. The difference is that there are no average annual benefits so the benefits are limited by the cost of the most likely alternative plan that could have produced the same environmental output as the multipurpose plan does. In other words, the cost of an alternative plan is used just as it was in the example above. The difference is there are no average annual benefits to which it can be compared.

Ecosystem Restoration Example

- Total Costs $7,000,000
- Separable Costs
  - FDR = $1,500,000
  - ER = $3,900,000
- Joint Costs 1,600,000
- Benefits
  - FDR = $1,930,000
  - ER = not quantified

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Ecosystem Restoration SC-RB

The table shows that 22.9 percent of the joint costs are allocated to flood damage reduction, the remainder to ecosystem restoration. Note this allocation is made without an estimate of the average annual benefits of ecosystem restoration. The alternative cost for the output of the ecosystem restoration can be obtained from the formulation process, in this case possibly from the IWR Plan outputs generated by the incremental cost analysis.

Ecosystem Restoration SCRB

	Flood Damage Reduction	Ecosystem Restoration	Total
Average Annual Benefits	1,930,00	None	
Least Cost Alter.	2,940,000	5,350,000	8,290,000
Limited Benefits	1,930,00	5,350,000	7,280,000
Separable Costs	1,500,000	3,900,000	5,400,000
Remaining Benefits	430,00	1,450,000	1,880,00
Weights	22.9%	77.1%	100%
Allocated Joint Costs	370,000	1,230,000	1,600,000

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Allocated Cost

The allocated costs would then remain to be cost shared.

Allocated Costs

- FDR = $1,870,000
- Ecosystem Restoration = $5,130,000
- Total Project = $7,000,000

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Review Questions

1. What is the difference between cost allocation and cost sharing?
2. What are some methods besides the SC-RB method used for cost allocation?
3. What is a separable cost?
4. What is a remaining benefit?

Section Summary and a Look Forward

The non-Federal partner pays different shares of the cost for different project purposes. Thus, thh non-Federal share of a $10 million navigation project will likely be different from the non-Federal share of a $10 million flood damage reduction project. In some multipurpose projects there are elements of the project that simultaneously serve two or more purposes. The non-Federal partner's savings from such joint use project elements will depend on how much of the cost is allocated to one purpose or the other. The process of assigning project costs to different project purposes is called cost allocation. The Corps has used many different cost allocation strategies over the years. One of the more complex techniques is the SC-RB method which has been demonstrated in this module.

References and Suggestions for Further Reading

Two good sources of general background on cost allocation are classic texts for water resource economists and engineers. The first reference is Chapter 23 Cost Allocation in *Economics of Water Resources Planning* by L. Douglas James and Robert R. Lee, McGraw-Hill, New York, 1971. The second reference is scattered locations throughout *Principles of Engineering Economy* by Eugene L. Grant, w. Grant Ireson, and Richard S. Leavenworth, John Wiley & Sons, New York, 1976.

The government documents of most value are also dated. A good starting point for a description of the SC-RB method is "Proposed Practices for Economic Analysis of River Basin Projects," a Report to the Inter-Agency Committee on Water Resources by the Subcommittee on Evaluation Standards, revised in May 1958.

For those with access to a good set of old Corps guidance Cost Allocation for Multipurpose Projects Allocation of Cost is found in EM 1160-2-101 1 January 1958. More recently Section IX - Multipurpose Projects of ER 1105-2-100 pages E-228 through E-269 is a good source of information. EC 1105-2-219 Cost Allocation for Multipurpose Projects Including Ecosystem Restoration is a particularly useful document. It was the source of one of the examples in this module.

Selected Notes to the Instructor

Student Learning Objectives:

Students will be able to distinguish cost allocation from cost sharing

1. Students will be able to identify several alternative ways of allocating costs
2. Students will be able to describe the SC-RB method of cost allocation
3. Students will understand the ways in which the SC-RB method is modified for ecosystem restoration projects

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Instructor Notes and Exercises:

We suggest you do the first meal exercise (Exercise M3.1) on a board, interactively with the students. Have them focusing on you and make them listen intently; hence no net, i.e. slides to read. Encourage note taking. We want them to get "their" intuition here, not "ours." You can make copies of these exercise notes available to all afterward if you like, or refer to it by name on their CD for the course. If you prefer you may create your own slides from these materials that reflect your own comfort with the material.

It is important to note that the example here is NOT an example of SC-RB. It is a simple intuitive example intended to acquaint students with the concepts in a familiar setting. It is an opportunity or excuse to offer some terminology and introduce concepts. Make sure students know this was not the SC-RB. Your task in this module will be to help them with the transition from the meal problem to a real problem.

When you get to a real problem and people are confused it can help to say, "those costs there, they are basically the plate costs." And instead of prorating joint costs on weight (sort of a benefit measure) or cost (sort of a cost measure) we need to find a clever way that satisfied all the water resource agencies and their constituents. That is the SC-RB method. So when you get to a real example let people know they already know the basic concepts and only really have to concentrate on the method for prorating the joint costs.

Equally important, however, is the fact that the SC-RB is not the only method in use. Be mindful of the module objectives. Even though the SC-RB gets most of the emphasis the language and alternatives to SC-RB are important too.

The principle exercises in this module will be the two examples of cost sharing. These can take a lot of time. Time saved in the earlier modules can be easily swallowed up here. Consider how important it is to cover the SC-RB method and allocate your time accordingly.

Slide M3-1

Exercise M3.1 Cost Sharing and Purposes
This is an example of different cost sharing percentages for different purposes. You may want to draw the parallels as you go along. The alternative is to treat the entire exercise as a whole and then add the reality dimension at the end. The choice is more one of personal style and the class' personality.

Entrees sell for $5/pound in one of those load'em up and weigh'em buffets. Salads sell for $2/lb. Potatoes are sometimes offered in salads and sometimes with entrees. They are also offered on their own at times.

Slide M3-4
Question 1: You are not very hungry and buy .5 pounds of salad. How much does lunch cost?
Answer 1: .5 x $2 = $1
Point 1: The purpose of this meal was to "eat healthy." This is like a single purpose project. Point out that different sized meals have different prices.

Question 2: You are hungry and buy 1 pound of entrée. How much does lunch cost?
Answer 2: 1 x $5 = $5
Point 2: The purpose of this meal was to "fuel up." It is like a single purpose project, with a different purpose.

Once the exercise is completed you should review it if you opt not to do a review as you go approach. Whenever you review these stages of it stress that these were single purpose meals. We are using a very familiar situation to introduce complex concepts so do not be shy about making the simple connections crystal clear. This could be a good argument for explaining as you go. Do not be too subtle.

Question 3: You are very hungry and buy .5 pounds of salad and 1 pound of entrees. How much does lunch cost?
Answer 3: .5 x $2 + 1 x $5 = $6
Point 3: The purposes of this meal were to fuel up while eating healthy. This is like a multipurpose project.

Make the point that this was a multipurpose meal. Point out that different purposes have different prices. You could have pigged out on 1.5 pounds of entrees! If anyone gets too serious about the numbers remember it is to make the arithmetic easy. Remind them we have all seen the large fries, apple pie, two triple cheeseburgers and a diet Coke meal ordered if we have not ordered it ourselves.

Slide M3-5
Question 4: The meal cost $6 but what is your share of the cost?
Answer 4: 30% x $1 + 70% x $5 = $3.80
Point 4: Your cost is of utmost importance to you.

Question 5: Who shares the cost with you and how much do they pay?
Answer 5: Your employer pays $2.20.
Point 5: Your employer cares about this value.

Question 6: Your employer paid 37% of your lunch costs. Do they pay that percentage all the time?
Answer 6: No, the percentage share as well as the absolute amount paid depends on a few things. How much you eat, what you eat, and what your share of the cost is for each food.
Point 6: Your share is not a simple percentage, it must be calculated new for each meal.

Slide M3-6

So far, to figure out your lunch costs we need the following things. The parallel concept for a multipurpose project is introduced in parenthesis after each item to begin to introduce the notion of cost allocation and cost sharing.

1. A meal (a plan)
2. Separation of the meal into different purpose foods (project purposes)
3. The cost of each purpose food (cost assignment)
4. The subsidy on each type of food (cost sharing percentages)
5. Some math to figure your cost and your employer's cost (a cost allocation technique)

So far so good. Now let's consider another lunch when the cafeteria introduces a new pricing strategy. Until now meals were weighed and charged in virtually weightless Styrofoam containers. Durable china plates are now used for all meals and the meal is weighed with the plate.

Slide M3-7
Question 7: You are very hungry and buy .5 pound of salad, 1 pound of entrees, and the plate weighs .5 pounds. The cashier rings up the salad and entrees with no problem. Then he starts to ring up the plate's weight on the entrée key. You stop him and argue the plate is not an entrée item and you do not want to pay $5 per pound for it. If you have to pay for the plate you'd prefer to pay $2 per pound. The cashier, a part owner, wants your business but does not want to lose money and all of his costs have been going up. He explains to you that he must pay for the plates too and many of them are broken. He also points out that the plate is holding your entrée as well as your salad and if you were eating only the entrée there would be no argument. You both agree the plate is part of the salad food and part of the entrée food. To reflect this you decide to prorate the cost of the plate over those two food categories. But how will you do that?

Slide M3-8
The owner suggests you use the value of the meal less the plate as the basis for developing weights to prorate the plate cost. As you spent $5 on entrée and $1 on salad he suggests the plate be charged at 1/6 the salad price plus 5/6 the entrée price or about $4.50 per pound. (1/6 x $2) + (5/6 x $5) = $4.50 per pound.

You do not like this idea so much and suggest that the price should be based on relative weights of food. With .5 pounds of salad and 1 pound of food the price would be (1/3 x 2) + (2/3 x 5) = $4.00 per pound of plate.

Assume the owner agrees to your method. What does lunch cost you?
Answer 3: .5 x $2 + 1 x $5 + .5 x $4 = $8

Point 7: There are several different ways to prorate the cost of common elements to the different food categories. These are just two of them. The final choice depends on criteria such as debating skills, fairness, store policy, and the like.

Slides M3-9, 10 & 11
In addition to the points made before they started charging for plates, repeated here for convenience, there are some new features to this problem. There is a slight change in orientation as our example gets more involved. New concepts are introduced here. To figure out your lunch costs we need the following things. Once again the Corps' parallel concept is indicated in parenthesis.

1. A meal (a plan)

2. Separation of meal into purpose foods (project purposes)
3. Identification of meal features that serve more than one purpose (joint-use facilities)
4. Assign costs to food from each identifiable purpose (separable costs)
5. Determine a method to allocate the plate cost to the other food categories (SCRB or other method)
6. Apportion the plate costs to the food categories (allocate joint costs)
7. Sum all costs by food category (costs by project purpose)
8. Get subsidy on each type of food (cost sharing percentages)
9. Calculate your share and your employer's share of the meal costs (cost sharing or cost apportionment)

Ask if anyone has questions about how to figure out what a meal costs them? Make sure people understand the concept here. You should have the math from the meal example on the board or flip chart. Review it. Stick with the meal. When you are confident there is general understanding of the meal example make the point that if they can understand this they can understand multipurpose project cost allocations. Let this example set like this. Go back over it now and use it to launch into the next section. Explain that the meal is like a project, it can have one or more food categories (project purposes), and so on.

Slide M3-15

Exercise M3.2 Two Purposes
We want students to understand what a multipurpose project is. It is not a project with incidental benefits. It is a meal with salad and entrée served on one plate. We need the students to be able to identify the salad and entrée in their projects. Then they have to be able to identify the plate. Ask for examples of multipurpose projects from their Districts. Have the student clearly identify the project purposes. Ask how they know it was a multipurpose project. Probe to see if it was incidental--no cost allocation needed; an add-on, which would rely on additional costs; or if it was formulated as multipurpose with separable elements and costs. If they have no examples to offer use the example from the case study for this chapter. This would be a good time to introduce it.

Module M-4: Trade-Off Analysis, Selection and Cost Apportionment

Student Learning Objectives

- Student will know several techniques for comparing plans with different outputs
- Student will understand the concept of a "trade-off" situation and its significance to plan designation and selection

M4-2

Student Learning Objectives

- Student will understand the basis for designating the NED/NER plan
  - The student will be able to distinguish the "least environmentally damaging plan" (Clean Water Act)
  - The student will be able to distinguish the NED/NER from NED (or NER) plans with incidental NER (or NED outputs and from plans with "add-on" purposes

M4-3

Student Learning Objectives

- Student will know the criteria for plan selection
- Student will know the cost-apportionment consequences of deviating from the NED/NER Plan and selecting the locally preferred plan (LPP)
- Student will know several techniques to allocated costs between NED and NER for the NED/NER plan and related plans

M4-4

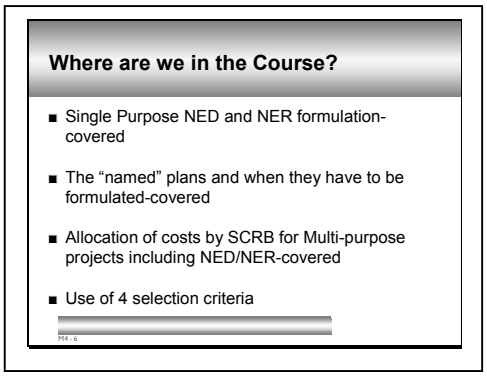
We are leaving our focus on formulation of multiple purpose plans to discuss some issues dealing with comparing multipurpose plans.

The bad news is that it is tricky.

The Good News is that this is a Relatively Short Module

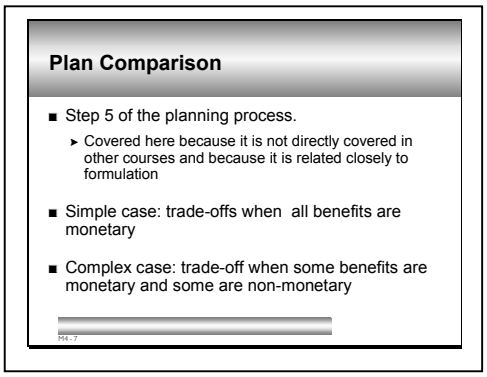
M4-5

We have already covered:



1. Single purpose NED and NER formulation, evaluation and selection
    a. Remember that the 4 reformulation criteria- acceptability, completeness, effectiveness and efficiency are now the 4 selection criteria
    b. These terms were defined in G3 and in the single purpose modules.
    c. These concepts are still applicable in multiple-purpose planning
2. Integrating NED and NER (M2 Module)
3. The named plans and when they have to be formulated, and their level of detail (Module G2)
4. Allocation of costs by SCRB for multiple purpose projects. This included NED/NER applications (Module M3)

We have talked about plan comparison in the context of single purpose planning. However, plan comparison has special challenges in the context of multiple purpose planning. Therefore, let us explicitly consider plan comparison.



An Exercise

Let's return to day 1 and the transportation activity (see slides G3-12 to 15). Here are the costs of four differentiated alternatives and the transportation outputs:

Comparing Alternative Costs and Reduction in Trip Times (RTT)

	Cost ($)	RTT[1]	$/RTT
1. Northway (through the scenic woods)	100	25	4.00
2. Southway (through the wetlands	80	22	3.63
3. Main Street Widening (through the town)	90	18	5.00
4. Main Street Buses (non-invasive alternative)	40	10	2.50

[1] Reduction in trip times. Current delays are 30 minutes. Target state standard is 15 minutes but this is no "absolute."

M4 - 8

Plan comparison is the 5th step of the planning process. It is where we compare plans to each other, rather than to the without project condition, which was the basis for evaluation. In order to make a selection at step 6 of the planning process, we have to know what the plans do in comparison to each other.

Comparing Alternatives: Weighing Impacts

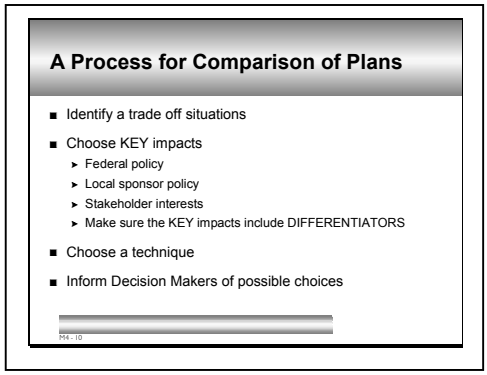
	Step 1			Step 2					
	How relatively costly is each alternative (scale of 100)			How important is each alternative (scale of 10)					
	Econ	E.Q.	SWQ	Econ	EG	SWB	Total Cost[1]	RTT	Total Cost/RTT
1	100								
2	80								
3	90								
4	40								

M4 - 9

A Process

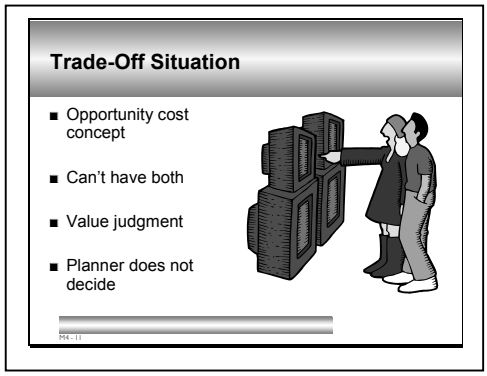
Consider the following process for comparing plans

1. Identify trade off situations. These require special emphasis.
2. Choose KEY impacts. Plans have many impacts. Choose those most relevant to decision making
3. Choose a comparison technique
4. Inform decision makers of possible choices



Identify Trade-of Situations

Plan comparison is based upon a trade-off situation. A trade off exists when you must give up something to get something else. Guns and butter are trade-offs assuming I have to give up some of one to get more of another. Stated another way, a trade off exists where resources are relatively scarce and have value.



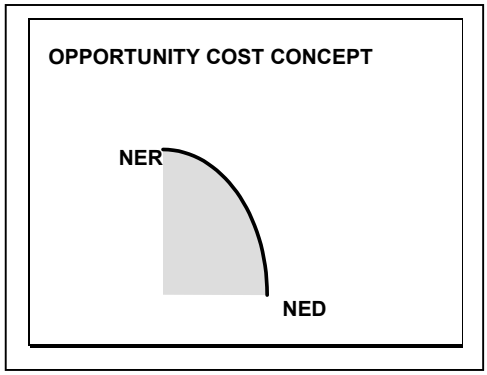
Making a trade off is sometimes fairly simple. This is the case where benefits from both purposes can be monetized and where we have confidence that the dollar benefits are comparable across purposes. In that case, all we have to do is add the monetary benefits up, compare them to costs and pick the plan with the largest net benefits.

Unfortunately, this situation is rare. We don't really believe that recreation and navigation benefits are additive in a meaningful way. More important we know that NER benefits are not currently put in monetary form.

The complex case is therefore the most common case: some benefits are monetary and some are not. How do we compare plans? We simply state what each plan does relative to another. For example, Plan X reduces more flood damages than plan Y, but plan Y has greater restoration benefits than Plan X. This may occur for one of two reasons. First, plans X and Y may use the same limited resource; I can only use the resource once and have to choose between the quantities of damage reduction versus restoration that I wish to "buy". Second, plans X and Y use separate and non-competing resources; my formulation and evaluation have hopefully optimized each on its own terms. The former situation is called a "trade-off" situation. A decision to build plan X precludes building plan Y and visa versa. The latter situation permits separate decisions on whether to build each plan.

It is useful to distinguish the two situations above because the distinction explains a lot of decision making. In the real world, plans often have interdependencies (trade off situation) and independencies (non-trade off situation).

Trade-off situations, as used in this course, are based on the opportunity cost concept. Conceptually we can value an output by the value of the other output we had to give up. Slide M4-12 illustrates the concept. In order to get more NER, we must give up NED and visa versa. If we can get more NER without giving up NED, we are not in a trade off situation—and we are probably not done formulating either. The graph represents a situation where there is a competition for resource, such as land (or storage capacity); we can use it for NED or for NER, or for a combination of both anywhere along the curve.



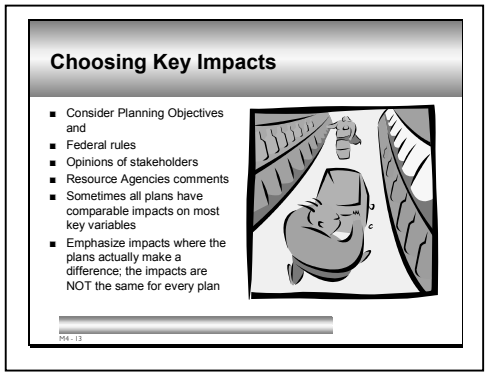
Trade-offs are based on value judgments. This is especially true when the outputs are measured in dissimilar units (flood control dollars versus habitat units, for example). The curve in slide M4-12 for example, does not tell you how much of NED or NER to produce; the curve represents cost efficient combinations of NED/NER.

The formulator's contribution is not their preferences for one output over another, but rather the presentation of data for the decision-makers to choose, based on their values and preferences. Conceptually, in a trade off situation, it is the formulator's job to present the curve to decision-makers. As part of their contribution, they need to make sure they is actually in a trade off situation. There is probably little or no resource based trade off between an NER single purpose plan in one part of a basin and a flood control one in another because they do not require the same resources to be implemented (there may be a local political trade-off or budget constraint, but they are not the subjects of this course).

CAUTION: The fact that the two plans occupy different land may mask the fact that they in fact are significantly related and do represent a trade-off situation. To use the old cliché, water flows downhill and therefore what happens in one part of the basin may affect what happens in another.

Choose Key Impacts

Clarity for decision-makers requires simplicity (or transparency as used in the Planners Manual). There are hundreds of impacts of a Corps plan. These must be reduced to a few KEY impacts, perhaps 5 or 10, in order to be useful to decision makers. Consider:

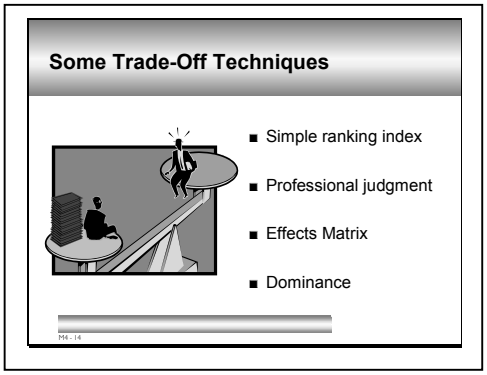


1. Planning Objectives
2. Federal policy and costs. Lock delays, residual flood damages, etc.
3. Stakeholder concerns. If the local sponsor has a concern, it is a good idea to highlight it even if it is not important to plan selection from the Federal level. Examples include: construction times, school impacts, and use of local sponsor lands.
4. Resource Agency concern, whether we think they are important or not.
5. **DIFFERENTIATORS**. Even though an impact may be very important, it may be the same across all plans. Suppose all plans provide the same level of flood protection. Level of

protection would not be a differentiator among plans. Especially in a trade off situation, emphasize the differences among plans. If there are no significant differences, then rethink your formulation.

Choose a Comparison (Trade-Off) Technique

Since trade-offs cannot be shown on a simple curve except in concept, once you have a trade off situation, you have to have some practical ways of comparing the plans or "trading off". The Planning Manual discusses them. Our purpose here is to remind you of several that are commonly used within the Corps. These are:



1. Simple ranking index. Each plan is ranked against the other from highest to lowest based upon impacts. If there are 5 plans then the highest rank is 5 for any impact and the worse or lowest is 1.

    a. The impacts themselves can be weighted. For example environmental impacts may be twice as important as recreation impacts and four times as important as navigation impacts.

    b. The decision-maker can accept the overall ranks and weights or choose her own.

2. Effects matrix expands the simple ranking index to cover (we used a variation of this for our exercise):

    a. Relative ranks. Instead of a 5 to 1 ranking, each plan would be ranked on a scale of 10 depending on the importance of the impact

    b. Weights would be assigned, either positive or negative, denoting the amount of the impact.

    c. Importance times amount, summed across impacts yields a number; the higher the better.

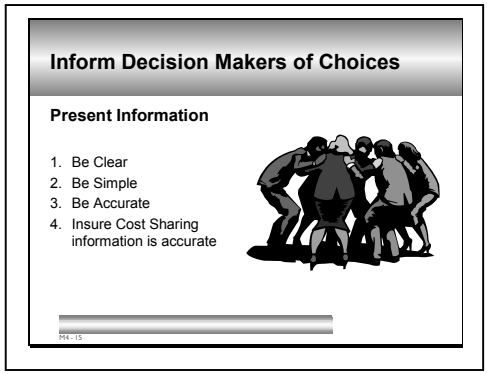
    d. Again, the formulator is simply informing the decision maker as to which plan is better, given the weights and ranks. The decision maker may wish to choose his own ranks and weights

3. Planner Judgment. In this case, planners say what they would do if they were the decision-makers. They quantify the differences in impacts and make subjective judgments as to which plans are preferable. This is the most commonly used technique in the Corps, since it is inexpensive to implement and captures input from some of the people most knowledgeable about the projects and most knowledgeable about the Federal decision rules. If you use this technique, be sure to include all members of the study team. Different professions tend to have different values; surfacing these differences at this point can be beneficial.

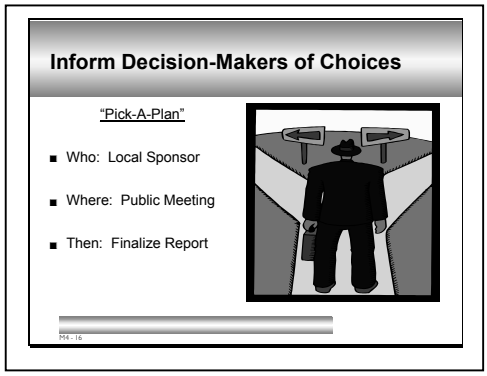
4. Dominance. This occurs when one plan is better than another over the whole range of relevant variables. At first blush, such a plan might appear to be a failure of formulation; after all, dominance can be, and often is, used as a screening tool in building plans from measures. However, the Corps is required to formulate several "named" plans, like the LPP, ESA, LERDA, and nonstructural plan. Such plans may be inferior but may have to be carried into the final array for one reason or another. One of the ways to avoid spending a lot of effort on such plans is to eliminate them ordinally from selection by comparison to other plans, hence limiting the level of evaluation detail necessary.

Present Information

You are close to the goal of planning: to present accurate information to decision-makers. Try to keep the trade-offs as clear, simply and accurate as possible. Summary systems of accounts often work well. Above all, be very clear on the cost-sharing implication of the plan.



This information will be the bases for the local sponsor picking-a-plan. Usually a public meeting is held and the report is prepared for Washington decision-makers.



Designation of the NED/NER Plan

The NED/NER plan is defined as the plan which maximizes not NED/NER benefits (P & G). It is designated toward the end of the planning process based up evaluation, comparison, and consistency with current policy. It is designated from the final array of alternatives.

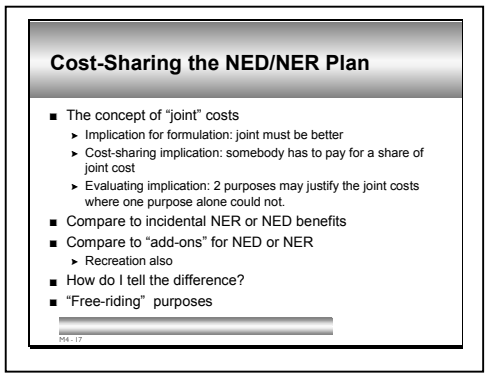
The NED/NER Plan should be distinguished from the Least Environmentally Damaging Practical Alternative (LERDA). The Clean Water Act states that the proponent agency must consider a plan which accomplishes the proponent agency's purpose with the least adverse impact on the environment. This might imply that the agency must adopt such a plan even though it has fewer net NER/NED benefits. Districts should consider such plans, but need not carry them through to the final array if they fail the net NER/NED test.

Plan Selection Criteria

The plan selection criteria for the NED/NER plan are our old friends the formulation criteria:

a. Acceptability
b. Completeness
c. Efficiency
d. Effectiveness

Cost-Sharing the NED/NER Plan



We said back on the first day that it helps to know where you are going. Cost sharing is designed to affect decisions and it does. Therefore, it is important that formulators understand the cost sharing rules for the NED/NER plan. Equally important, the formulator should try to understand the implications of the cost-sharing rules for formulation and evaluation. The following material will help in this regard, by introducing you to the issues senior planners are currently struggling with.

When we allocated costs in M3, we were primarily focused on identifying what purpose pays for joint costs (see paragraphs E-63f (4) and (5) of ER 1105-2-100 for the costs that are included in a SC-RB). A joint cost is the cost of a feature, which is necessary for both NER and NED purposes.

1. The cost-sharing implication is that both purposes must pay for a portion of the joint facility.

2. The implication for formulation is that joint use must be better than serving each purpose separately by independent features. Otherwise, there would be no reason to use the feature jointly.

    a. This implication follows when the two purposes are not in conflict

    b. And also follows beyond the point of no conflict and into a trade-off situation

3. The evaluation implication is extremely important. It means that benefits from both purposes, NED and NER, monetary and non-monetary, can be used to justify the cost of the joint feature(s). Even though neither purpose alone could justify the cost of the facility, you can nevertheless build the feature.

Contrast: Incidental Benefits

Contrast the above to single purpose plans which have large incidental benefits to the other purpose.

An example of a large NER plan with a little flood control is Tres Rios; this plan was formulated as a multipurpose project. Gowanus Creek, New York was a navigation plan, which had significant restoration benefits associated with restored circulation in the Bay.

Policy is that an incidental NER benefits cannot be used to justify a single purpose project that is not justified by its own NED benefits. However, if a local sponsor shows up for one NER cost-share, then there is potential for a NED/NER plan; i.e., an expansion of the study from single purpose to multiple purpose.

It is okay to count the benefits (unless precluded by policy, such as land development in flood control), but…

The student may confuse recreation policy with NER policy. Recreation policy itself is tortured. For flood control, the flood control benefit-cost ratio must exceed unity. For navigation and hurricane protection, primary benefits must exceed 50% on project costs; however, recreation benefits cannot be used to increase the size of the project.

a. They cannot be used to justify any increments to the project
b. They do not require cost-sharing
c. They do not require and cannot be used to justify any significant specific feature

Contrast: Add-Ons

Now contrast the above to "add-ons" for NED or NER. In this instance, there is a local sponsor willing to pay for additional costs in order to see (say) NER added to NED. The rules are

1. The original purpose must carry the joint facility, which cannot be reformulated based on the add-on.

2. The add-on purpose does not have to pay for any joint costs.

3. The add-on purpose does have to pay for any increase (separable) cost.

4. The add-on itself may be formulated as an additional feature.

5. Recreation is neither NED nor NER, but may be an add-on to either. It must pay for its additional costs, but need not pay for joint costs.

A recent example is Cape May Meadows, NJ. The project was formulated for ecosystem restoration. But with some incremental costs, hurricane and storm damage reduction was added (benefits>costs) with no loss to the ecosystem restoration component.

Appropriateness

When is it appropriate to:

a. Have a project with incidental NER or other outputs. This might occur where the features embody good environmental design leading to environmental sustainability. For example, a set back levee; replacing a traditional might generate restoration benefits by allowing a meander to naturally return. The features would have to be very limited.

b. Add-on to a primary purpose. Any time a primary purpose is justified, it is appropriate to look for an "add-on" federal feature. We assume that the add-on is small and that the sponsor of the primary purpose is not offended by bearing the full cost of the joint facility. This would occur when the sponsors were the same or "good will" was involved.

c. Share costs. This might occur when neither purpose is justified alone and both are significant in amount. Sharing cost especially appropriate where separate sponsors are involved

Complexities

By now you should have some sense of how sponsors of different "purposes" might react to all of the above rules?

1. Claim that the feature is not joint and therefore "I" shouldn't have to pay for it.

2. Claim that the outputs are merely mitigation for an adverse impact and therefore "I" shouldn't have to pay for it. This is a huge problem for resource agencies. By the rules of cost-sharing they are given an enormous incentive to find that environmental features merely represent mitigation. If it is enhancement, then someone other than the sponsor of the offending purpose must pay for the features. The local sponsor for the NED purpose has an equally strong incentive to claim environmental enhancement rather than mitigation.

An example of the above problem is the reformulated Yazoo Basin project in Mississippi. Cost sharing issues drive both farmer and environmentalist positions.

The idea of denying that you are getting a benefit from a project feature, in the hopes of avoiding any payment, is called "free-riding" in the economic literature.

The sharing of joint costs involves several practical complexities. These stem from the fact that joint use of a feature implies that two separate purposes must pay for one feature. Each of those purposes has different cost sharing amounts and attributes, such as up-front cash contributions. Hence, it will matter to a single local sponsor whether flood control is 60% or NER is 60%. Even though both are 35% non-Federal, flood control requires a 5% cash contribution.

Complexities

- Allocated joint costs
  - Each purpose pays
  - What if sponsorship is different
  - What if cost sharing is different
- Expect people to respond to incentives
- Planner as honest broker

M4 - 18

The cost-sharing problem will be exacerbated if the sponsorship is split. Each sponsor will be trying to minimize their share, presumably. In addition, the timing of when funding comes available; who get to complain about cost overruns; and similar "construction" problems will make joint projects more complex.

The Corps has experience in dealing with multiple purpose projects, especially reservoirs and beach erosion. In both cases, either heavy Federal financial participation, sizable benefits from cooperation in joint facilities and the saleable nature of some of the outputs (especially power, water supply, and beach recreation) enabled the Corps and its cost-sharing partners to reach acceptable solutions.

We can expect local sponsors to respect an honest attempt at a fair allocation of costs for joint facilities. In some cases, in the past and in the future, the local sponsors may be less price conscious than we expect.

Time for a Break in the Lecture

Take out a piece of paper and
Make a list of features which
Could contribute to both NER and FC
In other words, joint features

M4 - 19

Let us try an exercise.

Don't Worry if You Did Not Get Many

- The truth of the matter is that the Corps really has not gotten into a lot of multi-purpose planning for Environmental Restoration
- You know as much as your instructors
- So the challenge to you is to find true multi-purpose projects involving NER

M4 - 20

Alternative Cost Allocation Methods

Cost-Sharing the NED/NER Plan

- We have covered SCRB, the technique of choice for joint cost allocation
  - And a check on formulation too
  - But it can be expensive
- Where costs of one purpose are small, or joint costs are small:
  - Alternatives to SCRB
  - Benefits foregone or use of facilities.

M4 - 21

Let us turn to cost sharing of the NED/NER plan.

We have already covered SC-RB (module M3). We should note here that SCRB is also a check on formulation. For example:

1. SCRB cannot allocate joint costs where single purpose projects provide the same level of output as the Multiple Purpose (MP) project at lower cost than the separable cost of that purpose.

2. If separable costs are greater than benefits so that there are no remaining benefits, this implies that adding the separable increment is not justified.

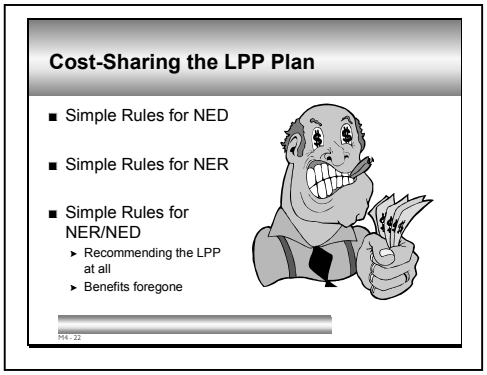
Further, SCRB can be expensive and time consuming. It requires the formulation of two additional projects: the single purpose NED and NER for the same level of output as for the joint project. Therefore, where the costs of one purpose are small, or joint costs are small, then consider alternatives to SCRB and coordinate with higher authority. Alternatives include benefits foregone or use of facilities.

1. Benefits foregone, comparing one project to another is theoretically incorrect as a method of allocating costs. As in the case of small amounts of reservoir reallocation, however, it may approximate a reasonable amount of joint costs. The assumption is that the larger purpose was sized properly, meaning marginal benefits and marginal costs were converging for the final increment. Therefore, benefits forgone approximates attributable costs.

2. Another simple method for allocating joint costs is use of facilities. Basically it calls for a percent allocation based on how much the facility is used by each purpose. Where both purposes make substantial use of large joint facilities, this method breaks down. Where one purpose dominates in use of the joint facilities, this method offers a less costly opportunity for an approximation.

3. The existing guidance is clear—you must use SC-RB, unless you check with higher authority before using a shortcut method.

Cost-Sharing the LPP



Now let us overlay the Locally Preferred Plan (LPP) over the NED/NER plan

Basic Rules

Review:

1. LPP and NED

    a. If the LPP is smaller, it is the subject of the categorical exemptions for flood control and harbors at ER1105-2-100, paragraph 3-3b (11) and paragraph 3-2b(10) respectively. Federal government will recommend the plan and cost-share in it.

    b. If the LPP is more costly than the NED plan but produces at least the same outputs, it will be recommended but Federal governments contribution is limited to the amount it would have contributed to the NED plan.

2. LPP and NER

    a. If the LPP is smaller, the Federal government will recommend the plan and cost-share it.

    b. If the LPP is larger, the Federal government will recommend the plan, but will limit its contribution to the amount it would have contributed to the NER plan.

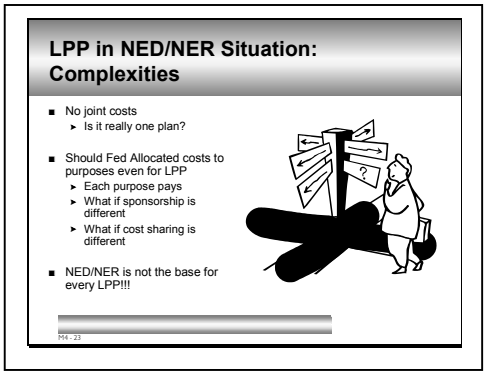
The LPP and NED/NER rules flow from the rules above:

3. LPP and NED/NER.

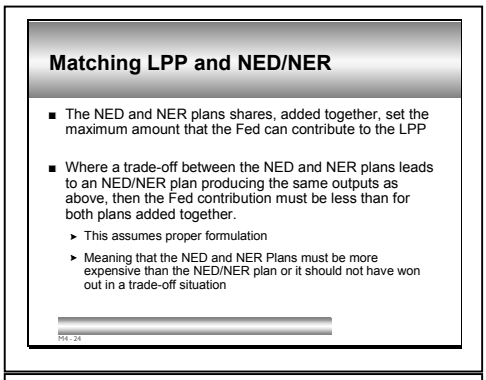
    a. If the LPP is smaller, the Federal government will recommend the plan and cost-share it.

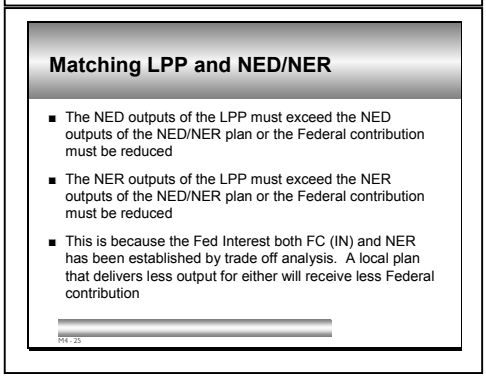
    b. If the LPP is larger, the Federal government will recommend the plan, but will limit its contribution to the amount it would have contributed to the NED/NER plan.

Complexities



Although the application of the LPP rules to the NED/NER plan sounds simple, a number of complexities have arisen.





1. Sometimes the NER/NED plan is merely the sum of two different plans in the same basin. There is no use of joint facilities. In fact, there is no trade-off either.

    a. This extreme situation should be treated like two different plans.

    b. The formulation of a true NER/NED plan (one which has joint facilities) gives rise to either

        i. A bad plan if the two independent plans are better than the NER/NED plan. This means that the NER/NED plan cannot be the basis for cost sharing; the two different plans, one for NER and one for NED should be the basis for cost sharing

        ii. A preferable plan if the NER/NED plan is better than the two independent plans. In this case, cost sharing should be based on the NER/NED plan and must be less for the Federal government than the cost sharing would have been for the two separate plans.

2. Suppose that the LPP has more NED but less NER outputs than the NED/NER. Now it makes no sense to use the NED/NER as the base for Federal contribution to the LPP. The same result obtains if the NER outputs are greater but NED benefits are reduced. Either way, an adjustment must be made to increase non-Federal costs because the optimized Federal outputs will not be forthcoming

a. This is because the Federal Interest in both flood control (or navigation) and NER have been established by trade off analysis. A local plan that delivers less output for either will receive less Federal contribution.

3. Obviously, having two different sponsors to deal with can cause practical issues of how to split the cost increment between the LPP and the NED/NER. This issue does not arise in a single purpose LPP, since there is probably only one sponsor (but not always). In a certain sense, it may seem to be a matter for the two sponsors to work out. Remember, however, that the Corps is going to recommend the LPP. So it must assign the costs to the proper purpose.

Study delays, missteps and poor reports usually have to do with misunderstandings of policy applications, often because the correct application is not obvious. So try to get higher authority (Division especially) on board with what you think the policy is. This is especially necessary where the cost sharing for the sponsor or sponsors is embedded in the policy question. A large part of successful formulation is knowing when and how to ask the right question.

Final thought: despite all the rules in this module, you cannot formulate by numbers. In fact, most of the rules are generated in response to new and challenging real world situations that arise in the field. It is the rules that catch up. This is especially true in the environmental arena. No one has all the answers to environmental sustainability; we haven't even asked all the right questions. That is what makes formulation an art; the real world is complex and challenging.

Review Questions

1. When does the NED plan have to be identified; when not?

2. What level of detail must the NED Plan be?

3. The cost of the NED Plan is 50; the NER 75; a joint plan producing the same outputs costs 150; the LPP costs 190. How much above its normal share must the local sponsor contribute?

4. Why might the amount in 3 be increased?

5. When does a trade off situation exist?

6. Name four 4 trade-off techniques.

7. What are the three situations in which NED and NER benefits are both delivered by one project?

8. Why is cost-sharing for the NED/NER plan more complex than for the NER or NED plans?

9. When might a technique other than SC-RB be reasonable for allocation of joint cost?

10. Name at least two measures that might be candidates for joint use.

Section Summary and a Look Forward

Section Summary

Trade-offs occur when you cannot efficiently give more of one purpose without giving up some of another purpose.

Jointly used features may involve no joint cost sharing, if incidental benefits or add-on purposes are involved

- However this means the primary purpose must carry the joint facility costs alone.
- The net effect may be no project at all.

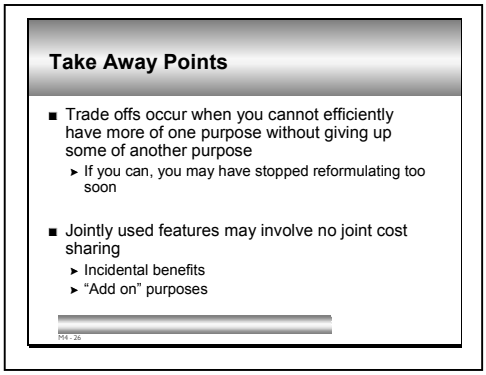
Joint use of features, which require joint cost sharing, have a major benefit: benefits from both purposes justify the joint feature. Hence, a project may be created where there was none before.

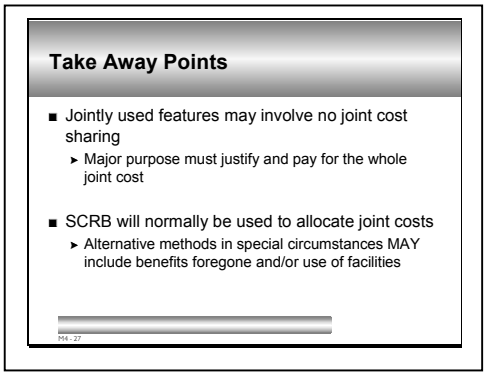
SCRB will normally be used to allocate joint costs but simpler methods may suffice in special circumstances.

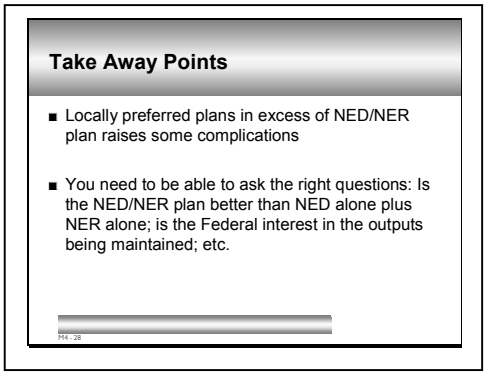
- The "certainty" of the SCRB method may ease free-riding concerns among sponsors.

Locally preferred plans in excess of NED/NER plan complicate cost apportionment

- Situation: LPP has more NED, but less NER or visa versa.
- Situation: 2 purposes, one sponsor. Allocation from one purpose to another will change cost-shared amount or attributes.
- Situation: 2 purposes, two sponsors. Allocation from one purpose to another will change local share and may lead to sponsor arguments.

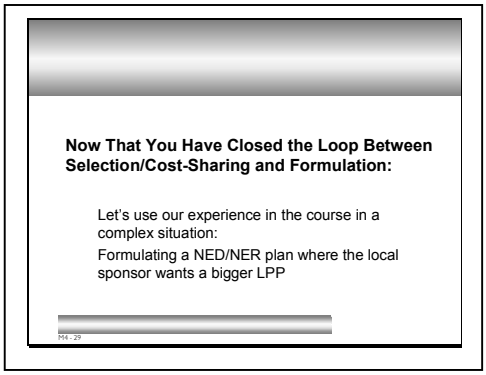




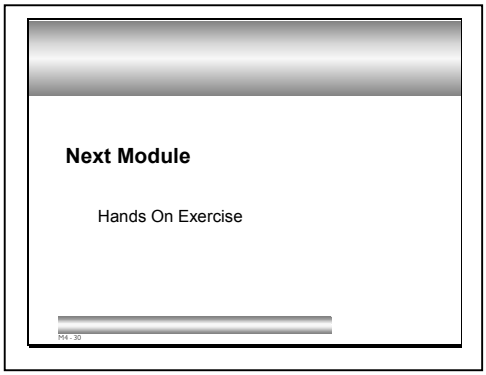


Look Forward

Let us use our experience in the course in a complex situation: formulating a NED/NER plan where the local sponsor wants a bigger LPP.



Next Module: Hands on Exercise.



References and Suggestions for Further Reading

Yoe, Charles and Kenneth Orth. Planning Manual Chapter 8. Institute for Water Resources, IWR Report 96-R-21, November 1996.

Planning Guidance Notebook, April 2000, ER 1105-2-100, CECW-P.

Planning – Cost Allocation for Multipurpose Projects Including Ecosystem Restoration, October 2000, EC 1105-2-219, CECW-P.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will know several techniques for comparing plans with different outputs
2. Student will understand the concept of a "trade-off" situation and its significance to plan designation and selection
3. Student will understand the basis for designating the NED/NER plan
    a. The student will be able to distinguish the "least environmentally damaging practical alternative" (Clean Water Act)
    b. The student will be able to distinguish the NED/NER from NED (or NER) plans with incidental NER (or NED outputs and from plans with "add-on" purposes
4. Student will know the criteria for plan selection
5. Student will know the cost-apportionment consequences of deviating from the NED/NER Plan and selecting the locally preferred plan (LPP)
6. Student will know several techniques to allocated costs between NED and NER for the NED/NER plan and related plans

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Instructor Notes and Exercises:

This module comes late in the course and offers an opportunity to refresh the student's memory about formulation and about its practical consequences for cost sharing. The importance of the named plans can be skipped or just reinforced with a copy of the handout from G2 on day 1. You also don't need to cover evaluation of NER/NED since M2 covered that; nor do you need to cover SCRB since M3 covered that.

Therefore, there are three critical areas that need to be covered:

1. Plan Comparison Trade-off analysis.
    a. Trade off analysis
    b. Designation of NED/NER Plan
2. Plan Selection
3. Cost sharing when a plan has NER and NED outputs
    a. Incidental outputs. One purpose gets a totally (or almost totally) free ride
    b. Incremental outputs. One purpose pays no joint costs only separable costs

c. Jointly produced outputs. Both purposes share in joint costs and pay their own separable cost

d. In each case, you will have to be sure the student understands the evaluation and formulation consequences

i. Incidental outputs. There are no significant separable costs. Plans are not formulated or optimized for incidental outputs, only on the basis of primary project outputs. Recreation in connection with hurricane and storm damage reduction is a prime example.

ii. Incremental outputs. Formulate only the separable portion. The "joint" part of the project MUST be justified and formulated without the benefits from the incremental output. Recreation with flood damage reduction on environmental restoration is a prime example.

iii. Jointly produced output. Neither purpose alone has to justify the joint costs. The (conceptual) sum of NED and NER must exceed costs. Therefore there is a strong incentive to convince the local sponsor(s) that NER and NED fit together. Without each other, there may be no justified project. This is not easy to explain to local interests—but we can start with our young planners.

4. Cost sharing when the Locally Preferred Plan is not the NED, NER, or NED/NER plan

a. Prior modules will cover NED and NER deviations, but it won't hurt to restate them briefly

b. For the NED/NER deviation, start with a simple analogy to NER alone or NED alone. The symmetry will make sense to the student.

c. Then cover one or two complications; for example, where the LPP has less NER output but more NED output than the NER/NED plan. Relate this problem to a formulation setting.

By the time you finish this module, you will be making some fairly sophisticated points, ones that even experienced formulators can find difficult. The inclusion of NER in a multipurpose setting is both exciting and challenging. So invite the student to learn with you at this point.

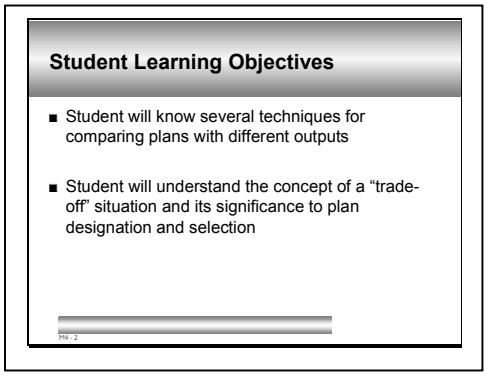
Slides M4-8 & 9
Exercise M4.1
The exercise should indicate the importance of values in trade-off analysis. People who think EQ is important will place a high EQ cost on step 1 and step 2 and a high weight on EQ. People who think SWB is important will place a high SWB cost on step 3 and step 4 and a high weight on SWB. People who believe in efficiency will put a high weight on economics and may even revel at considering option #4 because it doesn't reduce RTT enough. Notice also that the environmentalist has some choices to make: is the forest more important than the wetland. People who think SWB is important may have to choose between disruption to business and disruption to communities. And astute students will point out that a cost based analysis can not rule out the no action alternative.

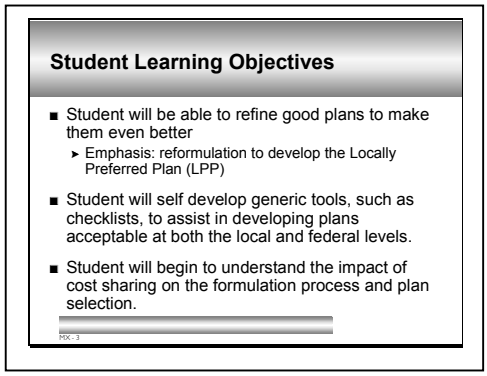
Slides M4-19 & 20
Exercise M4.2
The purpose of this exercise is two-fold:

1. We have stressed the complexities of joint use and cost sharing of facilities. We have also stressed a basic and fundamental opportunity to create projects where there was none before—by using NER and NED to justify the costs of joint facilities, which neither could justify alone. This opportunity, however, assumes that there are a lot of joint costs to share between NER and our other primary purposes. However, remember that NER seeks to restore the natural environment, whereas both navigation and flood control seek to "enhance" or "improve" nature. It is not clear that there is much opportunity for positive joint use. We will have to be innovative. Jointness can come from the purchase of land; it can come from lowering the creek bed to allow groundwater to irrigate plantings while at the same time increasing flood flows; it can come form the clearing of land of structures; it can come from low flow detention basins; it can come from replacing sandbar with dredge material; it can come from the use of rock for fish habitat; it can come from zoning which restricts upstream run off of rainfall and sediment; etc.

2. We want, per slide 17 to come to more of a partnership with the students. Some of the Corps leadership's concern is with the potential lose of experienced formulators. Hence a lot of this course is designed to deal with that concern. How to deal with NER as a full project purpose is a related concern, but different in the sense that even experienced formulators will have difficulty "getting their arms around" the complexities and the opportunities.

Module MX: Hands on Exercise based on Murrieta Creek, Flood Control, Environmental Restoration and Recreation, Final Feasibility Report, August 2000





It is now time for us to practice applying the principles we have learned so far in a multipurpose, interdisciplinary setting. We want to get as real world as we can in the short time we have.

This chapter is divided into 4 student exercises. The exercises are described in the 4 power point briefings in Appendix E. This part of the workbook discusses the issues associated with each of the four exercises. It is intended as a brief review and refresher after the course is completed.

Exercise 1: Developing Planning Objectives and Constraints

There are three sources of objectives and constraints:

1. Corps guidelines for conducting planning insist that we determine a plan for flood damage reduction based upon maximization of NED benefits. This is a constraint on our planning in the sense that we must formulate a reasonable NED plan, if one exists.

    a. If one does not exist, or if we fail to formulate it, there is no basis for recommending Federal participation in any plan. The mere existence of flood damage reduction benefits is not sufficient.

    b. You must be clear with the local sponsor on this point. This is especially critical where the sponsor wants a flood damage reduction plan which is larger than the NED plan and which has a BCR of less than unity.

    The same is true for the NER plan.

    The same is true for the NED/NER plan.

2. Local Sponsor and Stakeholders. In Murrieta Creek, there were strongly held and divergent opinions on what ought to be done. Values differed. In such a planning setting it makes

sense to plan broadly, starting with the planning objectives. This is particularly the case where the local sponsor is sophisticated and independent.

3. Environmental Agencies, Laws and related sources.
    a. These place constraints on our planning, by insisting that we do not cause any serious and unmitigatible harm, either to the environment or to other aspects of society. An example from Murrieta was the decision to constrain out affecting the lower income apartment house to avoid environmental injustice.
    b. On the other hand, environmental sustainability may give us the opportunity to work positively in pursuit of environmental outputs.

Exercise 2: Identify Measures and Combine them into Single Purpose Plans

It is clear that you ought to identify measures that serve each planning objective.

It is not as clear that the only way to combine measures into multipurpose plans is to first combine them into single purpose plans and then look for joint measures. This approach was reasonable for Murrieta, but the student should that he must be careful not to eliminate relatively poor performers for flood control and for restoration, which turn out to work well for joint purposes. For example:

	Benefits		Costs	BCR
	Flood Control	Ecosystem Restoration1/		
Measure 1	100	0	110	0.9
Measure 2	0	100	105	0.95
Measure 3	50	60	105	1.05

1/: Ecosystem restoration benefits are put in dollar terms here for ease of explanation

A second approach would be to explicitly look for "joint" measures right from the beginning. You would ask yourself to think of measures that can serve two purposes at once. This might make great sense in a Murrieta situation: the problems and opportunities make clear that you are going to strain to find either a flood control or an ecosystem restoration plan which is justified and even harder to find such plans that an active and knowledgeable local sponsor, like RCFC&WCD, will approve. Perhaps then it is "joint ness" which can provide the justification. Of course you still have to formulate an NED and an NER plan for cost-sharing purposes.

To summarize:

There are situations where "single purpose" formulation will likely lead to multipurpose plans. "Single purpose" formulation means that you will formulate for one purpose first, then the second, then compare. These situations are:

1. Where one purpose dominates, you might start with measures serving that purpose and then modify the measures for the second purpose

2. Where many measures are likely to be justified, for both purposes. Here the array of alternative measures and plans is likely to be large. Therefore, we expect lots of options. Hence we want ones that have high service for both purposes.

There are other situations where joint formulation will likely work:

1. Where neither purpose is strongly justified by NED/NER. Here you need measures which make very heavy contributions to both purposes, so you might as well start looking for then from the beginning.

2. Where neither purpose dominates.

CAUTION: The above tells you where to start. In theory, after incremental analysis, you should wind up in the same place, no matter which way you start.

Strategies

One strategy is to consider all measures from the perspective of the Federal Interest. If we are looking at flood damage reduction, then it would make sense to look at all measures that meet the planning objectives and constraints from the perspective of flood damages reduced and related NED benefits.

However, this does not mean that we should eliminate other strategies. For example, in Murrieta Creek, some stakeholders hated "concrete" solutions. It is reasonable to create an alternative that constrains out "concrete", evaluate it preliminarily and see how it fares. We would then present the information to see whether the stakeholders still had a problem. Perhaps they could be convinced that the increased cost of precluding "concrete" was not worthwhile. If not, and if their opposition appeared significant, it would make sense to carry this option through. CAUTION: there is no requirement to carry this type of option through; it just makes good planning sense.

In contentious planning settings, it is particularly advisable to use different formulation strategies-other than Federal Interest-to formulate plans.

Exercise 3: Combine single purpose plans into an array of multiple purpose plans

Our local sponsors are often very knowledgeable about flood damage reduction. They also must respond to local pressures. In Murrieta, the RCFCWCD felt it could not protect one city without protecting the other. This is perfectly understandable and legitimate. Unfortunately, the Corps authorities do not permit financial participation in plans based on such constraints. However, there is nothing to prevent the Corps from formulating a plan built around such a public strategy. If the local sponsor goes to Congress and makes a case by case change in cost sharing, then at least we can be satisfied that we have the best plan within the constraints of the public strategy.

Answer to alternative cost allocation problem in Exercise 3.

The answer to the alternative cost allocation problem in Exercise 3 is $16500 to flood control and $17500 to environmental restoration. The following is the allocation:

	Flood Control	Ecosystem Restoration	Total
1. Average annual benefits	2000	NA	--
2. Least Cost Alternative	2700	2200	--
3. Limited Benefits1/	2000	2200	--
4. Separable Costs2/	600	800	--
5. Remaining Benefits3/	1400	1400	2800
6. Percent	50%	50%	
7. Project Cost (First Cost)			34000
a. Separable	8000	9000	17000
b. Allocated Joint 4/	8500	8500	17000
c.Total	16600	17500	34000

1. Lesser of row 1 or row 2
2. For F.C., separable costs=MP-MP (less flood control)
   For E.R., separable costs=MP-MP (less ecosystem restoration)
3. Line 5=Line 3-Line 4
4. Percent in line 6 x $17,000

Cost Sharing the LPP

How do we, the Federal government, cost share the large LPP. The simple answer is to compute what we would pay for the NED/NER plan. We will pay that amount assuming the LPP produces at least the NED and NER outputs of the Federal plan (NED/NER). Otherwise, we must adjust somehow for the shortfall in NED or NER benefits. This problem will get more complicated when you have two different sponsors for the two purposes; or if the cost sharing by purpose is more divergent than for Murrieta. Many of the more complex issues surrounding cost sharing the LPP are still being considered at HQ, so stay tuned. As a formulator, you must be able to give specific answers on cost sharing, so you may need to request help from Washington.

Exercise 4: Reformulate and Write the District Engineer's Recommendation

This reformulation involved a major geographical and financial expansion of the project. Such efforts are becoming more commonplace within the Corps. It is worthwhile to look at the way the District proceeded. The District consulted with the local sponsor, as to what its objectives were. The sponsor wanted to provide a high and common level of protection to both cities. The sponsor wanted to do this in the most efficient way.

In addition, the sponsor wanted to avoid confrontations with environmental agencies. This was fortunate, because the Corps is constrained by Federal laws and policies to avoid environmental harm in conducting its mission. It is much easier for the Corps to recommend a locally preferred plan-with proper cost sharing-when it meet environmental criteria.

Therefore, the opposition of the environmental agencies to the expanded LPP was very serious in terms of the Corps' recommendation. This opposition took two major forms:

1. The environmental agencies objected to the District's without condition. The upstream work required mitigation and this in turn was based upon the without condition. The agencies believed that the local sponsor had caused environmental harm because of past activities. The agencies wanted that the mitigation for past actions built into the baseline (without project) condition, creating a better baseline environment than currently exists.

2. The environmental agencies objected to the Districts designation of the recommended LPP as the LEDPA (Least Environmentally Damaging Practicable Alternative). Under the Clean Water Act, the Corps has to recommend the alternative which accomplishes the Agency's objective with the least possible harm to the environment. The environmental agencies believed the best way to provide flood protection upstream was the purchase of homes. The Corps felt that its design permitted less annual maintenance cutting along the creek and therefore the recommended alternative was the LEDPA.

The AFB effectively lifted the NED constraint, but it could not and did not lift the EQ constraint. The Corps, the local sponsor and the agencies all recognized that fact.

The actual wording of the D.E.'s report became a major issue in the processing of the report. Here was the dilemma:

1. The large LPP had been formulated consistent with efficiency and environmental concerns. The local sponsor had agreed to pick up the extra cost. Therefore, a positive recommendation was made. This means that the Corps would continue to design positive plan; award the contract and oversee its construction. It would be the Federal Plan, even though the locals had to pay more for it. In fact, the wording was so positive that it was relatively easy for the Congressmen to get the job authorized as a normal Corps flood damage reduction project.

2. The other way of looking at the LPP is this: the upstream area is really separable and should be considered for local implementation. In this way, it would be clear that the Corps and the Administration did not like the uneconomic extension even if Federal funds were not involved. Congress could authorize the larger plan with traditional cost sharing, but it would have been harder.

Recreation policy

As to recreation, you will add it to any other plan to improve it. You cannot use recreation to justify the flood control or ecosystem restoration plans. This is because of policy. However, you might want to identify recreation opportunities as you go. For the sake of class time, we considered recreation only at the end of the formulation process. However, frequently recreation planning throughout the study period builds positive support for the project. In the case of Murrieta Creek, locals wanted to use recreation to

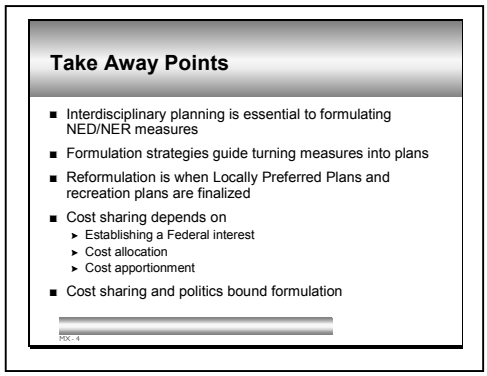
help them enjoy and appreciate the stream more. In addition, you are limited to 10 percent of Federal project costs and the measures must be picked from a list. Land acquisition for recreation is not permitted.

Review Questions

1. When do you formulate a Locally Preferred Plan?
2. How do you cost-share an NED/NER plan?
3. Can the District Commander recommend the Locally Preferred Plan?
4. What is the best way to develop a plan from measures?
5. What is the best way to develop NED/NER measures?
6. Why is formulation reiterated?
7. When is recreation added to NED/NER plans?
8. Must recreation be justified?
9. Can excess recreation benefits be used to justify an NED/NER plan?
10. Must an NED/NER plan have an underlying NED plan?

Section Summary and a Look Forward

Section Summary



Interdisciplinary planning is essential to formulating NED/NER measures.

> Interdisciplinary planning is essential for any Corps planning, but especially to NED/NER Plans.

Formulation strategies guide turning measures into plans.

> Whether you look for joint measures first or not depends on the planning setting. Murrieta might have benefited by this approach.

Reformulation is when Locally Preferred Plans and recreation plans are finalized.

You are required to produce LPP's as part of your study, if so requested

LPP's complicate District recommendations and are usually politically charged

Cost sharing a NED/NER plan depends on:

Cost allocation

Cost apportionment

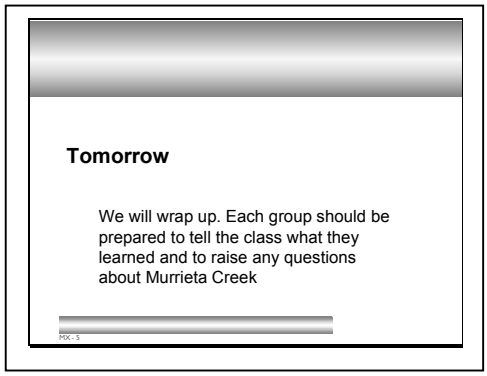
A large LPP plan has more complicated cost sharing:

Must establish Federal interest

Must retain NED and NER outputs

Cost sharing and politics bound formulation.

Looking Forward



This completes the workbook.

Selected Notes to the Instructor

Student Learning Objectives:

1. Student will be able to work on formulation tasks in an interdisciplinary team setting
2. Student will be able to apply the techniques developed in the course to develop a list of measures to address the planning objectives
3. Student will be able to apply the techniques developed in the course to develop a formulation strategy to combine measures into plans AND to eliminate plans and measures from further consideration
4. Student will be able to refine good plans to make them even better
    a. We will emphasize reformulation to develop the locally preferred Plan(LPP)
5. Student will self develop generic tools, such as checklists, to assist in developing plans acceptable at both the local and federal levels
6. Student will begin to understand the impact of cost sharing on the formulation process and plan selection

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Instructor Notes and Exercises:

This module is scheduled for 4 hours. It is an opportunity to pull together the threads of the course; therefore, you may wish to tailor this module to deal with issues you wound up emphasizing during the prior 2 and a half days. For example, your students may have had trouble with basics like the without project condition or what's included in benefits and costs. Therefore, emphasize those aspects of Murrieta Creek.

The module is organized around 4 exercises. These exercises should be done in teams of 7 to 10 (since there are about 30 students, this means 3 or 4 teams). The instructors should facilitate in order to ask the right questions. The teams should be interdisciplinary, since some of the material may be difficult to understand-especially the environmental material. The exercises and related discussion and presentation should each take about 1 hour, including breaks. The four exercises are:

Exercise 1: Develop Planning Objectives and Constraints.
First, present background material in a briefing. This will acquaint the students with the Study Area and its problems. The briefing, including student instructions, is in Appendix E-1. Assign the students to come up with the planning objectives and constraints in writing (butcher block). It is suggested that you have one group present the objectives and one present the constraints, just to keep things moving. Of course, don't tell the groups which ones are going to present.

a. Briefing time: 20 Minutes

b. Additional Material: Pages from the Main Report: p. 64-5 (Bridge Removal), p. 72-78 (Biological Resources) and p. 66-68 (Sedimentation Analysis)

c. Team time: 20 Minutes

d. Student brief: 10 Minutes

e. Hand out pages 99-100 of the Main Report (Planning Objectives; Planning Constraints)

f. Discussion: 10 Minutes

Exercise 2: Identify Measures and Combine into single purpose plans.
This will be a brainstorming session. Brief class on baseline conditions, especially the FMP (Flood Management Plan of the Local Sponsor). This briefing, including student instructions, is in the Appendix E-2. Given the planning objectives and constraints and what we have told them about the baseline condition in the briefing, students will be asked to identify measures for flood damage reduction first. Then they will be asked to identify measures for ecosystem restoration. Ask them to be as specific as possible as to location. We will also ask them for some strategies for combining measures into flood damage reduction plans and ecosystem restoration plans. We will then do a mid-exercise correction by handing out pages 101 to 113 (up to Recreation). We will then ask the teams to combine the measures into single-purpose alternatives for flood damage reduction and single-purpose alternatives for ecosystem restoration. We will then hand out pages 115-122 (flood damage reduction) and pages 125-132 (ecosystem restoration), along with tables 5.1-1, A-1 and A-2. The exercise would proceed as follows

a. Brief class: 5 Minutes

b. Teams brainstorm measures and strategies: 15 Minutes

c. Teams present results: 10 Minutes

d. Teams given additional material (pages 101-113) and combine measures into single purpose plans for flood damage reduction and ecosystem restoration: 15 Minutes

e. Teams present results: 10 Minutes

f. Hand out material on single purpose plans (p. 115-122, 125-132 and tables 5.1-1, A-1 and A-2. 5 Minutes

g. Break, as necessary

Exercise 3: Combine single purpose alternatives into an array of multiple purpose plans.
The materials from the prior two exercises are sufficient to conduct this exercise. Instructions are given on a power point briefing in the Appendix E-3. Use the first 6 slides. The remaining 3 should be used during the discussion and report out period.

a. Brief class: 5 Minutes

b. Teams combine single purpose alternatives into an array of multiple purpose plans and come up with cost-sharing (NOTE: One teams will be given a special problem in cost allocation and apportionment; it assumes, contrary to the actual case, that there are joint costs; see instructions in briefing): 20 Minutes

c. Two Teams present results: 10 Minutes

d. Discussion: 10 Minutes

Exercise 4: Reformulate.
At the AFB, the District was told to reformulate in order to be more responsive to the wishes of the local sponsor, the Riverside County Flood Control and Water Conservation District. Specifically, the District was told to look at upstream alternatives to protect the City of Murrieta (this means alternatives upstream of Reach 3) from both a flood damage reduction and an ecosystem restoration perspective. This exercise will have a mid-exercise correction. We will inform the teams of the new LPP as developed by the District. The student will then be asked to write the recommendation for the District Report. Student instructions are given in a power point presentation in Appendix E-4.

a. Brief Class on AFB: 5 Minutes

b. Teams reformulate for upstream reaches: 15 Minutes

c. One team reports on reformulation results and criteria

d. Brief Class on reformulation results: 5 Minutes

e. Teams write recommendation for District Commander: 15 Minutes

f. One team reports on wording of recommendation: 5 Minutes

g. Discussion of actual District Engineer's and Chief's wording of recommendation: 10 Minutes

APPENDIX A

REVIEW QUESTIONS AND ANSWERS

Review Questions and Answers

Module G1

Question G1-1:
What is plan formulation?

Answer G1-1:
Plan formulation is the process by which District planners create plans.

Question G1-2:
Where does plan formulation occur in the planning process?

Answer G1-2:
Plan formulation is the third step in the six step planning process.

Question G1-3:
Which of the following will likely be available at the first iteration of formulation? Pick one or more and explain why.

a. Planning objectives
b. Without condition
c. With condition
d. NER

Answer G1-3:

a. Planning objectives will be available – step 1.
b. Without condition will be available – step 2.
c. With condition will not be available – step 4.
d. NER plan will not be available – step 5/6.

Question G1-4:
What makes a NED plan reasonable?

Answer G1-4:
A reasonable plan does NOT have severe adverse impacts on a recognized Federal objective.

Question G1-5:
Define:

a. NED Plan
b. NER Plan
c. NED/NER Plan
d. LPP Plan

Answer G1-5:

a. The NED Plan reasonably maximizes NED benefits.
b. The NER plan reasonably maximizes NER benefits. At a minimum the NER plan must be cost effective. Since benefits are non-monetary the maximization concept is conceptual.
c. The NED/NER maximizes net (monetary & non-monetary) NED/NER benefits.
d. The LPP is a locally preferred plan which may be bigger, smaller or otherwise different than the NED/NER plan.

Question G1-6:
What is the role of constraints in determining the measures/plans, which can be considered?

Answer G1-6:
Valid constraints can eliminate plans from consideration because they are severely adverse environmentally or otherwise. Sponsor dislike is not a legitimate constraint.

Question G1-7:
What are the two dangers of "constraining out" plans or types of plans?

Answer G1-7:
First, you fail to define Federal financial interest. Second you may fail to find any justified plan.

Question G1-8:
What practical consequences follow from the determination of the NED/NER plan?

Answer G1-8:
The federal interest is limited to the NED/NER plan.

Question G1-9:
In what two senses is Formulation an Art?

Answer G1-9:
Different formulators formulate different. Different formulators don't always come up with the same answer. In Module G-2 we will add 2 related concepts: Formulation is an art in that most formulation is done without "all the facts". Further the art of formulation involves what to analyze in more detail and what to ignore or study at a minimum level of detail.

Question G1-10:
When is formulation "successful"?

Answer G1-10:
When three things occur:

1. Federal interest in funding is defined.
2. Locals are willing to pay all project costs above the Federal interests in funding.
3. Environmental agencies have no major objections to the selected plan.

Module G2

Question G2-1:
What is the "no action" alternative under NEPA?

Answer G2-1:
The without condition.

Question G2-2:
How long is the without condition?

Answer G2-2:
The period of analysis.

Question G2-3:
Name 5 items that are NOT included in project benefits and costs.

Answer G2-3:
Regional development benefits
Increased land values in developed flood plains
Improvement in trade deficit
Increase in non-OPEC oil flows
Increase in longshoreman's wage

Question G2-4:
Name several items that are not out of pocket but are still part of project costs.

Answer G2-4:
Interest during construction.
Value of lands taken by appraisal**.**

Question G2-5:
Distinguish measure, plan and program.

Answer G2-5:
Measures are size features/activities to address
Planning objective
Plans are combination of measure
Programs are combination of plans

Question G2-6:
Distinguish scale (size) from increment.

Answer G2-6:
A scale (size) is the same measure, at different sizes. An increment is a vertical a horizontal increase in plan's measure and output.

Question G2-7:
Name 2 types of scale other than size.

Answer G2-7:
Composition (material); location; timing, & duration.

Question G2-8:
What are the 2 purposes of a plan formulation strategy?

Answer G2-8:
First, combine measures into plans
Second, guide data collection

Question G2-9:
How many types of plans are required by Corps policy?

Answer G2-9:
There are 9, including the no action alternative: NED, NER, NED/NER, LPP, LEDPA, Reasonable and Prudent Alternative, and Environmentally preferred plans.

Question G2-10:
Why are some studies broader than others are?

Answer G2-10:
One factor is whether Federal Government will cost-share the project
Second is the "system" context

Question G2-11:
What is environmental sustainability?

Answer G2-11:
Heart of environmental sustainability is meeting needs of the present without compromising the quality of life for future generations.

Module G3

Question G3-1:
What is the starting point for plan formulation?

Answer G3-1:
The planning objectives.

Question G3-2:
Name the 3 kinds of formulation strategies and give an example of each.

Answer G3-2:
Policy (NED Plan)
Technical (incremental analysis)
Public (LPP)

Question G3-3:
Name at least 5 practical ways to identify measures for any type of planning situation.

Answer G3-3:
Brainstorm, ask District "Historian", checklist, other districts, written documents.

Question G3-4:
Name 3 ways to eliminate measures or plans without detailed evaluation.

Answer G3-4:
Screening criteria (on first round, use 4 formulation criteria); constrained out due to adverse impact; triviality.

Question G3-5:
What must come after initial formulation of plans and before reformulation?

Answer G3-5:
Evaluation.

Question G3-6:
Give at least 3 purposes for reformulating plans; give an example of each.

Answer G3-6:
Improve on 4 Formulation Criteria; e.g. incremental justification. "Mitigate" adverse impacts; e.g. induced flooding. Provide project "add-ons" like recreation.

Question G3-7:
Why might the project sponsor object to reformulating for "add-ons"?

Answer G3-7:
The "add-on" is a free rider to any joint costs.

Question G3-8:
Measure A for wetland restoration creates 5 acres of habitat for $100,000. Measure B creates 10 acres for $150,000. Habitat values per acre are the same. We have about $250,000 to spend. What should we do?

Answer G3-8:
Try spending more on Measure B and less on Measure A.

Question G3-9:
When should I stop changing the project in question 8?

Answer G3-9:
Where Q/$1A = Q/$1B at 250,000.The project is now cost effective. This assumes independent input. For interdependency, the formula is _____.

Question G3-10:
When should formulation end in theory and in practice?

Answer G3-10:
Theory. When we can't reformulate to get a better plan. Practice when we have NED/NER plan(s) identified and have a plan acceptable to local sponsor, without substantive environmental or other oppositions.

Module EC1

Question EC1-1:
What requirements or constraints does the National Environmental Policy Act impose on Corps Planners?

Answer EC1-1:
Section 102(2)(c) of NEPA includes the requirement for a Federal agency to prepare an EIS. NEPA is a law that imposes procedures on agencies to consider the effects of certain government actions on the environment; it does not demand that the alternative most beneficial to the environment be chosen. It requires the agency to use certain procedures, but it does not require the agency to take a particular action.

Question EC1-2:
What opportunities does the National Environmental Policy Act offer Corps Planners?

Answer EC1-2:
NEPA encourages productive and enjoyable harmony between man and the environment; promotes efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; and encourages enrichment of the understanding of the ecological systems and natural resources important to the Nation (42 USC 4321). In addition to complying with the procedural aspects of the Act, there may be opportunities to contribute to the policy established by NEPA in carrying out the numerous programs and activities within the Civil Works program.

Question EC1-3:
What is the judicial remedy if an agency has not complied with the National Environmental Policy Act?

Answer EC1-3:
The agency is enjoined from action until the agency has complied.

Question EC1-4:
What does Section 110 of the National Historic Preservation Act require a Federal agency to do?

Answer EC1-4:
It requires that the agency minimize harm to historic landmarks adversely affected by Federal projects.

Question EC1-5:
Does compliance with the Coastal Zone Management Act exempt public or private parties from compliance with other environmental laws?

Answer EC1-5:
No.

Question EC1-6:
Do Federal agency activities in the coastal zone have to be consistent with the state coastal zone management program?

Answer EC1-6:

Yes. Federal agencies must provide a consistency determination to the relevant State agency at least 90 days before final approval of the Federal activity.

Question EC1-7:
What requirements or constraints does the Endangered Species Act impose on Corps Planners?

Answer EC1-7:
The Act requires all Federal agencies to engage in biological assessments whenever their actions may affect listed species or their habitat and to consult with the FWS or NMFS whenever their actions may adversely affect listed species or their habitat.

Question EC1-8:
What opportunities does the Endangered Species Act offer Corps Planners?

Answer EC1-8:
There may be opportunities for the Corps to restore or protect habitat for threatened and endangered species, or to contribute to endangered species recovery plans, as part of ecosystem restoration, natural resources management, dredged material management and water control management projects and initiatives.

Question EC1-9:
Section 9 of the Endangered Species Act prohibits the "taking" of any member of a listed species. Describe the possible consequences of a violation of Section 9.

Answer EC1-9:
Civil injunctive suits by the United States; Civil injunctive suits by any person under ESA citizen suit provision (Section 11(g)); Administrative civil penalty action; Criminal prosecution by the United States.

Question EC1-10:
How does a taking under the 5th Amendment of the Constitution occur?

Answer EC1-10:
A taking under the 5th Amendment usually occurs by eminent domain in a condemnation proceeding in a court. It also can occur, however, when a government regulation goes "too far".

Question EC1-11:
What governmental entities have the primary responsibility for the allocation of water?

Answer EC1-11:
States have the primary responsibility for the allocation of water.

Question EC1-12:
Who writes the regulations governing the Corps implementation of the Section 404 program?

Answer EC1-12:
The Environmental Protection Agency writes the regulations governing the Corps implementation of the Section 404 program, and it can veto Corps Permit issuances.

Question EC1-13:
What are the implication of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for Corps Projects?

Answer EC1-13:
CERCLA operates under principles of strict joint and several liability. It imposes liability on the current owner or operator of a site as well as past owners, and operators of the site. It also imposes liability on anyone whose hazardous substances were disposed at the site. These liability classifications have been broadly interpreted by the courts. – "Touch it and you are liable".

Module EC2

Question EC2-1:
When is mitigation likely?

Answer EC2-1:
When environmental resources have less value in the with condition than in the without condition.

Question EC2-2:
Habitat values are 2000 in the with condition and 1700 in the without condition. Is the project an NER project or a NED project?

Answer EC2-2:
This appears to be an NER project since the values are higher in the with condition. It could be a NED project with incidental NER benefits.

Question EC2-3:
Who pays for the project in #2?

Answer EC2-3:
The NER proponent.

Question EC2-4:
List the four major resources for which the Corps must mitigate.

Answer EC2-4:
The four are: ecological, cultural/historic, aesthetic, water quality

Question EC2-5:
Which of the four major resources in #4 has no direct agency proponent?

Answer EC2-5:
Aesthetic resources

Question EC2-6:
What is the advantage of early coordination with resource agencies?

Answer EC2-6:
Early coordination permits avoidance of environmental harm and resource agency concern by the use of low cost design changes, such as the use of environmental windows.

Question EC2-7:
Who pays for mitigation?

Answer EC2-7:
The offending purposes. The exception is that NER should have no fish and wildlife mitigation.

Question EC2-8:
What is the preferred sequence of mitigation for ecological resources?

Answer EC2-8:
Avoid, minimize, rectify, reduce, compensate.

Question EC2-9:
There is no requirement to fully mitigate except for what resource?

Answer EC2-9:
Wetlands

Question EC2-10:
Who is responsible for recommending mitigation for a Corps project?

Answer EC2-10:
The District Commander, subject to higher authority review. The resource agencies play a powerful but not deciding role.

Module ER1

Question ER1-1:
What is the purpose of National Ecosystem Restoration?

Answer ER1-1:
The purpose is to restore a degraded ecosystem to its original, self-sustaining functions.

Question ER1-2:
What is the budget priority of National Ecosystem Restoration?

Answer ER1-2:
It has a high priority, coequal with urban flood control and commercial navigation. This priority is enhanced when the selected plan involves Corps expertise and avoids new land purchase.

Question ER1-3:
What is the cost sharing for National Ecosystem Restoration?

Answer ER1-3:
That depends on the specific authority used. Our generic authority is Section 210 of WRDA 1996. It requires 35 percent non-Federal cost sharing for first costs allocated to ecosystem protection and restoration, including LERRD. All operation, maintenance, repair, rehabilitation and replacement (OMRR&R) costs are non-Federal. For specific programs, see ER1165-2-501 and 502 and Appendix F, ER1105-2-100.

Question ER1-4:
Name the major 2 programmatic authorities which pertain to non-navigation situations.

Answer ER1-4:
The two are Section 1135 and Section 206. Bother of these could be used in navigation situations but don't require that. Section 1135 requires a Corps project; Section 206 does not.

Question ER1-5:
Is there any programmatic authority I can use for a major restoration project involving maintenance dredging or must I seek congressional modification of the existing project?

Answer ER1-5:
Use Section 207 of WRDA 1996, which is designed for just the above situation (see EP1165-2-502, page 8).

Question ER1-6:
Can I add recreation features to ecosystem restoration projects?

Answer ER1-6:
Yes. However, intensive recreation use may be incompatible with the restoration objective. Hence, recreation facilities must be limited. See EP 1105-2-502, Appendix B, and Recreation Development at Ecosystem Restoration Projects, especially the checklist at B-4.

Question ER1-7:
Is there mitigation for Ecosystem Restoration projects?

Answer ER1-7:
There should be no fish and wildlife mitigation, since mitigation implies we have made matters worse than would have occurred under the without project condition. Hence, if we need mitigation for fish and wildlife, we have should not be recommending the project. However, there may still be a need for cultural and historic mitigation.

Question ER1-8:
What additional restoration authorities are there beyond the regular program and programmatic authorities?

Answer ER1-8:
There are numerous opportunities to participate in efforts to restore the environment. Taken together, they represent a strong signal to try to improve the environmental situation. Some provide only hints or admonitions that have little direct applicability (Section 907 of WRDA 1986 tried to "monetize" environmental benefits; see Section 306, WRDA 1986 also). Others pertain to how we do business in our other programs (Section 906 requires concurrent implementation of mitigation and other project features). We are encouraged to participate in various Federal and local programs; e.g., the Gulf of Mexico program or the Chesapeake Bay program, Coastal America or the Migratory Flyway programs.

Question ER1-9:
What do all these authorities mean to me as a Formulator?

Answer ER1-9:
The bad news is that you have a lot of rules to follow. The good news is that you have a lot of options as well. These options are particularly valuable because of the high priority afforded ecosystem restoration. The bad news is that you have a lot of new terms and concepts to understand. The good news is that you have an interdisciplinary team.

Question ER1-10:
How does ecosystem restoration relate to watershed planning?

Answer ER1-10:
Watershed Planning is multiple purpose, pure planning not for Corps implementation; NER is single purpose, for Corps implementation. Despite this obvious distinction, there is a strong overlap. Watershed planning has a better ecosystem focus; this indicates whether the ecosystem measures are likely to

become self-sustaining or lose out to shocks from outside the immediate area. Hence a watershed focus moves the ecosystem plan up in the priority list.

Module ER2

Question ER2-1:
What are the three Environmental Quality (EQ) attributes?

Answer ER2-1:
Ecological, cultural or aesthetics

Question ER2-2:
Why are significant resources identified in ecosystem restoration plan studies?

Answer ER2-2:
To help identify the problems and opportunities the study is going to address

Question ER2-3:
What sets ecosystem restoration apart from other planning studies?

Answer ER2-3:
Significant resources

Question ER2-4:
What does an inventory identify?

Answer ER2-4:
The current condition of a significant ecosystems resources or objective endpoint

Question ER2-5:
What is a commonly used unit of measure for ecosystem restoration objectives?

Answer ER2-5:
Habitat units

Question ER2-6:
What is the primary outcome of step 2?

Answer ER2-6:
The forecast of the without project condition

Question ER2-7:
What should environmental outputs reflect?

Answer ER2-7:
The planning objectives and provide human valued benefits

Question ER2-8:
What are the three planning activities where HEP may be used?

Answer ER2-8:
Wildlife habitat assessments, trade-off analysis, and compensation analysis

Module ER3

Question ER3-1:
Without reviewing your notes, prepare a flow diagram that summarizes the principal elements of formulating ecosystem restoration plans that meet planning objectives.

Answer ER3-1:
Refer to the diagram on slide ER3-8. This chart organizes the building blocks of plan formulation, namely measures, outputs, and costs that support the planning objectives.

Question ER3-2:
Define and describe the difference between the concepts of ecosystem values and ecosystem services. Provide and example of an ecosystem value and an ecosystem service.

Answer ER3-2:
Ecosystem values refer to goods or services that derive human benefits, satisfaction, and affect human choices. Ecosystem services can be defined as broad classes of products and life-support services that ecosystems provide. A ready example of an ecosystem value might include a desirable or aesthetic experience, the price of food, or reduced flood damages. Corresponding examples of services might include, water supply, food production, and regulation/translation of stream current.

Question ER3-3:
List the four criteria that define a management measure.

Answer ER3-3:
Refer to slide ER3-25. The four basic properties of a management measure are that it (1) addresses the planning objective, (2) defines a feature or activity and where it is located, (3) has an estimable cost, and (4) has an estimable output.

Question ER3-4:
Define and differentiate among structural, non-structural, and active management restoration measures. Provide an example of each type of measure.

Answer ER3-4:
Structural measures are activities or features that result in the construction or deconstruction of artificially engineered features (e.g. water control structures). Non-structural measures are activities that do not directly lead to the construction of deconstruction of artificial structures (e.g., land purchases or relocation). Active management measures are activities or features that are used to transition artificial (man-made) features and actions to natural forces and materials (e.g., biodegradable netting or breaching of an earthen levee).

Question ER3-5:
Name at least three metrics for measuring environmental outputs. Assume that the planning objective is to restore aquatic and related habitat in a degraded wetland.

Answer ER3-5:
Among several possible outputs, consider (1) habitat units, (2) fish counts, or (3) sustained water depth.

Question ER3-6:
Name the 6 criteria that define an alternative plan.

Answer ER3-6:
Refer to slide ER3-45. The six basic properties of an alternative plan are that it (1) addresses the planning objective, (2) defines the management measures that it is comprised of, (3) defines a location where it would be implemented, (4) has a corresponding estimable cost, (5) has a corresponding estimable output, and (6) has a name that can be understood and/or tracked by those involved in the formulation and evaluation steps.

Module ER4

Module F1

Question F1-1:
When did the Corps of Engineers first become involved in flooding issues?

Answer F1-1:
Corps involvement in flood control began in the middle of the 19th century.

Question F1-2:
How did the National flood control program begin?

Answer F1-2:
The Flood Control Act of 1936 established the National flood control program. It was in response to recent severe floods on the Mississippi River. The Corps of Engineers was given responsibility for the program.

Question F1-3:
Is multipurpose watershed planning a new idea?

Answer F1-3:
Not at all. Water resource planning in the US has its roots in multipurpose planning. From the Gallatin Report to the 308 Reports to the Principles and Standards to the present day, multipurpose planning has been practiced. The emphasis on this kind of planning has waxed and waned with the changing needs of the Nation and National policy priorities.

Question F1-4:
How has the Corps' policy on nonstructural flood damage reduction measures evolved over time?

Answer F1-4:
Nonstructural measures have been encouraged since the start of the National flood control program began. In the 1970s interest in nonstructural measures reached a peak. The P&S required formulation of a primarily nonstructural plan. The 1980s and 1990s saw an emphasis on the NED Plan. More recently interest in nonstructural measures has reappeared.

Question F1-5:
Is there any limit on the size of a stream the Corps can consider for a flood damage reduction project?

Answer F1-5:
Yes. It must have an average annual flow of at least 800 cfs.

Question F1-6:
What authority does the Corps have to become involved in flood damage reduction other than the National program?

Answer F1-6:
Continuing Authority Programs have been added over time. CAP authorities known as Section 205, Section 208 and Section 212 also provide authority for flood damage reduction activity.

Module F2

Question F2-1:
What are the two essential elements of a flood problem?

Answer F2-1:
We need a flood or water and there must be valuable resources at risk of some sort of damage for a problem to exist. Otherwise a flood alone could be a good thing.

Question F2-2:
Why does the definition of a problem matter for the solution considered?

Answer F2-2:
The problem statement influences both planning objectives and the types of solutions one seeks. For example, if the flood problem is stated as a land use issue this points toward very different solutions that does the definition of an ice flooding problem.

Question F2-3:
How might the type of flood damage influence the plans formulated?

Answer F2-3:
Residential damages might be amenable to structure raising while industrial damages might not. Basement flooding could lead to utility cells and measures other flood problems might not suggest. Content damages with little structure damage might lead to evacuation and flood fighting options that other flood damages might not point towards.

Question F2-4:
What is a weakness of the recurrence interval estimate of flood frequency?

Answer F2-4:
All of the technical hydrologic and statistical issues aside, very few people really understand it well. The public has a great deal of difficulty understanding the concept correctly.

Question F2-5:
What does it mean if a flood has an exceedance frequency of .02?

Answer F2-5:
It means that the flow associated with this exceedance frequency has a 2% chance of being equaled or exceeded in any given year, all other things equal.

Module F3

Question F3-1:
How does a structural flood plan differ from a nonstructural flood plan?

Answer F3-1:
A structural plan is oriented more toward managing the flood or water portion of the flood problem. A structural plan is oriented more toward managing the resources portion of the flood problem.

Question F3-2:
What four relationships are required to estimate expected annual damages?

Answer F3-2:

1. An elevation-damage relationship
2. A discharge-elevation relationship
3. A frequency-discharge relationship
4. A damage-frequency relationship

These are called by many different names and the terms are given a different order at times, so similar answers are fine.

Question F3-3:
Which relationship of the Hydroeconomic model would a wider channel affect? An earthen levee? Detention ponds? Land use restrictions?

Answer F3-3:
The rating curve or elevation-discharge relationship. The damage curve or elevation-damage relationship. The frequency curve or frequency-discharge relationship. This could be either the damage curve or the frequency curve.

Question F3-4:
Name three plan formulation strategies.

Answer F3-4:

1. Formulating for planning objectives
2. Eliminating ideas
3. Expanding ideas
4. Water-oriented plans
5. Resource-oriented plans
6. And so on

Question F3-5:
Create a new plan formulation strategy.

Answer F3-5:
This is open to the students' imaginations. The point is that any way of thinking about building plans that works is a decent and acceptable strategy.

Module F4

Question F4-1:
What are some specific factors that could cause future expected annual damages to be different from existing expected annual damages?

Answer F4-1:
Changes in future hydrologic conditions and the future base of resources at risk for any of the many reasons they may change would be acceptable answers. This could include changes in climate, weather, rainfall, run-off, roughness coefficients, topography, ground cover, soil type, population, land use and so on.

Question F4-2:
How do induced damages differ from induced flooding?

Answer F4-2:
A flood damage reduction measure may result in more frequent, faster, or deeper flood flows. These would be examples of induced flooding. Induced flooding does not become induced damage until resources are damages by the induced flooding.

Question F4-3:
What four questions provide an intuitive definition of risk assessment?

Answer F4-3:
What can go wrong? How can it happen? How likely is it? What are the consequences?

Question F4-4:
Why is incremental analysis important for plan formulation?

Answer F4-4:
Economic efficiency is a goal for the Corps' Civil Works Program. Economic efficiency maximizes net economic value. That can only be done through marginal or incremental analysis. Requiring each identifiable increment t have benefits in excess of its costs assures that scarce and valuable resources will not be wasted.

Question F4-5:
What broad categories of environmental consequences can flood damage reduction projects produce?

Answer F4-5:
Flooding is natural. Some flood damage reduction measures are more unnatural than others. This provides another plan formulation strategy to add to those of the last module, i.e., developing plans that most closely resembles the natural system or that minimize environmental consequences. Habitat enhancements, water quality improvements, greenways, erosion and siltation reductions, biodiversity, sustainability and other environmental values can be served by some measures.

Question F4-6:
Name two exceptions to the selection of the NED plan.

Answer F4-6:
In addition to the well known locally preferred plan, if a recommended plan proposed contains economically inefficient increments an exception from the ASA (CW) must be obtained. Another common example might be if a sponsor desires a levee of sufficient height to meet FEMA's flood insurance requirements. If it is determined that such a levee has higher net benefits than smaller levees, then the levee desired by the sponsor can be recommended without having to analyze larger levees to identify the NED Plan. When the NED Plan has less than a 90 percent reliability of protecting against the 1 percent chance annual flood event, an exception to the NED Plan may be recommended.

Module IN1

Question IN1-1:
What is Inland Waterways?

Answer IN1-1:
It is a system of waterways congressionally defined that primarily serve tow traffic on intracoastal and river systems.

Question IN1-2:
How big are tows?

Answer IN1-2:
Tows vary in size based upon the individual barge sizes and the number of barges lashed together.

Question IN1-3:
What are the criteria for major rehabilitation?

Answer IN1-3:
A project structure or features must exhibit the potential for increased reliability and/or efficiency and be economically justified to qualify for Major Rehabilitation.

Question IN1-4:
Name an authorization for initiating a study.

Answer IN1-4:
Section 216 of the River and Harbors Act of 1970.

Question IN1-5:
What is the cost sharing for inland navigation?

Answer IN1-5:
It is 100% Federal.

Module IN2

Question IN2-1:
A lock exhibits increasing processing times. What could the problems be?

Answer IN2-1:
They could be several. There could be valve problems letting water into and out of the chamber. Structural integrity of the wall would require slower filling and emptying times to reduce hawser stresses, etc.

Question IN2-2:
The State of Texas does not allow open water disposal in Matagorda Bay. Is that a constraint?

Answer IN2-2:
Yes, it affects what can be considered for dredged material disposal.

Question IN2-3:
What is the hinterland for a lock?

Answer IN2-3:
The origin and destinations of the commodities which pass through it.

Module IN3

Question IN3-1:
What is one of the design considerations of a lock filling system with respect to traffic throughput?

Answer IN3-1:
While the filling and emptying system are designed to minimize hawser stresses and the potential for impact damage, they are designed to provide a fast and efficient lock operation.

Question IN3-2:
What are some nonstructural alternatives that would facilitate inland waterway traffic?

Answer IN3-2:
Traffic management has the greatest potential.

Question IN3-3:
Name three approaches to formulation.

Answer IN3-3:
Brainstorming, reviewing related study documents, interviewing experts.

Module IN4

Question IN4-1:
Is the plan with the highest benefit cost ratio the NED plan?

Answer IN4-1:
Not necessarily. The NED plan is the plan that maximizes NED benefits.

Question IN4-2:
Is the only exception to the NED plan a less costly plan?

Answer IN4-2:
No, a more costly plan can also be recommended. However, neither have much application in inland navigation unless they are involved in beneficial use of dredged material.

Question IN4-3:
What is a way to analyze separable element?

Answer IN4-3:
The normal way is to look at the incremental costs and compare them to the incremental benefits of the added reach

Module NH1

Question NH1-1:
What is Harbor Navigation?

Answer NH1-1:
It is the collection of independent channels that serve deep-draft ports along the coasts, bays, rivers and Great Lakes.

Question NH1-2:
Who has the responsibility for the construction and maintenance of deep-draft channels?

Answer NH1-2:
The Corps of Engineers.

Question NH1-3:
Who is responsible for relocations, lands, easements, and rights of way?

Answer NH1-3:
The local cost sharing sponsor.

Question NH1-4:
Name an authorization for initiating a study.

Answer NH1-4:
Section 216 of the River and Harbors Act of 1970.

Question NH1-5:
What is the cost sharing for harbor navigation.

Answer NH1-5:
It varies.

Module NH2

Question NH2-1:
A port with a 35-foot channel anticipates no growth in commodity movements, but move ships now draw 49 feet of water. Name problems and opportunities.

Answer NH2-1:
The problem is that most ships can only use the port if light loaded. The opportunities include channel deepening, lightering, and tide riding.

Question NH2-2:
The State of Maryland does not allow open water disposal in the Chesapeake Bay. Is that a constraint?

Answer NH2-2:
Yes, it affects what can be considered for dredged material disposal.

Question NH2-3:
What is the hinterland for a crude oil port?

Answer NH2-3:
The port itself.

Question NH2-4:
Name ship characteristic data needed in order to do economic analysis.

Answer NH2-4:
Some data needed includes arrival and departure drafts, carrying capacity, and operating costs.

Module NH3

Question NH3-1:
A port with a 35-foot channel anticipates no growth in commodity movements, but move ships now draw 49 feet of water. What is the opportunity for transportation cost savings?

Answer NH3-1:
The cost savings could come through economies of scale.

Question NH3-2:
The State of Maryland does not allow open water disposal in the Chesapeake Bay. Is that a constraint?

Answer NH3-2:
Yes, it affects what can be considered for dredged material disposal.

Question NH3-3:
What effect does increasing an alternative depth beyond 45 feet?

Answer NH3-3:
It drastically increases the cost-sharing ration for the increment of depth beyond 45 feet.

Question NH3-4:
If you anticipate no induced traffic to the port, should you need to do multi-port analysis?

Answer NH3-4:
The simple answer is no, however there may be reasons for needing to do a multi-port analysis.

Question NH3-5:
Who is responsible for confined dredged material disposal areas?

Answer NH3-5:
That is a cost share item between the non-Federal sponsor and the Federal government.

Module NH4

Question NH4-1:
Is the plan with the highest benefit cost ratio the NED plan?

Answer NH4-1:
Not necessarily. The NED plan is the plan that maximizes NED benefits.

Question NH4-2:
Is the only exception to the NED plan a less costly plan?

Answer NH4-2:
No, a more costly plan can also be recommended.

Question NH4-3:
What is a way to analyze the last added reach?

Answer NH4-3:
The normal way is to look at the incremental costs and compare them to the incremental benefits of the added reach.

Module M1

Question M1-1:
Distinguish between multi-objective planning and multipurpose projects.

Answer M1-1:
This language is messy and used in many different ways. A purpose is essentially a project output like flood damage reduction, hydroelectric power or navigation services. A project is multipurpose if purposely it produces more than one kind of output. Multi-objective planning refers to the policy goal of the planning process. Planning has been multi-objective in the past. For much of the 1980s and 1990s it was single-objective with National Economic Development as that objective. More recently there is interest in NED and NER objectives. The planning process and the plans are multi-objective. These multi-objective plans can be met by single purpose or multipurpose projects.

Question M1-2:
Give one example of multi-objective planning from the Corps' past.

Answer M1-2:
The idea here is for each participant to identify a multi-purpose project from his or her own District. The answer will vary depending on the participants background.

Question M1-3:
What planning objectives were identified by Senate Document 97?

Answer M1-3:
It required multi-objective planning to address development, preservation of resources, and well being of people.

Question M1-4:
When was the golden age of multipurpose reservoir projects?

Answer M1-4:
The 1960s are as close to a golden age for multipurpose projects as there has been.

Question M1-5:
What are the Corps' high priority outputs/purposes?

Answer M1-5:
These are currently flood damage reduction, hurricane and storm damage reduction, navigation or ecosystem restoration.

Question M1-6:
Can you formulate a water supply project? A hydropower project? A recreation project?

Answer M1-6:
None of these purposes can be pursued as a single purpose project so the short answer is no, no, and no. The Corps cannot conduct single purpose water supply studies, except for analysis of existing data under Section 22 of the Water Resources Development Act of 1974. This constraint does not apply to single purpose water supply modifications to previously constructed projects having flood damage reduction or navigation purposes.

Hydroelectric power development may be considered during planning for multipurpose projects involving dams and lakes and may be recommended if non-Federal development would be impractical. Current policy limits exercise of these authorities. Recreation is currently a low priority output so the Corps cannot formulate single purpose recreation plans unless a sponsor is willing to pay 100 percent of the associated implementation costs.

Module M2

Question M2-1:
What is the best way to formulate a multipurpose project?

Answer M2-1:
Problems and opportunities are identified and planning objectives and constraints are established. When these objectives can be met by multiple purposes, formulation strategies should incorporate these purposes from the very beginning. One of the most effective formulation strategies is to formulate to meet each planning objective. Then build plans from among the measures formulated to meet the individual planning objectives.

Question M2-2:
What distinguishes watershed planning from project planning?

Answer M2-2:
Watershed planning considers the entire river basin rather than focusing on a specific locale or reach of the river. This is a major distinction between it and project planning. It seems only reasonable that watershed planning with its more comprehensive view of a watershed and its problems should lead to multipurpose projects more often than not. Project planning is usually constrained to considering projects the Corps can implement. Watershed planning has no such constraint.

Question M2-3:
Define cost allocation.

Answer M2-3:
Cost allocation is the process of apportioning the total financial costs of a project among the purposes served by the project. This apportioning is made necessary by the fact that different project purposes have different cost shares associated with them.

Question M2-4:
What is the Corps' recommended cost allocation technique for multipurpose projects?

Answer M2-4:
Several cost allocation methods have been used historically by the Corps. The separable costs - remaining benefits (SC-RB) method of cost allocation is recommended for use with multipurpose projects.

Question M2-5:
What will the most likely multipurpose project look like in the future and how does that differ from the multipurpose projects of the past?

Answer M2-5:

Ecosystem restoration is likely to be included with one of the other high priority outputs in a single multipurpose project. This is markedly different from the multiple purpose reservoirs of the 1960s.

Module M3

Question M3-1:
What is the difference between cost allocation and cost sharing?

Answer M3-1:
Cost-sharing or cost apportionment is the practice of dividing the responsibility for paying the costs of a project between Federal and non-Federal interests. The first step required in determining cost shares is to allocate or assign the costs of the project to the different purposes served. Cost allocation is the process of equitably distributing project costs among the project purposes served. Once costs have been allocated, those costs can be shared according to the existing cost-sharing responsibilities.

Question M3-2:
What are some methods besides the SC-RB method used for cost allocation?

Answer M3-2:
In addition to the Separable Cost-Remaining Benefits method the following techniques have also been used: Alternative Justifiable Expenditure Method, Use of Facilities Method, Additional Cost, Percent of Benefits. On occasion no cost allocation has been used when the additional purpose outputs are incidental.

Question M3-3:
What is a separable cost?

Answer M3-3:
Separable costs are the costs incurred specifically to add a purpose to a project. These costs are normally estimated during plan formulation to evaluate the economic feasibility of including the purpose in a multipurpose project. The separable cost is the minimum cost that will allocated to a project purpose. Separable costs for any purpose X are determined by subtracting from the cost of the multipurpose project the cost of the most economical alternative project to obtain the same benefits for the other purposes with purpose X omitted.

Question M3-4:
What is a remaining benefit?

Answer M3-4:
Remaining benefits are the limited benefits less the separable costs of that purpose. Limited benefits are the lesser of project purpose benefits or the cost of an alternative single purpose project.

Module M4

Question M4-1:
When does the NED plan have to be identified; when not?

Answer M4-1:
NED plan must be formulated for all project purposes except environmental restoration. It does not have to be formulated for environmental restoration studies.

Question M4-2:
What level of detail must the NED Plan be?

Answer M4-2:
A very high level because it is either the recommended plan or sets the Federal funding level.

Question M4-3:
The cost of the NED Plan is 50; the NER 75; a joint plan producing the same outputs costs 150; the LPP costs 190. How much above its normal share must the local sponsor contribute?

Answer M4-3:
65 (50+70=125. 190-125=65)

Question M4-4:
Why might the amount in 3 be increased?

Answer M4-4:
The LPP produce less NED than the NED plan or less NER than the NER plan.

Question M4-5:
When does a trade off situation exist?

Answer M4-5:
When you must give up something (say FC) to get something (say environmental restoration).

Question M4-6:
Name 4 trade-off techniques.

Answer M4-6:
Dominance, ranking index, effects matrix, planner judgment.

Question M4-7:
What are the three situations in which NED and NER benefits are both delivered by one project?

Answer M4-7:
(1) NED or NER is incidental (no separable costs) no cost sharing of joint costs.
(2) NED or NER is an add-on (add-on pays only separable costs).
(3) NED and NER share joint costs (each pays a share of joint costs and their separable costs).

Question M4-8:
Why is cost-sharing for the NED/NER plan more complex than for the NER or NED plans?

Answer M4-8:
Two purposes and maybe two sponsors must pay for the same feature.

Question M4-9:
When might a technique other than SCRB be reasonable for allocation of joint cost?

Answer M4-9:
If costs are small or the costs of one purpose are small.

Question M4-10:
Name at least two measures that might be candidates for joint use.

Answer M4-10:
Lower creek bottoms, flood plain buyouts.

Module MX

Question MX-1:
When do you formulate a Locally Preferred Plan?

Answer MX-1:
Usually in reformulation, but always after the NED, NER or NED/NER plan is formulated.

Question MX-2:
How do you cost-share an NED/NER plan?

Answer MX-2:
First, use the Separable Costs Remaining Benefits method to allocate costs to purposes. Second, apportion costs by purpose to Federal and non-Federal sponsors, based on existing law.

Question MX-3:
Can the District Commander recommend the Locally Preferred Plan?

Answer MX-3:
Yes, but it must be clear that the District Commander does not support the plan; it is only because of the sponsor's cost-sharing that the LPP is recommended. Further, a wholly unjustified horizontal increment should not be recommended at all. A wholly unjustified horizontal increment is one where there is not measure meeting the Federal interest.

Question MX-4:
What is the best way to develop a plan from measures?

Answer MX-4:
Develop a formulation strategy. In the context of multipurpose planning, you need to decide whether you are going to pursue joint measures first or develop plans for each purpose first.

Question MX-5:
What is the best way to develop NED/NER measures?

Answer MX-5:
Brainstorming with an interdisciplinary team.

Question MX-6:
Why is formulation reiterated?

Answer MX-6:
To incorporate with project evaluations; to improve contributions to planning objective; and reformulation criteria.

Question MX-7:
When is recreation added to NED/NER plans?

Answer MX-7:
During reformulation when the NED/NER plan is known.

Question MX-8:
Must recreation be justified?

Answer MX-8:
Yes, if Federal funding (50%) is to be used.

Question MX-9:
Can excess recreation benefits be used to justify an NER.NED plan?

Answer MX-9:
No, this is settled policy.

Question MX-10:
Must an NED/NER plan have an underlying NED plan?

Answer MX-10:

1. No, the NED/NER plan does not need either an underlying NER plan or an underlying NED plan, at least in theory. "Jointness" implies that a combination of benefits could justify the cost of a measure.

MX Class Exercise Material

When is recreation added to NED/NER plans?

List of Flood Control Measures (E means eliminated at slide MX-13; R means retained

1. Control basin run-off through land use controls. E
2. Control future flood plain occupancy by restrictive flood plain zoning. E
3. Remove structures from flood plain. E
4. Elevate/flood proof existing structures. E
    a. Wet
    b. Dry
5. Multiple purpose reservoirs. E
6. Upstream flood control reservoirs. E
7. Detention basins. R
8. Improve early warning and evacuation systems. E
9. Provide parks, nature areas within the flood plain or floodway. E
10. Deepen channel-concrete, with attendant features. E
11. Deepen channel-open, with attendant features. E-1 (eliminated in reach 1)
12. Levee—on creek or set back. E-1
13. Floodway. R
14. Widen Bridge openings and/or remove bridge. R-1
15. Remove vegetation (snag and clear). E-1
16. Riprap channel. E-1
17. Widen channel-concrete. E
18. Widen channel-open. R
19. Ring levee. R
20. Flood plan acquisition and conversion. R

List of Ecosystem Restoration Measures

1. Revegetate R
2. Fertilize R
3. Water R
4. Deepen to reach ground water E
5. Widen channel to improve meander E-1
6. Eradicate harmful species (exotics) E-1,2,3
7. Restock E
8. Breach existing levees and rip rap R
9. Restore in-channel riparian zone R
10. Remove existing concrete lining from creeks R
11. In-channel contouring R
12. Restore floodplain R
13. Build benches E
14. Terrace E
15. Control riparian erosion E
16. Restore natural flow R

List of Joint Measures

2. Remove buildings and blockages. E-1
3. Deepen open channel. E
4. Floodplain purchase/conversion to NER. R-2 through 6. E-1
5. Flow regulators. R

APPENDIX B

PROBLEM IDENTIFICATION TECHNIQUES

Problem Identification Techniques

Be a Reporter

Investigative reporters identify and describe problems all the time. You can do a lot worse than to ask some who, what, when, why and how questions in order to identify problems. Some questions to ask of significant resources could include:

1. What happened or will happen to the resource?
2. What is or will be that event's impact?
3. Who or what does that or will that impact affect?
4. When did or will that impact happen?
5. How did it or will the impact occur?
6. Why did it or will it occur?
7. What could be done about what happens, its impact, who or what it affects, when, how, or why it occurs?

Ask and answer these question and you have a good start on identifying problems. Change the words from an "is" or "will" orientation to a "could" orientation and these questions can help you identify opportunities.

Utopia

Look at your study area and its significant resources. Create an idealized or Utopian ecological situation for your study area. Then compare it to the existing situation. What are the differences? Why do these differences exist? What do the differences suggest to you about the problems and opportunities in your study area?

Benchmarking

Xerox is credited with developing this technique for comparing practices among businesses. It can be easily adapted to ecosystem planning. Identify an ecosystem that is similar to your own in significant resources, size and other important aspects that is considered the best there is. Compare your ecosystem to the best. The results of this comparison can be used to identify problems and opportunities. This technique differs from Utopia in that it uses an actual ecosystem as the benchmark for comparison rather than an ideal. This is a technique that can be used to compare the conditions of specific significant resources as well as entire ecosystems.

Checklists

Examine your ecosystem with checklists in hand. You may have to develop your own checklists initially but there are a number of them that have been generated for problem identification purposes that may be of some use. *That's a Great Idea* by Tony Husch and Linda Foust has several situation analysis checklists. Arthur B. VanGundy has provided *The Product Improvement Checklist*. The *Planning Manual* provides additional checklist that may be helpful. These lists can help you identify problems and opportunities.

Inverse Brainstorming

James T. Higgins offers this technique and 100 others in his excellent book, *101 Creative Problem Solving Techniques*. In this technique, adapted for ecosystem restoration uses, you begin by considering your ecosystem and its significant satisfactory. Then you begin to see how many things you can find wrong with it. These become the bases for your problems.

Complaints

Have as many people who know the study area as possible brainstorm their lists of complaints. Group complaints into subject areas and group the groups as necessary to get to a definition of problems.

Draw a Picture of the Problem

Higgins has suggested that you draw a picture of the problem to make sure you are identifying the real problem. Drawing pictures draws on the creative side of the brain. Seeing the problem in a picture is a useful way to gain insights into the problem. The picture can be a flow diagram or a crude symbolic drawing, do not let the lack of artistic sense stop you from drawing the problem. Ecosystem problems often lend themselves nicely to visualization.

Why-Why Diagram

This technique, described by Higgins, is used to identify the causes of a problem in a systematic way. It is a useful tool for getting from early identification of the problem, or identification of a significant resources, to more nature problem statements. Divide a piece of paper into at least three sections. Write the problem in one section of the paper. In the middle section ask why this is a problem and list as many reasons for the problem as possible. The third section is the second level of "whys". Here you write the reasons for the factors identified in the middle section. Add as many why sections as you need to sketch and understand the problem.

Restatement

Once you have begun to define a problem or opportunity, restate it in as many ways as you possibly can. Imagine it from the perspective of different people: local resource agency personnel, recreationists, neighbors, scientists, uneducated people, politicians, and so on. Look at it like a member of another profession would. The goal is to identify as many different ways of expressing the problem as possible. Write them down. Do you see the problem any differently? Do you understand it better?

APPENDIX C

EXAMPLES OF MODELS PROVIDING INSIGHT INTO ECOSYSTEM RESTORATION MEASURES

EXAMPLES OF MODELS PROVIDING INSIGHT INTO ECOSYSTEM RESTORATION MEASURES		
Model	**Reference**	**Comment**
Comprehensive Aquatic System Model	DeAngelis et al. 1989	Aquatic communities
Hybrid v3.0	Friend et al. (1997	Carbon balance model
Forest Vegetation Simulator (FVS).	Tech et al (1998)	Terrestrial communities
Population dynamics models	Pulliam et al (1992 Dewhurst et al. (1995) Murphy and Noon (1992),Van Manen et al. (1997)	population members behave in spatially explicit ways
Wetland community model	Poiani and Johnson (1993)	Spatially explicit for wetland plants.
Species-based Habitat Suitability Indices (HSI)	(USFWS 1981)	for a variety of individual fish and wildlife species
The Instream Flow Incremental Method (IFIM)	(Bovee 1981, Orth 1987, Nestler 1993).	applies a habitat-suitability index for aquatic populations in flowing waters
Vegetation-based species richness model	Anderson et al. (1978)	southwestern floodplains
Wetland Evaluation Technique (WET)	Adamus and Stockwell (1983) Adamus et al. 1987 and Adamus et al. 1991	Guide to wetland restoration of functions and values
Wetland Valuation Assessment (WVA)	Louisiana Coastal Wetlands Environmental Work Group (1998)	for use in restoring coastal wetlands
The Index of Biotic Integrity	(Karr 1991, Karr and Chu 1997)	Fish and aquatic invertebrate indices.
Bog community model.	Lindeman's (1942) Williams (1971)	Energy flow emphasis
Wildlife Community Habitat Evaluation (WCHE)	Schroeder (1996)	for deciduous forested wetlands
Riverine Community Habitat Assessment and Restoration Concept (RCHARC)	Nesler et al. (1995)	community model developed for rivers
Hydrogeomorphic (HGM) approach	Brinson (1993), Smith et al (1995)	Guides protection and mitigation decisions based on wetland function
FRAGSTATS	(McGargigal and Marks 1995)	Spatially explicit landscape model
Program to Assist in Tracking Critical Habitat (PATCH)	(Schumacker 1998)	Spatially explicit population model
Population energetics models	(Kitchell et al 1974)	Fish in upper midwest
MINLAKE	Riley and Stefan (1987) Stefan et al. (1996)	One dimensional lake model

APPENDIX D

CLASS EXERCISES 1, 2, 3 AND 4
MODULE XER –
INCREMENTAL ANALYSIS EXERCISE WITH IWR-PLAN

Module XER: Incremental Analysis Exercise with IWR Plan

Student Exercises

Session 1: Identification of possible management measures

Background Information

Bussey Lake is a 213-acre backwater located on the Upper Mississippi River, lower Pool 10, near Guttenberg, Iowa (see map above). The project was selected for habitat restoration under the Upper Mississippi River System Environmental Management Program. Sedimentation had made the lake considerably shallower over a period of years and an important recreational fishery was threatened by the shallow water depths, low levels of dissolved oxygen, and an over-abundance of aquatic vegetation. Bluegill and largemouth bass were both considered as indicator species. Corps managers developed four basic management measures to improve the habitat: aeration, substrate improvement, aquatic plant harvesting, and dredging. Five different scales were analyzed for plant harvesting and seven scales were evaluated for dredging. Average annual equivalent costs were calculated for each management measure and scale using a 50-year project life. Costs included initial and operation and maintenance costs.

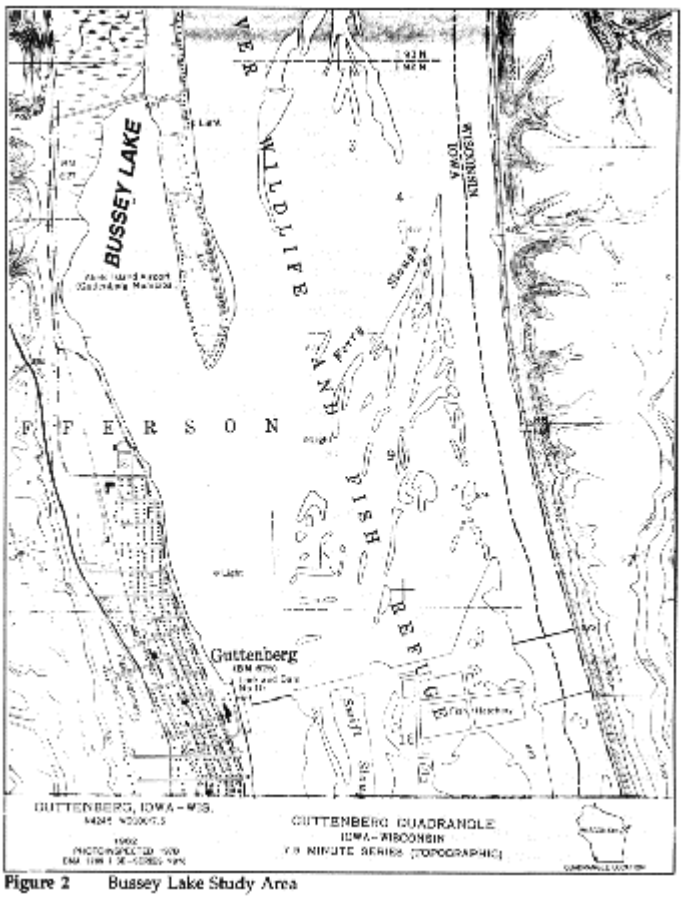

Figure 2 Bussey Lake Study Area

Exercise 1: Identification of possible management measures

The objective of this exercise is to improve the habitat for bluegill in the lake. The challenge is to identify specific management measures that can be taken in order to meet this objective. Having read the brief background information, it is evident that there are a number of possible management measures that can be taken to resolve the problem. Recall the procedure you learned in the previous sections (especially the plan formulation steps) and the information provided in the "G" modules.

Questions

1. From reading the background information, create a list of individual management measures. For the time being, do not consider combining individual measures to create plans.

2. How many management measures have you listed?

3. Can you think of other structural or nonstructural measures that can be used to resolve the sedimentation problem? If so please list them.

4. What other information would you need to fully define your management measures?

5. What would you pick as your output for the management measures in this case?

6. How would you measure your output?

Session 2: Adding Dependency and Combinability Relationships

Now let us introduce the dependency and combinability relationships between management measures. The process involves analysis of the management measures to identify those that can be implemented together and those that can not, as well as those measures which may only be implemented after the implementation of specific other measures. It is important to note here that the scales of any management measure are mutually exclusive.

Management Measures Relationships

For the management measures relationships in this example, we make the following assumptions:
Aeration is NOT COMBINABLE with dredging
Substrate improvement is DEPENDENT UPON dredging AND
Substrate improvement is DEPENDENT UPON harvesting of aquatic plant vegetation

Session 2 Exercise:

Questions

1. Using the information provided in Table A, and the management measure relationships assumptions given above, identify all possible plans (i.e., combinations of the management measures). Assume costs and outputs are additive, and calculate these for each combination.

2. How many combinations are possible?

Session 3: Costs and Outputs in CE/ICA

The following section will now be concerned with plan evaluation, specifically, the application of cost effectiveness and incremental cost analysis. The important variables that must be considered in any cost effectiveness and incremental cost analyses (CE/ICA) are the costs and outputs of the proposed solutions (management measures). The outputs of the proposed management measures in this particular example are the average annual habitat units as presented in Table B.

Session 3 Exercise:

In this exercise, the objective is to first identify management measures that are inefficient in production and second, to identify those management measures that are ineffective in production. The management measures that are "inefficient in production" are defined as those whose output can be provided at a lesser cost by another measure. In order to identify such measures, we can sort through the measures by their output level.

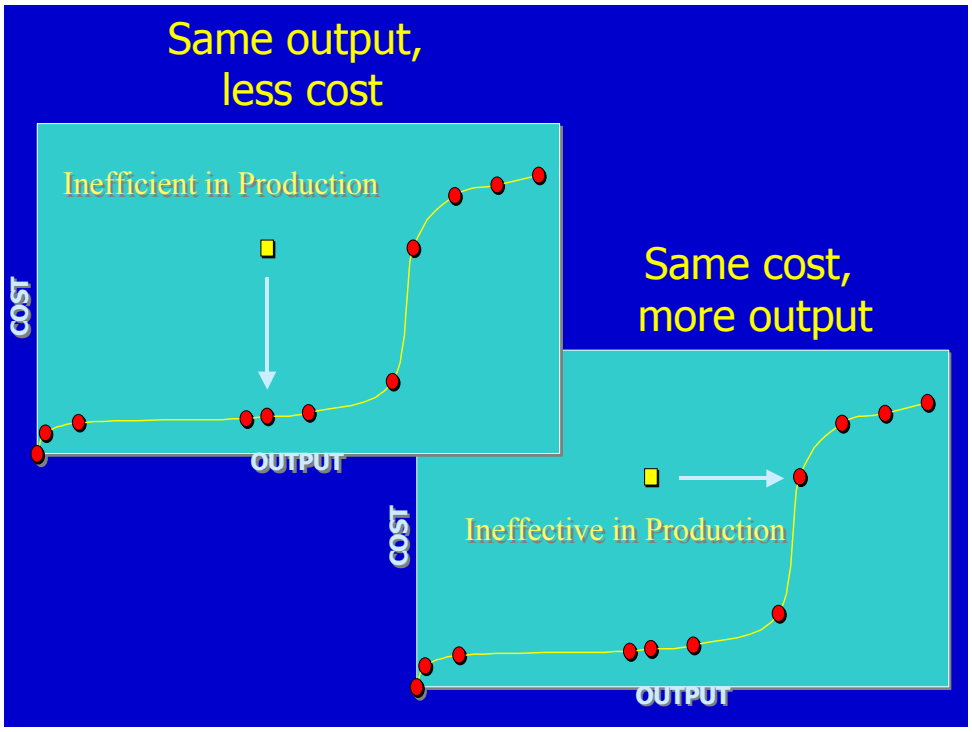

Figure 3.1: Illustration of cost efficient and cost effective plans

Wherever there are two or more measures providing the same level of output, holding everything else constant, then the more costly measures should be eliminated. This identifies the least-cost measure for every level of output under consideration. The management measures that are "ineffective in production" are defined as those where greater output can be produced at a lesser

or equal cost. If there exists a plan that produces greater output at a lesser cost, then the plans that produces less output at an equal or greater cost should be eliminated. Figure 3.1, illustrates these concepts of "efficiency" and "effectiveness."

Table B contains twenty-one possible combinations of the management measures, their associated costs and outputs. Use this table to answer the following questions.

Questions:

1. Identify those combinations of management measures that are economically inefficient in production (inefficient measures are those whose output can be provided at a lesser cost by another measure).

2. Identify those combinations of management measures that are ineffective in production (ineffective measures are those where greater output can be produced at a lesser or equal cost).

3. Now list the management measures that are cost effective. How many measures are cost effective?

Session 4: Incremental Cost Analysis

Once the previous screening and cost effectiveness procedures are performed, it is now time to perform an incremental cost analysis. At this juncture, one needs to compute the incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective level of output. This analysis provides information to assist in determining whether the additional output provided by each successive plan is worth the additional cost that must be incurred to implement it. Recall the procedures for calculating incremental cost and incremental output that were covered in ER4.

Equations

Incremental cost of Plan Y = [Cost of Plan Y] – [Cost of Plan X]
Incremental Output of Plan Y = [Output of Plan Y] – [Output of Plan X]
Incremental Cost per Unit of Plan Y = [Incremental Cost of Plan Y] / [Incremental Output of Plan X]

Where:
Plan X is considered the baseline to which all other plans are compared.
Plan Y refers to all the other plans

Session 4 exercise:

Steps

1. Calculate the incremental output, incremental cost, and incremental cost per unit of all plans. Here the no-action plan can be taken as the baseline condition, to which each other plan is compared.

2. The first comparison of the incremental cost and incremental output of plans can be accomplished by looking at the incremental cost per unit of each plan over the baseline condition.

3. As an arbitrary, but informed, decision rule, select the plan with the lowest incremental cost per unit and then retain this plan and any other plans that provide a greater output level than this plan. Remove from further consideration plans that have both lower output and higher incremental cost than this plan.

4. Make this Plan your new baseline condition, and repeat the process above for each successive plan (i.e., recalculate the incremental cost per unit for each of the remaining plans over the last selected plan, retaining the next lowest incremental cost plan each time, until there are no more plans to evaluate).

Questions:

1. Table D contains five plans and a no-action plan. Using the cost and output information in this table, take a few minutes and calculate the incremental cost, incremental output, and incremental cost per unit of advancing from the no-action plan (refer to equation 1 above).

2. Repeat question 1 above, but this time, select the plan with the lowest incremental cost per unit as your baseline instead of the no-action plan (don't forget to recalculate your incremental outputs and costs relative to this plan; refer to the equations above).

3. Perform the previous operation for each successive plan until you complete the selection of the last plan.

4. How many best buy plans are selected from this exercise?

Table A: Costs and Output of Management Measures and Scales

Scale	Management Measure	Cost ($1000)	Outputs (HU)
A0	No Action	0	0
A1	Aeration	9.7	22
D0	No Action	0	0
D1	Dredging (140,000 cu. Yds.)	101.6	24
D2	Dredging (220,000 cu. Yds.)	176.2	33
D3	Dredging (270,000 cu. Yds.)	205.2	44
H0	No Action	0	0
H1	Aquatic Plant Harvesting (63 Acres)	28.6	11
H2	Aquatic Plant Harvesting (106 Acres)	30.8	16
S0	No Action	0	0
S1	Improve Substrate	53.6	1

Table B: Plan Combinations

Combinations				Cost ($1000)	Output (HU)
A0	D0	H0	S0	0	0
A0	D0	H1	S0	28.6	11
A0	D0	H2	S0	30.8	16
A1	D0	H0	S0	9.7	22
A0	D1	H0	S0	101.6	24
A1	D0	H1	S0	38.3	33
A0	D2	H0	S0	176.2	33
A0	D1	H1	S0	130.2	35
A0	D1	H1	S1	183.8	36
A1	D0	H2	S0	40.5	38
A0	D1	H2	S0	132.4	40
A0	D1	H2	S1	186	41
A0	D3	H0	S0	205.2	44
A0	D2	H1	S0	204.8	44
A0	D2	H1	S1	258.4	45
A0	D2	H2	S0	207	49
A0	D2	H2	S1	260.6	50
A0	D3	H1	S0	233.8	55
A0	D3	H1	S1	287.4	56
A0	D3	H2	S0	236	60
A0	D3	H2	S1	289.6	61

Table C.1: Plan Combinations

Combinations				Cost ($1000)	Output (HU)	Evaluation
A0	D0	H0	S0	0	0	
A0	D0	H1	S0	28.6	11	Non-cost effective
A0	D0	H2	S0	30.8	16	Non-cost effective
A1	D0	H0	S0	9.7	22	
A0	D1	H0	S0	101.6	24	Non-cost effective
A1	D0	H1	S0	38.3	33	
A0	D2	H0	S0	176.2	33	Non-cost efficient
A0	D1	H1	S0	130.2	35	Non-cost effective
A0	D1	H1	S1	183.8	36	Non-cost effective
A1	D0	H2	S0	40.5	38	
A0	D1	H2	S0	132.4	40	
A0	D1	H2	S1	186	41	
A0	D3	H0	S0	205.2	44	Non-cost efficient
A0	D2	H1	S0	204.8	44	
A0	D2	H1	S1	258.4	45	Non-cost effective
A0	D2	H2	S0	207	49	
A0	D2	H2	S1	260.6	50	Non-cost effective
A0	D3	H1	S0	233.8	55	
A0	D3	H1	S1	287.4	56	Non-cost effective
A0	D3	H2	S0	236	60	
A0	D3	H2	S1	289.6	61	

Table C.2: Combinations of Cost Effective Measures

Combinations				Output (HUs)	Cost ($1000)
A0	D0	H0	S0	0	0
A1	D0	H0	S0	22	9.7
A1	D0	H1	S0	33	38.3
A1	D0	H2	S0	38	40.5
A0	D1	H2	S0	40	132.4
A0	D1	H2	S1	41	186
A0	D2	H1	S0	44	204.8
A0	D2	H2	S0	49	207
A0	D3	H1	S0	55	233.8
A0	D3	H2	S0	60	236
A0	D3	H2	S1	61	289.6

Table D: Incremental Cost Analysis

Plan				Output (HUs)	Cost ($1000)	Incremental Output: (Hus)	Incrementa l Cost ($1000)	Incremental costs Per Unit: ($/HU)
A0	D0	H0	S0	0	0			
A1	D0	H0	S0	22	9.7			
A1	D0	H1	S0	33	38.3			
A1	D0	H2	S0	38	40.5			
A0	D1	H2	S0	40	132.4			
A0	D3	H2	S0	60	236			

Table D-1: Incremental Cost Analysis: Selecting the first "Best Buy Plan" advancing from the no-action plan

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A0D0H0S0	0	0	NA	NA	NA
A1D0H0S0	**22**	**9.7**	**22**	**9.7**	**0.441**
A1D0H1S0	33	38.3	33	38.3	1.161
A1D0H2S0	38	40.5	38	40.5	1.065
A0D1H2S0	40	132.4	40	132.4	3.310
A0D3H2S0	60	236	60	236	3.930

Table E: Selecting the next "Best Buy Plan" advancing from the first selected plan

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A1D0H0S0	22	9.7	0	0	0
A1D0H1S0	33	38.3	11	28.6	2.600
A1D0H2S0	**38**	**40.5**	**16**	**30.8**	**1.925**
A0D1H2S0	40	132.4	18	122.7	6.817
A0D3H2S0	60	236	38	226.3	5.955

Table F: Selecting the third "Best Buy Plan"

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A1D0H2S0	38	40.5	0	0	0
A0D1H2S0	40	132.4	2	91.9	45.950
A0D3H2S0	**60**	**236**	**22**	**195.5**	**8.886**

Table G: Selected "Best Buy Plans"

Plan	Output (HUs)	Costs (1000) ($)	Incremental Output (HUs)	Incremental Cost (1000) ($)	Incremental Cost Per Unit ($)
A0D0H0S0	0	0	NA	NA	NA
A1D0H0S0	22	9.7	22	9.7	0.441
A1D0H2S0	38	40.5	16	30.8	1.925
A0D3H2S0	60	236	22	195.5	8.886

Table H: Incremental Cost Analysis

Plan				Output (HUs)	Cost ($1000)	Incremental Output: (Hus)	Incrementa l Cost ($1000)	Incremental costs Per Unit: ($/HU)
A0	D0	H0	S0	0	0	NA	NA	NA
A1	D0	H0	S0	22	9.7	22	9.7	0.441
A1	D0	H1	S0	33	38.3	33	38.3	1.161
A1	D0	H2	S0	38	40.5	38	40.5	1.065
A0	D1	H2	S0	40	132.4	40	132.4	3.31
A0	D3	H2	S0	60	236	60	236	3.93
A1	D0	H0	S0	22	9.7	0	0	0
A1	D0	H1	S0	33	38.3	11	28.6	2.6
A1	D0	H2	S0	38	40.5	16	30.8	1.925
A0	D1	H2	S0	40	132.4	18	122.7	6.817
A0	D3	H2	S0	60	236	38	226.3	5.955
A1	D0	H2	S0	38	40.5	0	0	0
A0	D1	H2	S0	40	132.4	2	91.9	45.95
A0	D3	H2	S0	60	236	22	195.5	8.886
A0	D0	H0	S0	0	0	NA	NA	NA
A1	D0	H0	S0	22	9.7	22	9.7	0.441
A1	D0	H2	S0	38	40.5	16	30.8	1.925
A0	D3	H2	S0	60	236	22	195.5	8.886

APPENDIX E

CLASS EXERCISES 1, 2, 3 AND 4

MODULE MX – HANDS ON EXERCISE BASED ON MURRIETA CREEK, FLOOD CONTROL, ENVIRONMENTAL RESTORATION AND RECREATION, FINAL FEASIBILITY REPORT, AUGUST 2000

APPENDIX E-1

CLASS EXERCISE 1

MODULE MX – HANDS ON EXERCISE BASED ON MURRIETA CREEK, FLOOD CONTROL, ENVIRONMENTAL RESTORATION AND RECREATION, FINAL FEASIBILITY REPORT, AUGUST 2000

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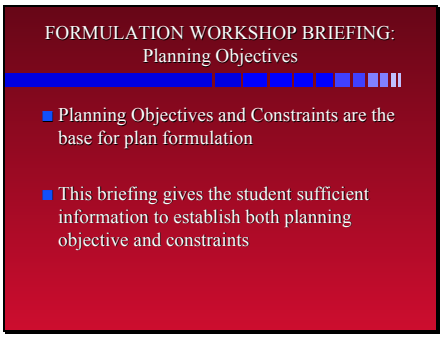

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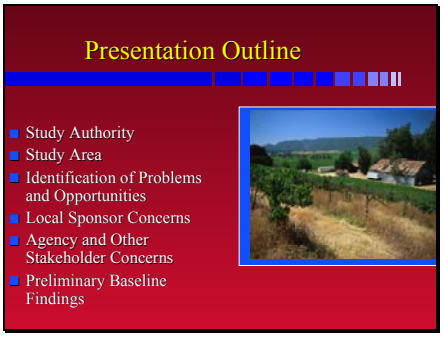

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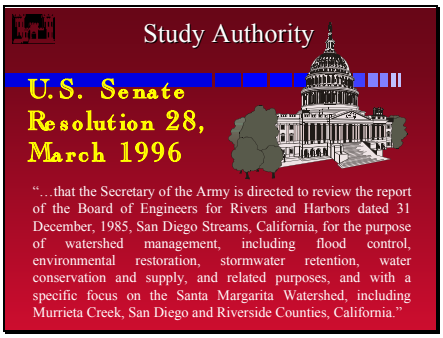

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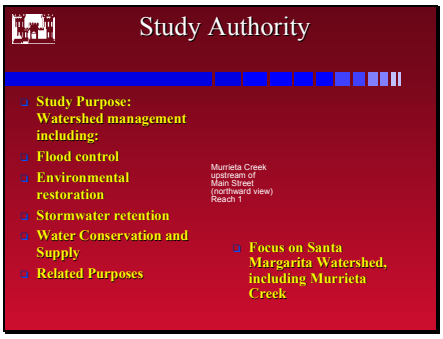

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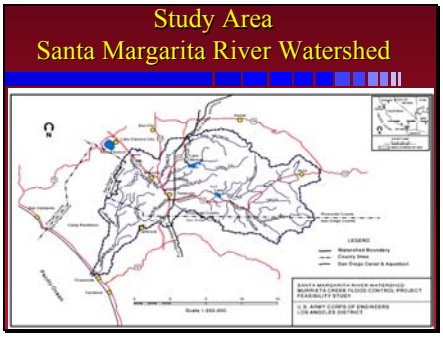

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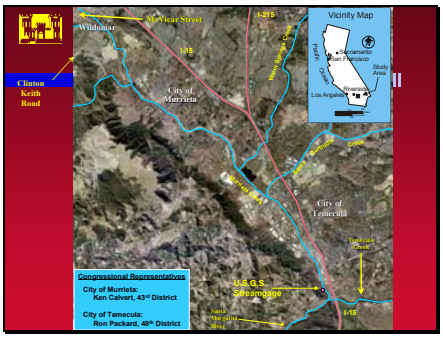

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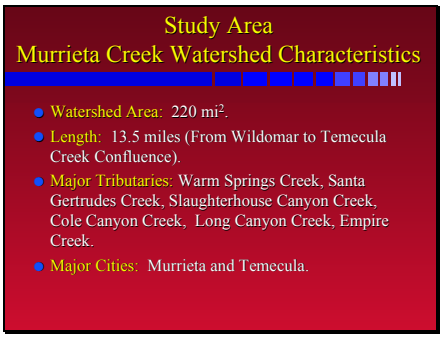

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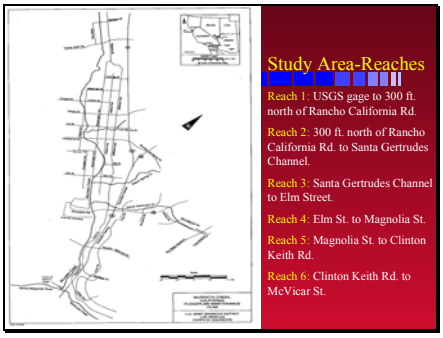

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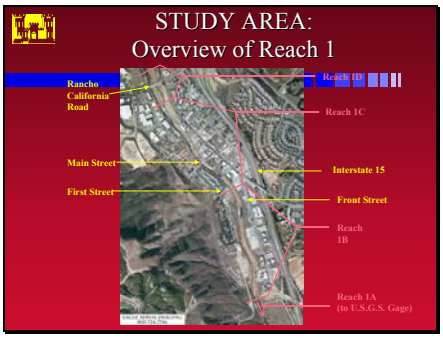

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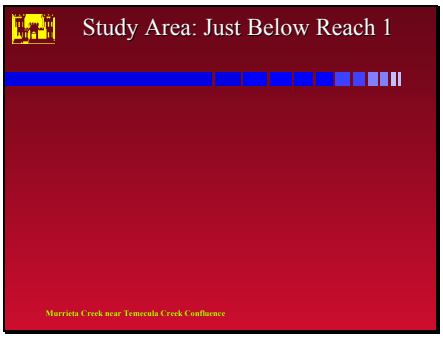

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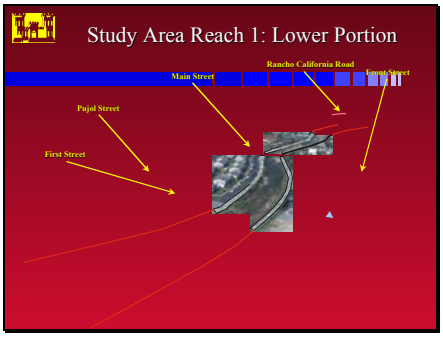

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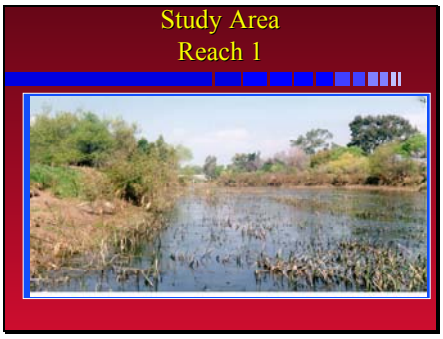

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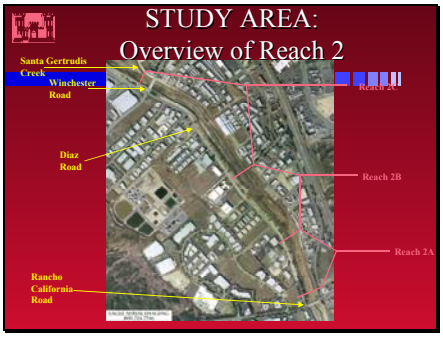

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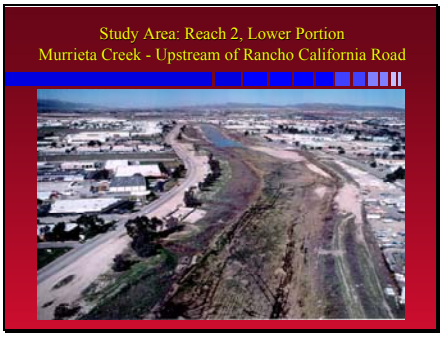

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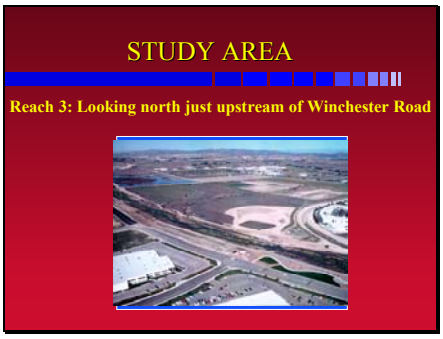

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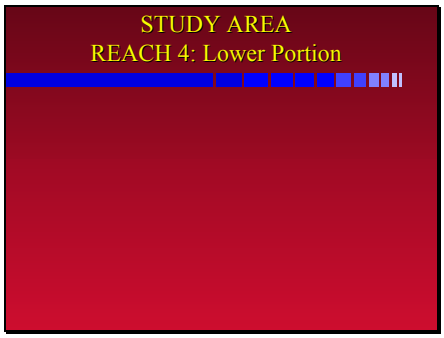

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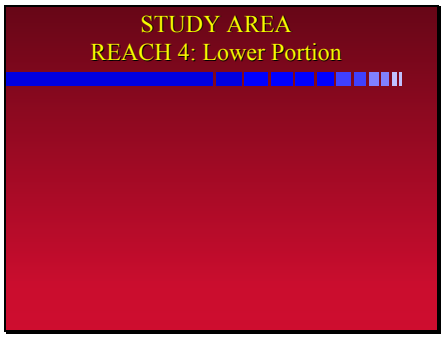

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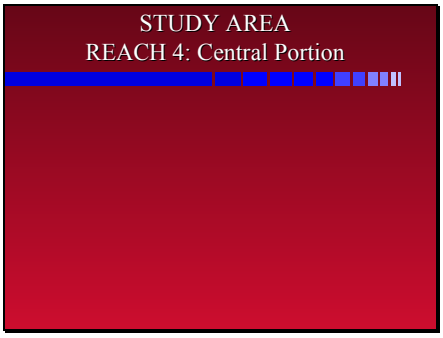

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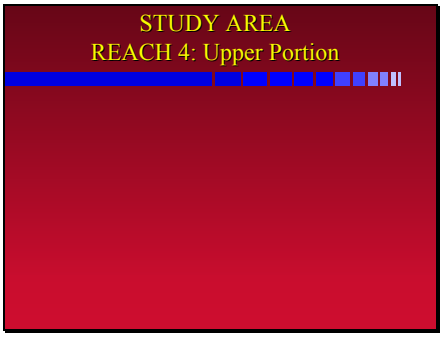

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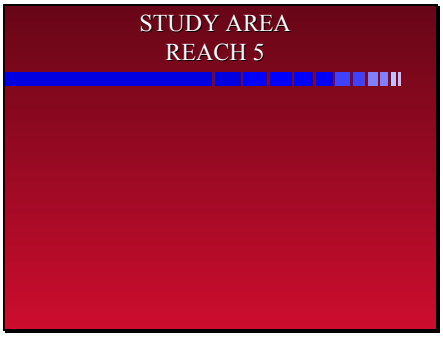

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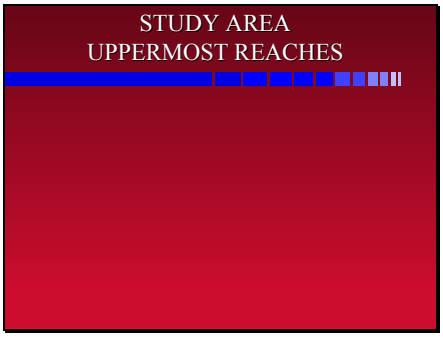

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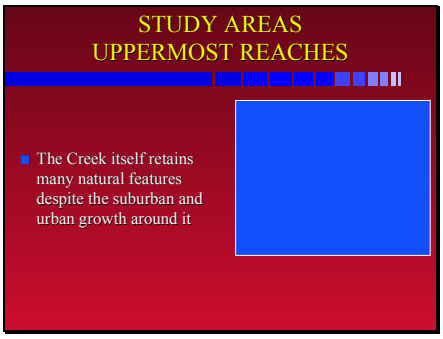

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Identified Problems

- Threat of Flooding.
- Loss of Wetland/Riparian Habitat in the Region.
- Diminishing of Functional Riverine System in the Murrieta Creek Watershed.
- Need for Recreational Facilities within the Rapidly Growing Region.

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Flood Problem

- Majority of Flood Damages are Industrial/Commercial
- These are centered in reach 2B in Temecula
- Damages in this sub-reach account for 50% of all without project damages

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Economics Assessment

Without Project Annualized Structural Damage ($1000's)

Reach Name	Structural Damages
Reach 1A	$20.1
Reach 1B	$60.2
Reach 1C	$639.9
Reach 2A	$130.0
Reach 2B	$1,980.7
Reach 3A	$24.9
Reach 3E	$3.1
Reach 4A	$18.3
Reach 4B	$18.5
Reach 5	$221.1
Total	$3,116.7

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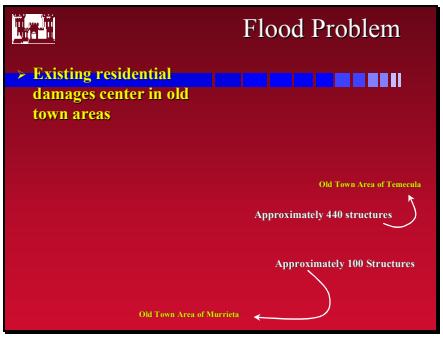

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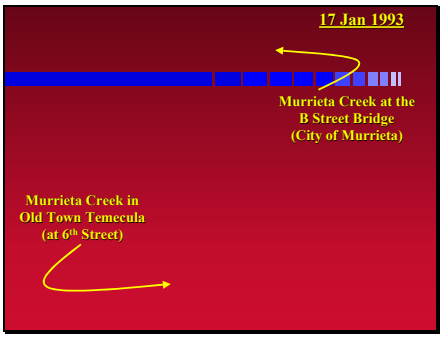

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Identified Problems

Threat of Flooding

- Increasing Levels of Damage Due to Flooding.
  - 1978 and 1980 Flood Event:
    - » U.S. Army Corps of Engineers staged emergency flood fights.
    - » Federal funds used to restore sections of the existing Murrieta Creek Channel.
  - 1993 Flood Event:
    - » 2 to 6 feet of sediment deposition from Winchester Rd. to Old Town Temecula.
    - » Estimated $2,000,000 in damages to public facilities along Murrieta Creek.
    - » Riverside County Flood incurred approximately $450,000 for facilities repair and channel work.
    - » City of Temecula and Kemper Corp. expended over $1,000,000 in clean-up and facility repair costs.
- Most damages occurred within the City of Temecula.

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Identified Problems

Loss of Wetland/Riparian Habitat along Murrieta Creek

- Channelization of Murrieta Creek Since 1930's.
- Degradation of Habitat particularly in the downstream areas.
- Problem has gotten worse since Flood of 1993,
  - Particularly in areas downstream of Warm Springs Creek
  - Warm Spring Creek is upstream terminus of Reach 3

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Identified Problems

Loss/Decline of Wetland/Riparian Habitat along Murrieta Creek

- Problem is manifested by decline in desirable wildlife and plant species
- Problem is manifested by increases in exotic species
- Problem is manifested by "patchiness" of good habitat and separation of riverine and upland habitats in many areas.

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Identified Problems: Loss of Wetlands

- Functional Assessment: estimates of the normal or characteristic activities that take place in wetland ecosystems
- Murrieta Creek is in the "riverine wetland class"
- Functions assessed:
  1) maintenance of plant community
  2) maintenance of detrital biomass
  3) spatial structure of habitat
  4) habitat interspersion and connectivity
- Ecosystem value measured in "Functional Capacities" (FC's)

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Biological Resources

- Existing conditions based on report by Jones & Stokes (1998).
- Vegetative communities:
  - Riparian and wetland communities
  - Upland communities
- Native wildlife
- Sensitive habitats
- Sensitive species
- Threatened and Endangered species.

Slide 42

Identification of Problems and Opportunities: Recreation

- The watershed is in the path of significant growth
- Land use plans of the Cities of Temecula and Murrieta, as well as Riverside County, show intend to accommodate growth
- Local recreation needs are large and will grow
- Many want trails and other ways to enjoy "their" creek

- WHAT IS FEDERAL (Corps) ROLE IN MEETING LOCAL RECREATION NEEDS?

Slide 43

Local Sponsor Concerns

- Desire to provide 100-Year level of flood protection.
- Desire to maintain aesthetic quality of the region.
- Desire to maintain creek functional capacities to the maximum extent possible in conjunction of providing flood control.

Slide 44

Local Sponsor Concerns

- Desire to provide enough protection to meet standards for FEMA
- Desire to provide equal levels of flood protection to both Cities

Slide 45

Agency and Stakeholder Concerns

- Environmental Agencies believe:
- Environmental Agencies perceive continued environmental decline.
- They believe that almost any structural alternative will exacerbate the historical trend.
- They believe that past actions of the local sponsor must be mitigated as part of this study

Slide 46

Agency and Stakeholder Concerns

- Some local residents are particularly concerned about the use of ‘concrete” to solve other problems
- They voice displeasure with the channelization of Santa Gertrudes Ck by the local sponsor

Slide 47

Preliminary Findings (Without Condition)

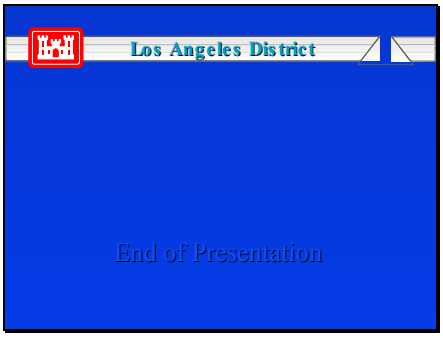
- Lower parts of the channel are severely constrained.
  - One extreme example is a lower income apartment complex-one of the few in the City
  - Other encroachments exist especially in the Old Town area of Temecula
  - This situation likewise constrains environmental restoration possibilities
- This problem is exacerbated because Sediment studies indicate that channel deepening is severely constrained

Slide 48

Sedimentation Analysis

- Performed to estimate the magnitudes of aggradation and degradation within the creek.
- Sediment budget analysis performed for the 10-, 25-, 50-, 100-, and 500-year events.

Slide 49



HANDOUT FOR EXERCISE 1, PART b

Pages 64-5; 66-68 and 72-78

3.4.5.3 Impacts Due to Bridge Removal

A hydraulic analysis was conducted on Main Street and Rancho California Road bridges to analyze the effects of removing the bridges on the water surface profiles for the 10-, 25-, and 100-year flood events. The HEC-2 models developed for computing the overflow boundaries of Murrieta Creek were used to compute the water surface profiles with and without the two bridges in-place. The water surface profile computed for the bridges removed were compared with the water surface profiles computed for the bridges in-place to determine the effects of removing the bridges. The results of this analysis are provided in Table 3.4-7 and Figure 3.4-9. The results of this analysis indicate that only removing the Main Street Bridge would be beneficial in lowering the water surface profile upstream of the bridges.

Table 3.4-7: Results of the Hydraulic Analysis for the Impacts on Bridge Removal.

Bridge	Results	10-yr	50-yr	100-yr
Main Street	Maximum Decrease in Water Surface Elevation	0.5 ft	1.1 ft	1.4 ft
	Maximum Increase in Flow Velocity	0.3 ft/s	1.0 ft/s	1.3 ft/s
Ranhco California	Maximum Decrease in Water Surface Elevation	0.5 ft	0.4 ft	0.1 ft
	Maximum Increase in Flow Velocity	0.1 ft/s	0.2 ft/s	0.1 ft/s

MURRIETA CREEK

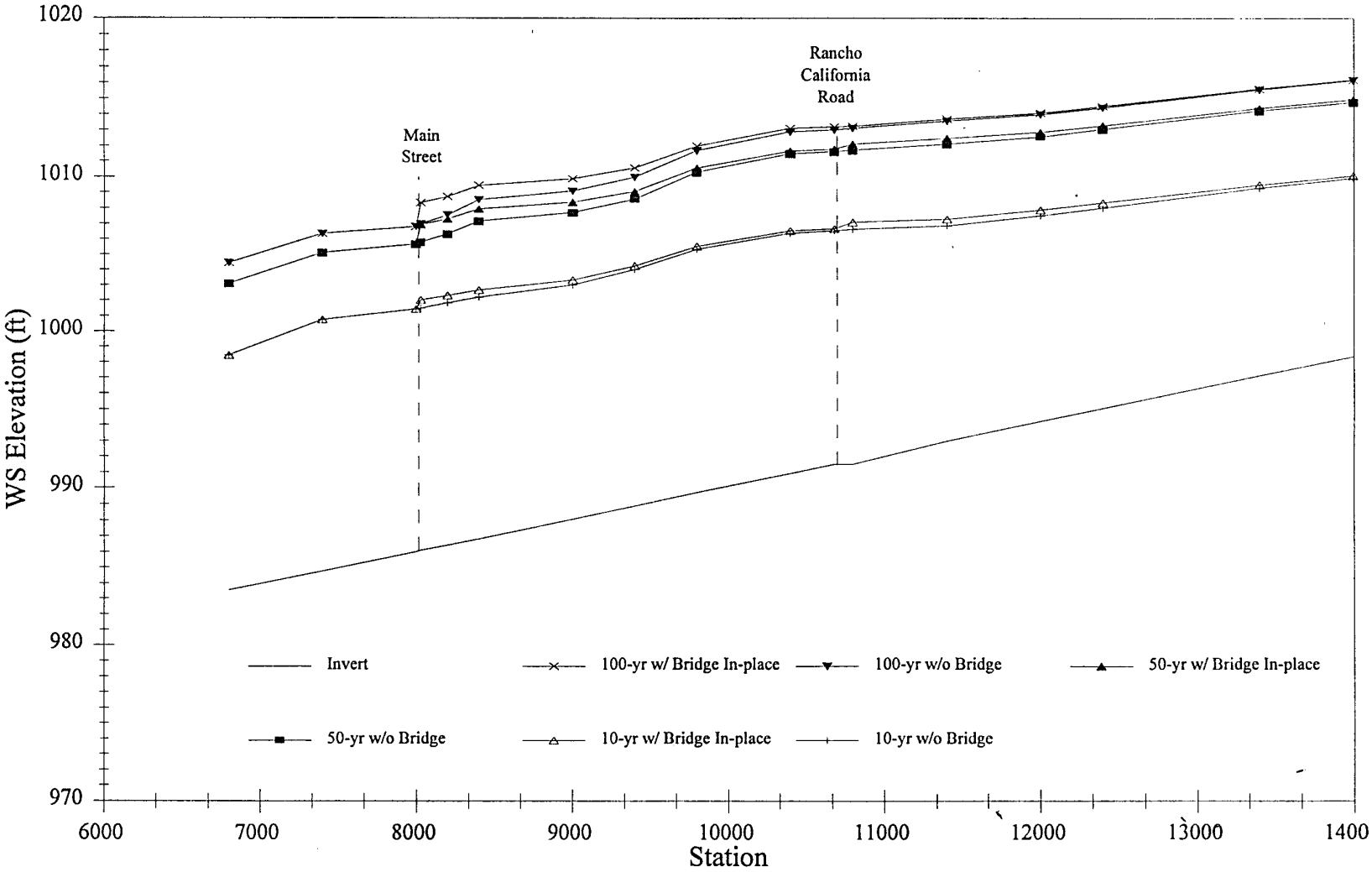


Figure 3.4-9: Effects of Removing Main Street and Rancho California Road Bridges.

3.4.5.4 Sedimentation Analysis

A sedimentation analysis was conducted on Murrieta Creek to determine the general trends and estimate the magnitudes of aggradation and degradation within the creek. The sedimentation analysis involved a qualitative analysis based on Lane's Relationship and a sediment budget analysis. The depth of deposition estimated from the sediment budget analysis was incorporated into the HEC-2 models developed for defining the overflow boundaries for the various flood frequencies. Therefore, the sediment budget analysis was conducted for the 10-, 25-, 50-, 100-, and 500-year flood events. The analysis is based on the hydraulics determined for the velocity condition of the roughness, adopted gradation curves of the creek, recommended transport function selected using SAM, and the sediment inflow computed for same three assumptions just mentioned. An analysis was then conducted to evaluate the sensitivity of the sediment budget analysis due to the reduction and increase of sediment inflow, selected transport function, gradation of the bed material, and hydraulics of the creek.

For the sedimentation analysis, Murrieta Creek downstream from about halfway between McVicar Street and Clinton Keith Road was divided into thirteen reaches. The creek upstream of this point was assumed to be in equilibrium, and therefore the supply reach for this study. The creek was divided into reaches of similar hydraulic characteristics of velocity, width, and depth. The reaches used in this analysis are provided in Table 3.4-8 and delineated in Figure 3.4-10. Table 3.4-8 also provides the average channel geometry and the average hydraulic conditions for both the velocity and capacity conditions computed for the 100-year flood event.

Detailed information on the sedimentation analysis of Murrieta Creek is provided in the Hydraulics Appendix (Appendix II-C).

Table 3.4-8: Information on the Reaches Used in the Sedimentation Analysis.

Reach	D/S STA	U/S STA	Average Channel Geometry					Average Hydraulic Characteristics for 100-yr Flood					
								Velocity Condition			Capacity Depth		
			Bottom Width (ft)	Invert Slope	z Left Bank	Z Right Bank	Bank Height (ft)	Flow Depth (ft)	Effective Width (ft)	Flow Velocity (ft/s)	Flow Depth (ft)	Effective Width (ft)	Flow Velocity (ft/s)
1	33+33	64+00	130	0.00206	3.2	4.2	14.0	14.9	240	9.5	16.4	240	7.8
2	64+00	98+00	110	0.00206	3.2	4.3	14.7	15.3	235	10.1	17.7	235	7.4
3	98+00	124+00	250	0.00206	6.6	4.5	14.9	14.0	400	6.7	16.7	400	4.9
4	124+00	168+00	280	0.00206	6.8	7.6	13.0	10.4	485	7.6	13.8	490	5.0
5	168+00	194+00	245	0.00206	3.7	4.0	16.9	10.0	315	12.2	13.9	340	6.7
6	194+00	246+50	100	0.00225	4.0	4.0	15.0	9.6	205	14.6	11.5	230	2.6
7	246+50	305+00	70	0.00294	4	4	13.1	9.0	170	8.4	8.8	175	6.5
8	305+00	360+00	70	0.00385	3.5	3.5	11.2	9.1	145	11.6	9.3	145	10.5
9	360+00	419+45	115	0.00558	12.4	9.7	7.7	7.9	245	11.0	8.8	250	9.3
10	419+45	467+10	120	0.00442	10.6	10.5	5.4	7.6	220	11.0	8.4	220	9.2
11	467+10	542+55	180	0.00634	9.3	15.1	4.8	6.7	280	10.3	7.2	280	9.6
12	542+55	568+00	35	0.00521	3.2	6.4	6.6	8.5	80	9.6	9.3	95	8.1
13	568+00	618+85	40	0.00640	10.5	8.3	3.6	4.4	95	8.1	4.8	95	7.0
Supply	618+85	645+20	10	0.00490	3.4	2.7	4.3	5.3	50	9.6	5.5	50	7.9

The results of the sediment budget analysis are provided in Tables 3.4-9 and 3.4-10. Table 3.4-9 summarizes the average change in bed elevation within each reach for various flood frequencies. The results indicate that degradation would occur within the creek downstream of Rancho California Road and aggradation would occur within the creek between Rancho California Road and Hawthorne Street. The results also indicate that the creek upstream of Ivy Street is in equilibrium. The maximum depth of deposition was estimated to 1 foot for the 10-year event and 3 feet for 500-year event. The trends determined from this analysis are in close agreement with the trends determined from the qualitative analysis summarized in the Hydraulics Appendix (Appendix II-C). There are only three reaches where the trends were not in agreement between the two analyses: Reaches 1, 3, and 11.

Table 3.4-9: Results of the Sediment Budget Analysis.

Reach	Average Change in Bed Elevation (feet)				
	10-yr	25-yr	50-yr	100-yr	500-yr
1	-1	-1	-1	-1	-1
2	-1	-1	-2	-2	-3
3	0	0	0	0	1
4	0	0	1	1	1
5	1	1	1	2	1
6	1	1	1	2	2
7	1	2	2	3	3
8	1	1	2	2	2
9	-0	-0	-0	-0	-0
10	-0	-0	-0	-0	-1
11	0	0	0	0	0
12	0	0	1	1	1
13	-0	-0	-0	-0	-1

Table 3.4-10: Bed Material and Total Sediment Yields from Murrieta, Warms Springs, and Santa Gertrudis Creeks

Frequency (years)	Creek	Sediment Yields in cubic yards[1]							
		Cond. 1[2]	Cond. 2[2]	Cond. 3[2]	Cond. 4[2]	Cond. 5[2]	Cond. 6[2]	Cond. 7[2]	Cond. 8[2]
10	Murrieta	25,000 (174,000)	13,000 (162,000)	50,000 (199,000)	24,000 (173,000)	55,000 (204,000)	18,000 (167,000)	94,000 (243,000)	19,000 (168,000)
	Warm Springs	6,000 (32,000)	3,000 (29,000)	11,000 (37,000)	7,000 (33,000)	10,000 (36,000)	5,000 (31,000)	14,000 (40,000)	-
	Santa Gertrudis	18,000 (31,000)	9,000 (22,000)	37,000 (50,000)	16,000 (29,000)	56,000 (69,000)	15,000 (28,000)	23,000 (36,000)	-
25	Murrieta	36,000 (243,000)	18,000 (225,000)	73,000 (280,000)	36,000 (243,000)	80,000 (287,000)	26,000 (233,000)	136,000 (343,000)	27,000 (234,000)
	Warm Springs	8,000 (46,000)	4,000 (42,000)	12,000 (50,000)	10,000 (48,000)	14,000 (52,000)	7,000 (45,000)	18,000 (56,000)	-
	Santa Gertrudis	28,000 (46,000)	14,000 (32,000)	56,000 (74,000)	23,000 (41,000)	84,000 (102,000)	23,000 (41,000)	35,000 (53,000)	-
50	Murrieta	45,000 (328,000)	23,000 (306,000)	91,000 (374,000)	46,000 (329,000)	99,000 (382,000)	33,000 (316,000)	169,000 (452,000)	39,000 (322,000)
	Warm Springs	10,000 (57,000)	5,000 (52,000)	20,000 (67,000)	13,000 (60,000)	17,000 (64,000)	8,500 (56,000)	22,000 (69,000)	-
	Santa Gertrudis	37,000 (60,000)	18,000 (41,000)	74,000 (97,000)	30,000 (53,000)	108,000 (131,000)	30,000 (53,000)	46,000 (69,000)	-
100	Murrieta	55,000 (363,000)	27,000 (335,000)	109,000 (417,000)	57,000 (365,000)	119,000 (427,000)	40,000 (348,000)	203,000 (511,000)	47,000 (355,000)
	Warm Springs	12,000 (70,000)	6,000 (64,000)	24,000 (82,000)	16,000 (74,000)	20,000 (78,000)	10,000 (68,000)	26,000 (84,000)	-
	Santa Gertrudis	47,000 (75,000)	24,000 (52,000)	95,000 (123,000)	36,000 (64,000)	136,000 (164,000)	39,000 (67,000)	59,000 (87,000)	-
500	Murrieta	82,000 (532,000)	41,000 (491,000)	164,000 (614,000)	88,000 (538,000)	177,000 (627,000)	60,000 (510,000)	302,000 (752,000)	69,000 (519,000)
	Warm Springs	17,000 (104,000)	7,000 (94,000)	35,000 (122,000)	23,000 (110,000)	30,000 (117,000)	15,000 (102,000)	38,000 (125,000)	-
	Santa Gertrudis	80,000 (122,000)	42,000 (84,000)	160,000 (202,000)	56,000 (98,000)	222,000 (264,000)	66,000 (108,000)	100,000 (142,000)	-
Average Annual	Murrieta	5,500 (36,000)	3,000 (33,000)	11,000 (41,000)	5,000 (35,000)	12,000 (42,000)	4,000 (34,000)	20,000 (50,000)	-
	Warm Springs	1,500 (6,500)	800 (6,000)	3,000 (8,000)	2,000 (7,000)	2,500 (7,500)	1,500 (6,500)	3,000 (8,000)	-
	Santa Gertrudis	2,500 (5,500)	1,500 (4,500)	5,000 (8,000)	2,500 (5,500)	6,500 (9,500)	2,000 (5,000)	3,000 (6,000)	-

Notes:
1. Two sediment yields are provided in this table: (1) yield associated with the bed material load, and (2) total sediment yield, provided in the parenthesis, that includes both the bed material load and wash load, which is based on the MUSLE Method.
2. Volumes are based on γ of 93 lbs/ft^3 for the bed material load and 87 lbs/ft^3 for the wash load.
3. The above conditions are the same conditions discussed in Section B.4 (Hydraulic Appendix).

3.4.6.2 Biological Resources

There is a wide diversity of habitat types and conditions within the general project area. There are 14 vegetation types or habitats in the project area. They are open water and aquatic bed, coastal and valley freshwater marsh, cismontane alkali marsh, meadow, ephemeral wetland, mule fat scrub, southern willow scrub, mixed southern cottonwood-willow riparian forest, riparian scrub, disturbed (ruderal), coastal sage scrub, grassland, coast live oak woodland, and non-native grove. Three non-vegetated habitats, classified as rock, sand, and developed, also occur in the project area. The following sections provide a brief description of the biological resources within, and adjacent to Murrieta Creek within the study area boundaries. A more complete description of the existing biological resources is provided in the Appendix I.

3.4.6.2.1 Description of Existing Biological Conditions

The extreme southern end of Murrieta Creek, downstream of Front Street, is characterized by native habitats where the dominant vegetation types in the channel and on the channel banks are southern cottonwood-willow riparian forest, mulefat scrub, and ephemeral wetland (general vegetation community attributes are described in the following section). Exposed bedrock lines most of the narrow channel in this stretch of the creek. Upland habitat consists of a small patch of Riversidian sage scrub surrounded by non-native grassland on the east and continuous Riversidian sage scrub to the west. Adjacent areas are undeveloped until Interstate-15 to the east. Where Murrieta Creek meets with Temecula Creek to form the Santa Margarita River the habitat is characterized by dense, multi-layered canopy oak riparian forest, southern cottonwood-willow riparian forest, and mulefat scrub.

Existing conditions from Front Street upstream to Rancho California Road are characterized by significant development which isolates the riverine system from surrounding upland habitats. In many locations, parking lots and structures directly abut the sideslopes of the channel reducing the upland buffer zone to a minimum. Throughout this stretch, the habitat along the bank is characterized by a narrow strip (sometimes patchy) of relatively mature riparian vegetation, with a multi-structured canopy layer and understory of common shrubby species. Within the channel, the vegetation is dominated by freshwater marsh with occasional young willow saplings. Nuisance species such as salt cedar (*Tamarix chinensis*), tree tobacco (*Nicotiana glauca*), cocklebur (*Xanthium strumarium*), and giant reed (*Arundo donax*) occur sporadically on the channel sideslopes and in the channel bottom.

Baseline conditions change in the vicinity of Rancho California Road. For example, the channel width ranges from approximately 25 feet in the southern end of the project area to approximately 150 feet upstream to Rancho California Road. Additionally, streamflow is perennial upstream to approximately Elm Street where it becomes ephemeral. Correspondingly, upstream of Elm Street, the vegetation tends to transition into more upland dominated species, including nonnative grasslands, disturbed areas, and open sandbar areas. Occasional stands of giant reed and salt cedar are scattered within this area of the creek. Base flows reappear farther upstream, and consequently give rise to emergent freshwater marsh vegetation. The meandering low flow channel is dominated by bulrush (*Scirpus* spp.) and cattail (*Typha latifolia*). The channel terraces tend to be less saturated, including areas of surface disturbance. These channel terraces support mulefat and willow, interspersed with opportunistic species such as cocklebur, sweet clover (*Melilotus alba*), and sunflower (*Helianthus annus*). Adjacency to the Temecula Creek and Santa Margarita River confluence enables wildlife movement to those riverine systems and the adjacent upland habitats. Based on habitat suitability and availability, and linkages, wildlife utilization up to Rancho California Road is expected to be relatively high.

From Rancho California Road upstream to Winchester Road, the channel significantly broadens between 150 feet to 300 feet. Streamflow appears to be perennial through this stretch with a relatively

wide low-flow channel attributable primarily to discharges by the SRWRF. Cattail and bulrush are the principal obligate wetland species associated with the low flow and saturated soils, whereas willows and mulefat are the dominant riparian species. This stretch of the creek, dominated by non-native grasslands and ephemeral wetlands, is highly disturbed with development adjacent to the uplands, approximately 25 to 100 feet from the channel banks. Salt cedar is more dominant near Winchester Road than in the downstream segment previously described.

Upstream of Winchester Road, the channel narrows to approximately 100 feet, yet surface flows encompass most of the channel. Cattails are abundant in the channel, while willows occur at the toe of the levees. Santa Gertrudis Creek discharges into Murrieta Creek approximately 400 feet upstream of Winchester Road, and has a significant affect on existing surface flows and the associated wetland vegetation as a result of the SRWRF discharges upstream of the confluence. Santa Gertrudis Creek is concrete and channelized beginning approximately 250 feet downstream of the Winchester Road bridge on the east bank of Murrieta Creek and continuing upstream on both sides of the banks of Santa Gertrudis Creek. In general, the Murrieta Creek channel slopes in this area are disturbed and/or exhibit erosion. Species observed along the channel sideslopes consist of pioneer species such as horseweed (*Conyza canadensis*), sunflower, and mustard (*Hirschfeldia incana*). Adjacent land uses are primarily commercial with some residential properties. This area is more undeveloped than seen in the southern portion of the creek. Within this undeveloped zone between Santa Gertrudis Creek and Cherry Street, the upland vegetation communities consist mainly of non-native grasslands, a thin strip of cottonwood riparian forest just north of Santa Gertrudis Creek that extends to the east from Murrieta creek, and mulefat scrub in an overflow wetland area adjacent to Warm Springs Creek.

From Warm Springs Creek to Elm Street the channel narrows again to approximately 70 feet. Sideslopes are generally sandy and sparsely vegetated with scattered non-natives and mulefat. The surrounding lands are generally undeveloped and provide a substantial buffer of upland habitat along both the east and west banks. Wildlife corridors to upland habitats are fragmented by the adjacent land use.

Just upstream of Elm Street, the SRWRF discharges effluent into Murrieta Creek, creating an area of freshwater marsh habitat that is approximately 50 feet wide that extends from 100 feet above the discharge point to the Winchester Road bridge. The effluent is the source of hydrology for the freshwater marsh, as the creek invert is dry and devoid of vegetation upstream. To the west of the channel is the SRWRF and to the east are disturbed fields and a trailer home.

Upstream from the effluent induced wetland to Kalmia Street is a long section of dry, mostly unvegetated channel. The dry sandy channel invert is approximately 30 feet wide with banks that range in steepness from 3:1 to 4:1. The sandy channel and banks have less than 5 percent cover with occasional patches of mulefat scrub and disturbed riparian areas. The west shelf and adjacent lands include disturbed farming and ranching lands including manure piles, while the east side of the creek is either developed or platted for development. The channel invert gradually widens upstream towards Kalmia Street.

The section of Murrieta Creek from Kalmia Street to Tenaja Road, although partially cleared per the FMP, includes occasional areas of habitat. The channel invert is approximately 180 feet wide in this section with banks ranging from 2:1 to vertical, and heights up to 8 feet. There are parallel berms in the invert oriented along the flowline which appear to be man-made and are up to 5 feet high. The occasional patches of habitat include mulefat scrub and southern willow scrub that are dominated by natives with scattered mature eucalyptus. The west shelf is primarily non-native grassland and the east shelf has a new residential development with 8-foot high double culverts, and riprap covered slopes. At Tenaja Road, the vegetation in the channel is less disturbed apparently due to a lesser degree of channel maintenance.

From Tenaja Road upstream to Magnolia Road (upstream of the FMP area) the creek has approximately 15 percent cover. The invert is approximately 110 feet wide with 2:1 slopes, 5 to 8 feet high on either side. Scattered patches of habitat include mulefat scrub, southern willow scrub, non-native woodland (eucalyptus), open-water/sand, and occasional oak trees. The land is dominated by development and disturbance adjacent to the creek along its east and west bank until the confluence of Murrieta Creek and Cole Canyon Creek.

At the confluence of Murrieta Creek and Cole Canyon Creek the cover in the invert is reduced and the land adjacent to the creek is dominated by non-native woodland (eucalyptus woodland). The habitat characteristics remain generally the same from the confluence to Calle del Oso Oro, and include a 100-foot-wide invert with 4 to 5 foot banks. The occasional habitat in the invert includes southern willow scrub, mulefat scrub, and mixed riparian scrub. The adjacent lands along the east bank include southern cottonwood willow riparian forest with a distinct eucalyptus component, as well as areas of disturbance and non-native grassland. The Bear Creek Airfield is on the west side of the creek just upstream of the confluence. The stream banks adjacent to the airfield have been recently altered either to form a makeshift levee or to increase the size of the airfield. Also on the west side of the creek are a known population of smooth tarplant, cismontane alkali marsh, small areas of mulefat scrub and ephemeral wetland, and large disturbed areas. Agricultural and residential developments are encroaching in the distance, but are not adjacent to the project area in this section of the creek.

Immediately upstream of Calle del Oso Oro is a broad bend in the creek hereafter referred to as the oxbow. The channel invert in the oxbow is primarily open water/sand, with areas of mulefat scrub and ephemeral wetland. On the outside of the bend (on the east side of the creek) there is a 6-foot high concrete retaining wall apparently to protect adjacent lands from flood flows. Beyond the retaining wall are disturbed areas and small trailer homes. On the inside of the bend (west) there is mulefat scrub and a few small hills with Riversidian sage scrub. Non-native grassland and disturbed areas dominate the remainder of the lands to the west of the creek.

Upstream of the oxbow the habitat changes dramatically. From the north (upstream) end of the oxbow to 2,500 feet upstream, the creek is confined in a 45-foot-wide invert with 20-foot-high banks. The creek is generally straight in this area with an open water/sand invert and southern cottonwood willow riparian forest dominated banks/shelves. Adjacent to the riparian habitat are areas of disturbed habitat including horse ranches and mobile/trailer homes. This narrow section then opens up into an area of relatively high quality riparian habitat.

The relatively high quality riparian habitat begins 1,000 feet below the confluence of Murrieta Creek and Slaughterhouse Canyon. It consists of a dense canopy of southern cottonwood willow riparian forest with a primarily non-native understory. Included are small patches of southern willow scrub and mixed riparian scrub. This habitat continues to 200 feet south of Clinton Keith Road, where the southern cottonwood willow riparian forest becomes much wider.

The wider southern cottonwood willow riparian forest has a very dense canopy, perhaps so dense that it is inhibiting the development of an understory. The trees are primarily native, but there are also many mature eucalyptus. The understory is not very well developed and primarily nonnative. West of the dense riparian area is a more open area classified as mixed riparian scrub which consists of both natives (e.g. mulefat, sandbar willow, etc.) and nonnatives (e.g. bermuda grass, sweetclover). This habitat description ends at Clinton Keith Road, the northern extent of the proposed project area.

3.4.6.2.2 Sensitive Habitats

Sensitive habitats are those that are considered sensitive by the California Department Fish and Game (CDFG) (e.g., communities with the highest inventory priorities) (Holland 1986). Habitats are generally considered sensitive because they support rare and endangered species and/or because very little of these habitat(s) remain. Many sensitive habitats have suffered significant losses due to urbanization or conversion to other habitat types such as agriculture.

Riparian and Wetland Habitats: Riparian and wetland communities within the Murrieta Creek study area include: ephemeral wetlands, southern cottonwood-willow riparian forest, southern willow scrub, mulefat scrub, coast live oak woodland, mixed riparian and disturbed riparian, cismontane alkaline marsh and freshwater marsh. Riparian and wetland communities are considered sensitive by the CDFG (Holland 1986). Wetland habitat is under the jurisdiction of the USACOE pursuant to Section 404 of the Clean Water Act of 1972 as amended in 1977 and 1984. Riparian habitat is regulated by the CDFG, pursuant to Section 1600 of the California Fish and Game Code.

It is estimated that California lost 91 percent of its wetlands by 1975 and that losses of riparian habitat in southern California floodplain areas may be as high as 95 to 97 percent (Bowler 1990). The loss and degradation of the riparian and wetland communities in southern California is the result of numerous activities including the filling and draining of these habitats, clearing of riparian vegetation, water diversion and impoundment projects, grazing, channelization, increased erosion and sediment transportation, increased urban runoff, alteration of nutrient status, lowering of water tables, contamination by agricultural fertilizer and pesticide use, human recreational activities, gravel mining, and the invasion of exotic species (Bowler 1990; Ferren 1990).

Three of the sensitive riparian vegetation communities (southern cottonwood-willow riparian forest, southern willow scrub, and mulefat scrub) present within the project study area provide important habitat for resident and migratory wildlife. The southern cottonwood-willow riparian forest provides multilayered canopy cover needed for sensitive nesting birds such as the Federally endangered least Bellos vireo and southwestern willow flycatcher. This habitat, though narrow and fragmented, is found in the upstream portions of the study area in small clusters and in more continuous strips from Rancho California Road to the Temecula Creek confluence. It has been thought that narrow and fragmented strips of this riparian habitat were not of adequate quality to support these sensitive species; however, recent studies have shown that least Bell's vireo and southwestern willow flycatcher may utilize these small patches for foraging during migration (Dr. Barbara Kus, personal communication).

The unvegetated stream channel of the study area is unlikely to provide breeding habitat for the Federally endangered arroyo southwestern toad, due to annual maintenance disturbances on the channel bottom, as described in the FMP. If any toads occupy the low quality habitat during periods when clearing is not taking place the likelihood of a population becoming established is minimal. The pooled bedrock portion of the creek south of 1st Street contains potential habitat for the Federally threatened California red-legged frog and the state Species of Special Concern southwestern pond turtle.

Coastal Sage Scrub: Coastal sage scrub, which includes Riversidian sage scrub, is considered a sensitive habitat by the CDFG (Holland 1986) because this community supports an extremely high number of sensitive species. The State of California has implemented a Natural Communities Conservation Planning (NCCP) program aimed at conserving and ensuring the biological integrity of entire communities while accommodating economic development. The first program initiated under the NCCP was the Southern Coastal Sage Scrub Program in 1992. This program includes 11 NCCP Subregional Planning Areas within four counties. Currently, a Multiple Species and Habitat Conservation Plan (MSHCP) is being prepared by the County of Riverside.

Loss of sage scrub within California is primarily due to grazing and urbanization. Estimates of losses of this community range from 36 to 85 percent; however, these estimates are dated, and additional losses have since accrued.

The Riversidian sage scrub provides habitat for the Federally threatened coastal California gnatcatcher. The sage scrub habitat upstream of 1st Street is of low quality due to the disturbed nature of the habitat within the project area; however, south of 1st Street on the west side of Murrieta Creek is a more continuous undisturbed area of sage scrub habitat where a coastal California gnatcatcher was detected. Gnatcatchers could utilize onsite sage scrub and associated habitats for foraging and breeding. Additionally, Quino checkerspot butterfly could potentially occur in the sage scrub habitat in this area.

3.4.6.2.3 Sensitive Species

Plant and animal species are designated as sensitive because of their overall rarity, endangerment, unique habitat requirements, and/or restricted distribution as defined by the USFWS (USFWS 1998a). In general, it is a combination of these factors that leads to a sensitivity designation. Sensitive species include those listed by the USFWS (1998a), CDFG (CDFG 1998a, 1998b, 1998c, 1998d), and California Native Plant Society (CNPS) (Skinner and Pavlik 1994). The CNPS listing is sanctioned by the CDFG and essentially serves as its list of candidate species for threatened or endangered species. Table 3.4.12 lists the sensitive species that are known, expected, or have the potential to occur within the study area. Sensitive species that were observed in the project area, or that are Federally listed and have a moderate or higher potential for occurring based on the presence of suitable habitat, are described further below. All additional species noted in Table 3.4-12 are described further in the species accounts included in Appendix I.

Table 3.4-12

Sensitive Plant and Animal Species Known or Potentially Occurring in the Murrieta Creek Project Area

Species	Sensitivity Rating*	Associated Habitats	Occurrence Potential
Plants			
Allium munzii Munz's onion	USFWS: PE CDFG: T CNPS: 1B, 3-3-3	chaparral, coastal scrub, and grassland with clay soil	low
Dodechema leptoceras Slender-horned spineflower	USFWS: E CDFG: E CNPS: 1B, 3-3-3	chaparral, alluvial fan scrub	low
Hemizonia pungens ssp. *laevis* Smooth tarplant	USFWS: SSC CNPS: 1B, 2-3-3	chenopod scrub, meadows, seeps, playas, riparian woodland, alkaline and foothill grassland	present
Lasthenia glabrata ssp. *coulteri* Coulter's goldfields	USFWS: SSC CNPS: 1B, 2-3-2	coastal salt marshes, playas, and vernal pools	low
Fish			
Gila orcutti Arroyo chub	CDFG: SSC	slow moving streams, sand or mud substrates	present
Invertebrates			
Euphydryas editha quino Quino checkerspot butterfly	USFWS: E	meadows, vernal pools, open sage scrub and chaparral, disturbed sites	low to moderate
Streptocephalus woottoni Riverside fairy shrimp	USFWS: E	vernal pools and ponds	low
Amphibians/Reptiles			
Bufo microscaphus californicus Arroyo southwestern toad	USFWS: E CDFG: SSC	gravelly/sandy washes, stream/river banks, arroyos, sage scrub, mixed chaparral	low to moderate
Rana aurora draytoni California red-legged frog	USFWS: T CDFG: SSC	marshes, slow streams, lakes, reservoirs, ponds, typically associated with deep water pools fringed by thick vegetation	moderate
Clemmys marmorata pallida Southwestern pond turtle	CDFG: SSC SDHS: T	pools and permanent or intermittent streams with emergent marsh vegetation along edges	low to moderate
Cnemidophorus hyperythrus beldingi Orange-throated whiptail	CDFG: SSC SDHS: T	prefers open sage scrub and chaparral, floodplains	moderate (surveys not required)
Phrynosoma coronatum blainvillei San Diego horned lizard	CDFG: SSC SDHS: E	sage scrub and chaparral, coniferous and broadleaf woodlands, sandy or friable soils	moderate (surveys not required)
Crotalus ruber ruber Northern red diamond rattlesnake	CDFG: SSC	chaparral, coastal sage scrub, along creek banks, rock outcrops or piles of debris	moderate (surveys not required)
Thamnophis hammondi Two-striped garter snake	CDFG: SA SDHS: T	aquatic habitats, preferring rocky streams with protected pools, cattle ponds, marshes, vernal pools	moderate (surveys not required)

Table 3.4-12 con't

Sensitive Plant and Animal Species Known or Potentially Occurring in the Murrieta Creek Project Area

Species	Sensitivity Rating*	Associated Habitats	Occurrence Potential
Birds			
Vireo bellii pusillus Least Bell's vireo	USFWS: E CDFG: E	restricted to riparian woodland with understory of dense young willows or mulefat	low to moderate
Empidonax traillii extimus Southwestern willow flycatcher	USFWS: E CDFG: E	dense riparian woodlands of willow, cottonwood and other deciduous shrubs and trees	low to moderate
Coccyzus americanus occidentalis Western yellow-billed cuckoo	CDFG: E	restricted to dense, tall cottonwood and willow riparian woodlands of the valley foothill and desert	low
Accipiter cooperii Cooper's hawk	CDFG: SSC (breeding) Audubon: NABL	oak woodlands, willows or eucalyptus	low
Falco peregrinus anatum American peregrine falcon	USFWS: E CDFG: E	near large bodies of water where they feed on waterbirds	low
Elanus leucurus majusculus White-tailed kite	CDFG: SA (nesting)	riparian or oak woodland, grassland or open fields for foraging	present (surveys not required)
Haliaeetus leucocephalus Bald eagle	USFWS: T CDFG: E	lakes, rivers, marshes, seacoasts	low
Aquila chrysaetos canadensis Golden eagle	USFWS: P CDFG: SSC	grassy and open shrubby habitats, nests primarily on cliffs with secondary use of large trees	low
Polioptila californica californica Coastal California gnatcatcher	USFWS: T CDFG: SSC	coastal sage scrub	high; previous detection
Mammals			
Dipodomys stephensi Stephens' kangaroo rat	USFWS: E CDFG: T	disturbed grassland habitat, soil low in clay content	low
Chaetodipus fallax fallax Northwestern San Diego pocket mouse	USFWS: SSC	open, coastal sage scrub, annual grassland and desert habitat	low
Lepus californica bennettii San Diego black-tailed jackrabbit	USFWS: SC CDFG: SSC	open chaparral, open coastal sage scrub, and grasslands	present

*Status Codes:
U.S. Fish and Wild Service (USFWS): E = Endangered; T = Threatened; P = Protected under the Bald Eagle Act of 1940; SSC = Species of Special Concern.
California Department of Fish and Game (CDFG): E = Endangered; SA = Special Animal; SSC = Species of Special Concern
California Native Plant Society (CNPS) (Skinner and Pavlik 1994)
List 1B - Plants rare, threatened and endangered in California and elsewhere
CNPS R-E-D Code
R (Rarity): 1 = Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction or extirpation is low at this time; 2 = Occurrence confined to several populations or to one extended population; 3 = Occurrence limited to one or a few highly restricted populations, or present in such numbers that it is seldom reported
E (Endangerment): 1 = Not endangered; 2 = Endangered in a portion of its range; 3 = Endangered throughout its range
D (Distribution): 1 = More or less wide spread outside California; 2 = Rare outside California; 3 = Endemic to California
NABL = National Audubon Society Blue List
SDHS = San Diego Herpetological Society; E = Endangered; T = Threatened

HANDOUT FOR EXERCISE 1 (Part e)

Pages 99-100 of the Main Report (Planning Objectives)

3.9 PLANNING OBJECTIVES

The national objectives are general statements and not specific enough for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent pubic concerns for desired positive changes in the without project conditions. The planning objectives are specified as follows:

a. To reduce flood inundation damages which occur in the Cities of Temecula and Murrieta.

b. To reduce costs associated with participation in the National Flood Insurance Program for residents in the Cities of Temecula and Murrieta.

c. To restore the riverine ecosystem along Murrieta Creek to create habitat that would become a self-sustaining, functioning system that has a high value for terrestrial and aquatic wildlife use.

d. To provide recreational opportunities associated with Murrieta Creek that can be incorporated into a multipurpose project.

3.10 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions on the planning process. The planning constraints identified in this study are as follows:

a. Opportunities to provide flood damage reduction or ecosystem restoration by expanding the channel along Murrieta Creek are limited, particularly in the Old Town area of the City of Temecula. In some portions of this area, the existing creek channel has a maximum capacity of as little as 12,300 cfs, which corresponds to a flood event which might, on average, have a 10% chance of occurring in any given year. The opportunity to enlarge the channel by widening is constrained by local development where structures have been constructed very close to the edges of the creek. Given the extent of existing development, it was also recognized that ecosystem restoration activities might be extremely limited or impossible within certain reaches.

b. A constraint associated with the most constricted channel reach was that of the location of a lower-income apartment complex and its associated parking area in close proximity to the channel. Opportunities to widen the channel in this location were limited by the high cost of relocation of this structure, or the high cost of reconstruction of a parking facility in close proximity to the existing apartment complex. Removal of this structure in order to create greater flood control capacity may violate guidance provided in Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations", dated February 11, 1994, which states that, "To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental

effects of its programs, policies and activities on minority populations and low-income populations in the United States…" As this facility is one of few lower-income housing complexes in the City, and its removal may constitute a disproportionate environmental impact, it becomes a planning constraint.

c. The opportunity to deepen the creek, thereby increasing capacity, is constrained by the channels' natural tendency to refill the channel bottom (invert) with sediment during a flood event, eliminating the capacity increase.

d. For Federal participation in a plan of improvement, the benefits of a plan, either monetary or non-monetary must exceed the costs. In the case of flood control and recreation, the monetary reduction of flood damages and the monetary value of recreational opportunities must exceed the costs. In the case of ecosystem restoration, the increased value of habitat must justify the costs.

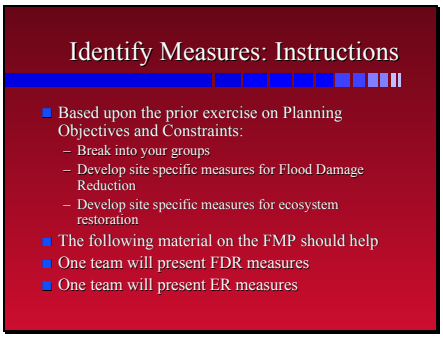
APPENDIX E-2

CLASS EXERCISE 2

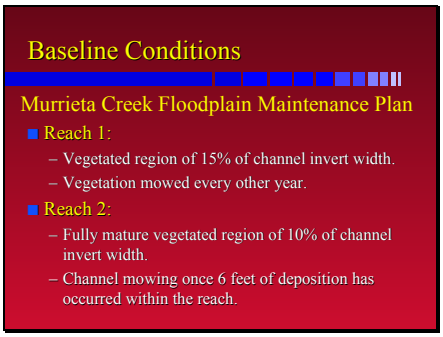
MODULE MX – HANDS ON EXERCISE BASED ON MURRIETA CREEK, FLOOD CONTROL, ENVIRONMENTAL RESTORATION AND RECREATION, FINAL FEASIBILITY REPORT, AUGUST 2000

Slide 1

Slide 2



Slide 3



Slide 4

Baseline Conditions

Murrieta Creek Floodplain Maintenance Plan

- Reach 3A: (Santa Gertrudis to Warm Springs)
  - Fully mature vegetated region of 20% of channel invert width.
  - Channel mowing when 5 feet of deposition has occurred.
  - RFCWCD has purchased the area North of the Santa Gertrudis Creek Confluence (east of Murrieta Creek)
- Reach 3B: (Warm Springs to Elm Street)
  - Annual mowing.

Slide 5

Baseline Conditions

Murrieta Creek Floodplain Maintenance Plan

- Reach 4:
  - Restore and repair channel banks after major flood events.
- Reach 5:
  - 20-foot wide vegetated region comprising of intermediate vegetated conditions.
  - Mowing when channel reaches a Manning's coefficient equivalent to 0.085 or deposition of 1 foot of sediment.

Slide 6

Baseline Conditions

Murrieta Creek Floodplain Maintenance Plan

- Reach 6:
  - 50% of existing vegetation allowed to mature.
  - Vegetated region maintained only when 1.5 feet of sediment accumulates.

Slide 7

Mid –Exercise Correction

- Key pages of the report describe the measures the District considered.
- Read these pages.

Slide 8

Combine Measures Into Single Purpose Plans

- Combine the District's measures into single purpose plans for flood damage reduction and for ecosystem restoration
  - What is your purpose in doing this
  - What if the local sponsor tells you some of the measures are "unacceptable"
- What strategies are you using at this point?
- Do you expect your single purpose plans to be implemented?
- One team will report on flood damage reduction
- One team will report on ecosystem restoration

Handouts for exercise 2 (part d)

Pages 101 to 113

3.12.2 NON-STRUCTURAL FLOOD DAMAGE REDUCTION MEASURES

3.12.2.1 Flood Insurance

This measure does not alter floodplain characteristics and thus does not reduce, but rather reimburses losses due to flooding. The cities of Temecula and Murrieta are currently enrolled in the National Flood Insurance Program (NFIP). While no additional study of this measure is required, the effects of providing other types of flood control on the requirements associated with providing flood insurance were evaluated. Participation in the program is a measure that is required with the implementation of any Federal flood control project.

3.12.2.2 Floodplain Management

This measure affects potential future flood damages to new development. It does not affect future damages to existing development. Regulating development within floodplains established by FEMA is a legal requirement of the NFIP. This measure is already in effect. Floodplain regulation is the responsibility of the cities of Murrieta and Temecula, and the Riverside County Flood Control and Water Conservation District. Since the watershed has not been completely built out and development may be expected to occur in the future, comprehensive evaluation of new development projects must consider effects on Murrieta Creek and its tributaries. Floodplain management is required in order to ensure the continued function of any implemented flood control plan, that all development occurring in the future must not cause an increase in peak discharges in Murrieta Creek or its tributaries beyond that assumed in the development of the flood control plan.

3.12.2.3 Emergency Response

The purpose of actions taken in response to an actual emergency, such as flooding, is to reduce the potential for some types of damages, including those that relate to public safety, that result from inundation. Typical actions taken as part of an emergency response include using heavy equipment and materials to maintain streets to provide safe driving conditions. This can include, but not be limited to barricading and/or sandbagging of locations subject to hazardous flooding. Local records and historical experience in other flood prone areas, however, indicates that because of the speed at which the water rises in this area, damages to existing development cannot be prevented, although the threat to human life can be minimized. It was determined that because emergency response in the study area would not provide significant reductions in flood inundation damages, and therefore, does not meet the needs of the local sponsor, no further examination of this alternative would be pursued. Reduction of emergency response expenses was, however, carried forward as a project objective in conjunction with flood control measures.

3.12.2.4 Flood Warning

A floodwarning system is an integral element of emergency response, floodproofing, and evacuation plans. A floodwarning system processes weather information (rainfall) to assess the

likelihood of flood event and issues warnings to occupants of floodplains, which may enable evacuation of people and property. Due to the short warning times associated with the flood events in this watershed, floodwarning did not appear to offer any large measure of protection, even in combination with evacuation of structures. Therefore, this alternative was not pursued for further evaluation in this study.

3.12.2.5 Evacuation

Evacuation plans primarily entail the temporary removal of people from the areas where flooding is imminent, and are carried out when forecasts of flooding, or flood warnings are made. This measure achieves little in reducing flood damages, as most damageable property remains in the floodplain, but can be very effective in saving lives in areas subject to extremely severe flooding. Because the flooding that is the subject of this study primarily involves damages associated with inundation of structures, pursuit of evacuation plans was not examined further.

3.12.2.6 Floodproofing

This measure attempts to reduce damage susceptibility of individual or small groups of structures. Structures can be "dry" floodproofed (where the water is kept out of the structure) or "wet" floodproofed (where water entry is accommodated). Due to the fact that most damageable structures in the floodplain are single-story, "wet" floodproofing was not considered to be an option as no convenient evacuation area exists for content relocation during a flood event.

Floodproofing of structures was examined for a variety of event magnitudes, including 25-year, 50-year, 100-year, and 500-year flood events. Neither wet nor dry floodproofing measures were determined to be economically feasible, and were not pursued. Due to the lack of economic justification, this alternative was not pursued further in this study.

3.12.2.7 Elevation of Structures

Elevation of structures consists of raising each structure onto pilings to reduce or eliminate damage to the structure and its contents due to inundation. Elevation of structures was examined for a variety of event magnitudes, including 25-year, 50-year, 100-year, and 500-year flood events. Events of less than 25-year magnitude create extremely localized flooding, and were not pursued. Due to the limited number of structures affected during a 25-year event, and the high cost of elevating these few structures, this alternative was determined economically infeasible. There are between one hundred and two hundred structures in the 50-year floodplain. Elevating these structures was determined to be economically infeasible. There are slightly more than two hundred structures in the 100-year floodplain. Elevating of these structures was also determined to be economically infeasible. Elevating of structures within the 500-year floodplain was also determined to be economically infeasible. Due to the lack of economic justification, this alternative was not pursued further in this study.

3.12.2.8 Floodplain Acquisition/Conversion

Floodplain acquisition/conversion consists of the purchase of real estate and converting the existing land-uses of the active floodplain to uses which might minimize flood damage during those periods in which flood events would cause flood inundation damage. The land could then be developed

in such a way so as to experience minimal inundation damages due to flood events. Examples of this type of land would be parks, golf courses, natural habitat, etc. However, due to the fact that the area immediately adjacent to the creek from the Santa Gertrudis Creek confluence through Old Town Temecula currently has extensive commercial development, the costs to purchase this land and remove the structures would be extremely high. In addition, this alternative would not be acceptable to the City of Temecula due to the economic importance of Old Town. There is no other location in the nearby area to move these historic structures to maintain this economic asset. Therefore, this alternative was not pursued for in this reach. This measure was, however, retained for further study in association with the reaches of Murrieta Creek upstream of the Santa Gertrudis confluence. Development in that area is sufficiently low that this measure was deemed viable for further study.

3.12.2.9 Summary of Non-Structural Flood Damage Reduction Measures

Flood insurance and floodplain management is forwarded for further consideration in the planning process since they would be requirements with the implementation of any potential Federal flood control project. Flood plain acquisition/conversion is also forwarded for further consideration in the reaches of Murrieta Creek upstream of the Santa Gertrudis confluence.

3.12.3. STRUCTURAL FLOOD DAMAGE REDUCTION MEASURES

3.12.3.1 Removal of Impediments to Flow

Objects in the channel impede flow by decreasing channel capacity and increasing the frequency and severity of flooding. Removal of obstructions was examined as a means of reducing flood damages. The most prevalent impediment found in the channel is vegetation. However, the reduction in capacity attributed to vegetation is minor in comparison to the overall limited capacity due to small channel size. This is especially true in the Old Town area of Temecula where channel size is especially constricted. Given that the bankfull capacity on the Old Town area under the provisions outlined in the Flood Plain Maintenance Plan is approximately 12,400 cfs, which is an event which has an approximately 10% chance of occurring in any given year, and that removal of the vegetation would cause no more than a 10% increase in existing capacity under a best-case scenario, removal of vegetation would not provide sufficient creek capacity to reduce damages significantly. In addition, reduction in the vegetation from that allowed under the provisions of the Flood Plain Maintenance Plan would have a significant adverse impact on the aquatic ecosystem. Therefore, this alternative was eliminated from further consideration.

3.12.3.2 Channelization

The purpose of this measure is to increase the flow-carrying capacity of the existing creek channel by lining the channel to provide faster flow. Alternatives involving concrete lining of the channel were eliminated early in the plan formulation process due to the unsuitability of this option in this otherwise natural creek. Concrete would accelerate floodflows to an unacceptable level, causing erosion of the downstream channel. It would also cause irreversible changes in the geomorphic balance of the natural channel such that downstream and upstream channels might be forced to modify their meander wavelength and height to compensate for the sudden change caused by the loss of channel roughness and increase in velocity, as well as the sudden starvation of floodflows in regards to sediment uptake. Reduction of pervious bed and banks might affect groundwater infiltration rates, impacting the court-imposed minimum infiltration of surface waters currently required for Camp Pendleton, further downstream. This measure was eliminated from further consideration.

3.12.3.3 Channel Widening

The existing channel of Murrieta Creek is largely incised into the surface of the floodplain. Therefore, additional channel capacity can be realized by widening the existing channel in order to accommodate larger flood events than can be currently carried. Because Murrieta Creek is a natural channel (i.e., both bed and banks are primarily comprised of natural soils), and is in a general "equilibrium" state in regards to inflow and outflow of sediment, there is no opportunity to excavate the channel below its existing grade without the channel refilling during each flood event and reducing the capacity to its "without-project" condition. Therefore, enlargement of the channel to accommodate larger flood events must be achieved through channel widening alone.

3.12.3.3.1 Extensive Channel Widening

This measure entails widening the channel sufficiently to enable it to carry substantial flows during large storm events. This alternative utilizes maximization of flow capacity as the principle determinant for design. In the Old Town area, this would require the demolition of an apartment building, several single-family homes, and several industrial/commercial buildings. Due to the high cost of purchasing these lands and structures, and the limited benefits expected to be gained as a result of the extensive channel enlargements, this alternative was eliminated from further consideration.

3.12.3.3.2 Limited Channel Widening

Limited channel widening entails widening the channel in such a way so as to not require extensive demolition of structures or other costly infrastructure. This alternative utilizes preservation of structures and other infrastructure as the means to minimize costs. This is particularly important in light of the modest benefits to be achieved. The channel widening alternative is limited to control of a moderate flood event, as the constraint of keeping the channel within an area, which would not require large-scale structure removal precludes control of large flood event. The channel-widening alternative, for any level of protection examined, did not generate sufficient economic benefits to be justified. In addition, even with bridge replacement, a widening plan alone cannot accommodate floodflows generated during a 1% exceedance flood event, which is the desire of the local sponsor. It was recognized, however, that this plan, with inclusion of a detention basin alternative, would provide a level of protection desired by the local sponsor, and was therefore carried forward as a potential element of a larger alternative plan. It was also noted that with the addition of a limited floodwall on the west bank of the creek, this alternative would be economically justified. This measure is therefore carried forward for further consideration.

3.12.3.4 Bridge Replacement/Modification

Replacement of bridges that restrict flow or limit channel capacity is a viable means of reducing flood damages. In examining the effects that this measure would cause on flood peaks, it became apparent that the replacement or modification of two bridges could be performed to reduce flood damages, thereby allowing certain moderate flood events to remain in-channel. These bridges are the Rancho California Road bridge which crosses Murrieta Creek just upstream of the Old Town area and the Main Street bridge which crosses the creek within the Old Town area. Preliminary evaluation of these bridges indicated that they have a limited capacity to carry flood flows and would therefore act as a constriction point. The demolition and reconstruction of the Main Street bridge would enable the channel

to be widened to its maximum extent and would increase flows as much as possible. Although the Rancho California Bridge is not capable of conducting flood flows from the largest flood events, it is a relatively new bridge its replacement would not be economically justified. Modification of the approaches will be considered instead of replacement. The replacement and modification of these bridges was pursued as viable option in conjunction with other measures, including floodwalls, channel enlargement (widening), and detention basin alternatives.

3.12.3.5 Floodwalls

Floodwalls are vertical walls added atop the existing banks or levee tops to confine flood flows to the existing channel footprint and prevent breakout of floodwaters. Floodwalls require considerably less real estate than a levee concept, but may cost more in their construction. A floodwall plan, which included bridge modifications was investigated during the study to determine if it was an economically justified alternative. This alternative consists of constructing concrete flood walls along the edges of the existing channel of Murrieta Creek from Winchester Road down to the southern end of Old Town Temecula. A total of 6 floodwall heights were evaluated, ranging from heights necessary to contain flows from a 25-year event to heights necessary to contain a 1000-year event. Based on analysis of the various events, it was determined that wall heights would range from 7.5 feet maximum/1 foot minimum to 19 feet maximum/1 foot minimum height (depending on location along the creek and the local surface contours) would control the flood events. It was also determined that none of these floodwalls would be economically justified when interior drainage and bridge modification costs were included. Floodwalls are, however, carried forward as a potential component of an overall plan for channel improvements since they could be economically feasible in concert with a channel widening effort.

3.12.3.6 Levees

This alternative would consist of constructing earthen embankments, or levees, along the banks of the creek to keep flood flows within the channel. This alternative has the disadvantage of requiring greater amounts of land than a floodwall alternative, although the construction costs may be less. Levees would be, because of their land requirements, difficult to implement due to the limited room available in the Old Town area. Creation of a levee option would require the demolition of numerous structures. This would result in an increase in costs without providing additional flood damage prevention benefits as compared to a floodwall alternative and was, for this reach, eliminated from further consideration. This measure was maintained for further consideration where levees would be used in the development of detention basins, and in the reaches upstream of the confluence of Murrieta Creek and Warm Springs Creek where the encroachment of development does not pose a constraint.

3.12.3.7 Ring Levees

Ring levees consist of constructing a levee or berm around specific infrastructure and/or groups of infrastructure in order to prevent floodwaters from entering structures and causing damages. Since all of the structures which need to be protected are spread out more or less evenly throughout the length of Murrieta Creek from Winchester Road through the Old Town area of Temecula, placing ring levees around the structures would end up being longer and more extensive than simply putting levees or floodwalls along the banks of the creek. This would result in much greater costs than other alternatives without providing additional benefits due to flood protection. For areas of development further upstream, the benefit of constructing individual ring levees was far outweighed by the costs of these structures.

Therefore, this alternative was eliminated from further consideration with the exception of a ring levee around the water treatment plant.

3.12.3.8 Dams

The purpose of dams is to reduce downstream flood flows by holding water in storage upstream of areas where protection is desired. In order for dams to be constructed, they must be located in a place where sufficient storage space is available. This is typically either at the mouths of deep canyons or in large valleys. Within the Murrieta Creek watershed upstream dams are already existing or are in construction. Lake Skinner exists as a result of a dam constructed in the upstream area of the Santa Gertrudis watershed. The Eastside reservoir is currently being constructed in the upper reaches of the Warm Springs watershed. However, these dams are in the upper headwater reaches of the watershed and therefore do not receive large amounts of runoff water. These reservoirs are filled through the use of pipelines from distant water sources. In order for a dam to function well as a flood control structure, it must gather as much water as possible during the peak of the flood event. This requires a location in which it concentrates floodflows from a large drainage area, and upstream of the damage centers. The only possible locations for a dam that would meet these criteria would be at the confluence of Murrieta Creek and Warm Springs Creek or a pair of structures, on Warm Springs and Murrieta Creek, a short distance upstream from their confluence. The construction cost of a structure or structures of sufficient size to control large flood events would be prohibitive in comparison to the benefits. Therefore, this alternative was eliminated from further consideration.

3.12.3.9 Detention Basins

Upstream detention of floodflows consists of creation of storage so that floodflows are collected in a suitable location upstream of the damage center(s), stored for the critical part of the flood event, and then gradually metered out at a rate that would keep the flows within the channel until the peak of the flood event has passed. The design of upstream detention basins can take on many forms. Multiple smaller upstream basins could be placed along each of the major tributaries (Murrieta Creek, Warm Springs Creek, and Santa Gertrudis Creek) or a single large detention basin could be placed downstream of where flows from tributaries converge. These detention basins could be either off-line where only peak flows spill over into the basin from the channel(s), or be on-line where higher flows are restricted by a control structure and waters slowly back up into the storage area of the basin. Detention basins also provide the opportunity for creation of additional in-channel habitat. The following sections contain a description of potential alternatives for detention basins.

3.12.3.9.1 Multiple Upstream Detention Basins

This alternative consists of constructing detention basins upstream along some of the major tributaries of the watershed. Initially, many such sites were examined. Placing moderately sized detention basins along Murrieta Creek, Warm Springs Creek, and Santa Gertrudis Creek could work in concert to reduce flood peaks by creating storage for the waters in excess of channel capacity. Based on landform information in the upstream areas along these tributaries, it was determined that these basins would require more excavation for the storage needed than downstream options, resulting in a substantially higher cost. Warm Springs and Santa Gertrudis creeks flow through low-lying rolling hills just upstream of their confluence's with Murrieta Creek, rather than a broad, flat floodplain. In addition, substantial modification to the existing environment would result. This would require mitigation that would further increase construction costs. Along Murrieta Creek, there are several locations where a

smaller upstream detention basin could be constructed. However, a detention basin along Murrieta Creek alone above the Warm Springs and Santa Gertrudis confluences would not hold sufficient flows to significantly reduce flood damages downstream. As a result of these issues, multiple upstream detention basins were eliminated from further consideration.

3.12.3.9.2 Single Large Detention Basin Alternatives

These alternatives consist of constructing a single large detention basin upstream of the potential damage centers. For the Murrieta Creek watershed, an ideal location for this single large detention basin is along Murrieta Creek in the vicinity of the confluences of Warm Springs Creek and Santa Gertrudis Creek with the Murrieta Creek mainstem. This location would allow the basin to collect flows from any two or three of the creeks, allowing flexibility in how the floodflows are detained. This is an area, which is already fairly flat, and therefore excavation and disposal costs would be minimized. For these reasons, several distinct designs for detention were developed. These designs could potentially include both off-line and on-line detention basins, and either a single and compartmented design, all of which are discussed in greater detail below. All detention basin plans are based on the concept of allowing the channel to carry as much water as possible during a flood event, but that under a condition in which breakout of floodflows would occur such that damages would occur, the excess floodwaters would be stored in a detention basin(s) until the end of the event, metering the water into the channel at a rate the downstream channel can accommodate. Initial analysis of the detention basin concepts indicated that costs would exceed benefits to be derived. However, because of the limited flood protection likely to be provided by channel improvements and the desire of the local sponsor to achieve approximately 100-year flood protection for properties adjacent to Murrieta Creek, the detention basin concept was retained for further evaluation. In anticipation of a plan at this location, the local sponsor purchased land between Warm Springs Creek, Santa Gertrudis Creek, Murrieta Creek, and Jefferson Avenue.

3.12.3.9.2.1 Off-line Multiple Pool Detention Basin

This alternative is a refinement of the local sponsor's preliminary plan for the detention basin site and consists of an off-line, multiple pool detention basin. A representation of this detention basin is shown in Plate 1. The overall detention basin was segmented into 5 separate compartments in order to preserve in place existing underground utility lines, which run through the basin. Each compartment would be excavated downward from the existing ground surface. To confine floodwaters within the basin, a levee would be required around the perimeter of the basin. In order for water to distribute throughout the basin, interior overflow weirs and reinforced concrete pipes would be placed between the individual compartments. This alternative is less effective in reducing flood damages when compared to the other detention basin alternatives. Therefore, it was not carried forward for further consideration.

3.12.3.9.2.2 Off-line Single Pool Detention Basin

This alternative is similar to that discussed above, with the exception that the detention basin has no interior partitioning. This was done primarily to increase the volume of storage within the real estate constraints. A representation of this detention basin is shown in Plate 2. Internal levees within the detention basin would not be required but the underground utilities would be relocated. This relocation consists of simply lowering the utility lines deeper into the ground to be below the surface of the fully graded detention basin. As with off-line multiple pool detention basin, the hydrologic analysis indicated that this alternative was not as effective in reducing flood peaks as other alternative basin configurations. Therefore, this alternative was eliminated from further consideration.

3.12.3.9.2.3 Two Creek In-Line Detention Basin

This alternative consists of an in-line detention basin through which low flows are permitted to pass unaffected through the basin and then through an outflow control structure at the downstream end of the basin. As floodflows increase to a rate that the downstream channel cannot safely carry without breakout, floodwaters back up within the basin. In this alternative, a flow control structure is located on Murrieta Creek just upstream of the confluence with Santa Gertrudis Creek, and would only control flows downstream of Warm Springs Creek, and that of Murrieta Creek upstream of Santa Gertrudis Creek. Flows from Santa Gertrudis Creek would remain uncontrolled, with the peak discharge passing unaffected through the downstream channel. This peak arrives before the peaks of Murrieta and Warm Springs Creeks so that the overall net effect is to reduce the combined peak flow in the downstream, floodprone areas. This alternative is the most effective of any of the detention basin plans in reducing peak discharges in the downstream channel, based on the cost per unit discharge reduced. As this alternative would be capable of achieving the level of protection desired by the local sponsor in conjunction with channel improvements, and has the potential to be combined with restoration features to form a multi-purpose plan, it was carried forward for further consideration.

3.12.3.9.2.4 Three Creek In-Line Detention Basin

This detention basin captures flow from Murrieta Creek, Warm Springs Creek, and Santa Gertrudis Creek. A representation of this alternative is shown in Plate 3. By placing a control structure downstream of the confluence of Murrieta and Santa Gertrudis Creeks, floodflows from all three creeks might be reduced. In order to obtain an adequate volume of storage, an embankment would be constructed around the perimeter of the basin. Because the portion of Santa Gertrudis Creek between Jefferson Avenue and Murrieta Creek currently consists of a soft-bottomed trapezoidal channel with concrete side slopes, locating the embankment along on the south side of Santa Gertrudis Creek also presents the opportunity to eliminate the concrete side slopes. This alternative provides a minimal advantage in reducing flood peaks over that of the Two Creek basin, at a higher cost. Therefore, this alternative was eliminated from further consideration.

3.12.3.10 Summary of Preliminary Flood Damage Reduction Measures

The potential project area can be divided into two separate reaches – above and below the confluence of Murrieta Creek and Warm Springs Creek. Preliminary analysis indicated that, downstream of the confluence, an alternative plan consisting of channel widening, floodwalls and bridge modification/ replacement might be economically justified based on Federal criteria. To provide the level of flood protection desired by the local sponsor, these same measures would be combined with the two creek detention basin. Alternative plans in the reach above the confluence would include the measures of floodplain purchase, channel widening, levees and a partial ring levee.

3.13 PRELIMINARY ECOSYSTEM RESTORATION MEASURES

Ecosystem restoration alternatives for Murrieta Creek were examined for their contribution to increasing the quality or quantity of habitat in the area. The Corps of Engineers does not have the authority to pursue ecosystem restoration projects that simply preserve the existing condition of an

environmental resource. Therefore, those plans that did not appear to generate an increase in benefit could not be recommended for implementation. Specific ecosystem restoration measures for Murrieta Creek focused on alternatives that would provide greater extent and/or quality of in-channel riparian and peripheral channel habitat, particularly given the paucity of such habitat types in the area. The difficulty in developing restoration plans for Murrieta Creek involves determining the causes of existing degradation, and attempting to develop a plan that accommodates the causes in such a way that the restored habitat would survive in the rapidly changing environment, and be compatible with future uses, recreation demands, and future ecological needs. The approach taken in this study was to develop plans that would become self-sustaining, naturally functioning, with a high value for terrestrial and aquatic wildlife use, while being compatible with flood control and recreational uses, and providing incidental water quality improvements for the benefit of the environment. Numerous preliminary ecosystem restoration measures were evaluated both individually and in combination with other alternatives to determine potential environmental benefits. These measures, in general, focused on: (a) manipulation of the landscape in order to modify hydrologic or vegetative opportunities, (b) re-creation of the physical structure needed to support certain habitat types, (c) set-aside of property to ensure broad ecosystem objectives, (d) exotic species management, and (e) revegetation, to ensure native species domination of the restored areas. These measures were examined for the entire project reach from the streamgauge at the downstream end of the City of Temecula, to upstream of Clinton Keith Road above the City of Murrieta. Many of these were dropped from further consideration upon input from resource agencies and study team. Preliminary ecosystem restoration measures included:

3.13.1 Channel widening and restoration of an in-channel riparian zone, USGS streamgauge upstream to Rancho California Bridge

This alternative consisted of widening the channel sufficiently to accommodate a permanent in-channel riparian zone. Because the riparian zone would be permanent, the remainder of the channel would have to be large enough to accommodate all floodflows, as the sediment deposited within the riparian vegetation zone, and the density and hydraulic resistance of the vegetation could not be relied on to pass a significant quantity of runoff. Variations on this alternative included the presence or absence of revegetation efforts. Given the lag time in development of a climax riparian zone plant community, the primary difference would be that revegetation would generate a significant benefit in a shorter timeframe.

Because of the significant width of channel required for this alternative, and the high cost of real estate in this reach, this alternative would be extremely expensive in comparison to the benefit it would generate. However, due to the intense interest in restoration within this reach, a scaled down restoration alternative for a portion of this reach was carried forward for a detailed cost and benefit analysis.

3.13.2 Channel widening and restoration of an in-channel riparian zone, Rancho California Bridge upstream to Santa Gertrudis Creek

As with the alternative above, this alternative consisted of widening the channel sufficiently to accommodate a permanent in-channel riparian zone. Because the riparian zone would be permanent, the remainder of the channel would have to be large enough to accommodate all floodflows, as the sediment deposited within the riparian vegetation zone, and the density and hydraulic resistance of the vegetation

could not be relied on to pass a significant quantity of runoff. Variations on this alternative included the presence or absence of revegetation efforts. Given the lag time in development of a climax riparian zone plant community, the primary difference would be that revegetation would generate a significant benefit in a shorter timeframe.

Because of the significant width of channel required for this alternative, and the high cost of real estate in this reach, this alternative would be extremely expensive in comparison to the benefit it would generate. Therefore, this alternative was dropped from further consideration.

3.13.3 Two Creek Riparian Area

The objective of this alternative would be to create a natural riverine system on County-owned land beginning immediately upstream of Santa Gertrudis Creek and extending upstream past Warm Springs Creek to approximately Jefferson Ave. Because of the availability of unoccupied land, this alternative could include low-flow channels, natural backwaters and ponded areas, a transition zone from freshwater marsh to willow riparian habitat, and an upland buffer zone of mulefat scrub and/or coastal sage scrub. It could also integrate a series of seasonal wetlands/ponds that provide additional habitat functions for herptefauna, fish, birds, mammals, and invertebrates. Santa Gertrudis Creek would not be incorporated in this alternative. The land outside the existing channel on which this alternative would be constructed, is currently separated from the creek by a small levee constructed from material dredged from the existing channel. The upland area would be excavated to that width necessary to reestablish a meandering stream course with backwater areas.

Preliminary ecosystem analyses indicated that this alternative might generate a significant environmental benefit for a reasonable cost. This alternative was carried forward for further analysis.

3.13.4 Three Creek Riparian Area

The objective of this alternative was also to create a natural riverine system on County-owned land extending from just downstream of the confluences of Murrieta and Santa Gertrudis Creeks upstream to approximately Jefferson Avenue. This alternative would encompass the downstream-most reaches of both Santa Gertrudis and Warm Springs Creeks. The alternative would include low-flow channels, natural backwaters and ponded areas, a transition zone from freshwater marsh to willow riparian habitat, and an upland buffer zone of mulefat scrub and/or coastal sage scrub. It would also integrate a series of seasonal wetlands/ponds that provide additional habitat functions for herptefauna, fish, birds, mammals, and invertebrates. The land on which this alternative would be constructed is also currently separated from the creek by a levee that confines the creek during most flow conditions. The upland area would be excavated to the depth of the channel bed, and to that width necessary to reestablish a meandering stream course with backwater areas. Santa Gertrudis Creek is currently lined with concrete from the confluence upstream to past Jefferson Avenue. The concrete would be removed in this

alternative. The flood prone area would be expanded considerably from the existing condition.

Preliminary ecosystem analyses indicated that this alternative might generate a significant environmental benefit for a reasonable cost. This alternative was carried forward for further analysis.

3.13.5 Santa Gertrudis Creek Corridor Restoration

This alternative consists of removal of the concrete lining of Murrieta Creek between the confluence and Jefferson Avenue, and restoration of the reach to a natural bed/natural bank stream course. This would allow reestablishment of a corridor between headwaters and lower portions of Murrieta Creek. Although believed to be a significant cost, this alternative was believed to produce a significant environmental benefit, and was carried forward for further analysis.

3.13.6 Exotic Species Management

This restoration measure would increase habitat value by active management of exotic species. The focus of this alternative would be on removal of exotics from the upper project reaches. Target species include, but are not limited to: giant reed, salt cedar, tree tobacco, cocklebur, and castor bean. These species tend to crowd out and replace more desirable native species that have higher resource value and provide better habitat to wildlife. These measures can be undertaken anywhere in the project area, and can be done in combination with any of the other measures. This alternative was considered for all reaches in the project area. Due to a low occurrence of exotics in the reach downstream from Warm Springs, the benefit derived for this area was somewhat lower than those upstream. Therefore, this measure was forwarded for further analysis for the reaches of Murrieta Creek upstream of Warm Springs Creek.

3.13.7 Floodplain Restoration from Warm Springs Creek to Tenaja Road

This alternative would widen the channel and flood prone area, enhance existing vegetation in the corridor, and lessen side slopes of the channel. The reach of channel in this alternative is at the downstream end of the City of Murrieta. This reach has historically been straightened, with meanders eliminated, and earthen berms installed. Channel widening in this reach would result in the creation of additional in-channel riparian habitat. The lessened side slopes and wider invert would reduce potential for erosion and increase habitat value and accessibility. In-channel contouring would create topographic features conducive to increased habitat diversity.

Although this alternative was determined to generate some environmental benefit, it was deemed to be a lesser output that those of other alternatives due to a lack of sufficient water resources for vegetative growth. Therefore, this alternative dropped from further consideration.

3.13.8 Floodplain Restoration from Tenaja to Calle del Oso Oro

This alternative would widen the flood prone area, enhance existing vegetation in the corridor, and lessen side slopes of the channel. The reach of channel in this alternative is approximately 6,075 feet long, and is located in and upstream of the City of Murrieta. This reach has historically been straightened, with meanders eliminated, and earthen berms installed. Channel widening in this reach would result in the creation of additional in-channel riparian habitat. The lessened side slopes and wider invert would reduce potential for erosion, and increase habitat value and accessibility. In-channel contouring would create topographic features conducive to increased habitat diversity.

This alternative was determined to generate a significant environmental benefit, and was therefore carried forward for additional analysis.

3.13.9 Floodplain Restoration from Calle del Oso Oro to Upstream of Oxbow (Sta. 535+85)

This alternative consists of restoring a more natural riparian system in the upstream portions of Murrieta Creek between Calle del Oso Oro upstream to the large oxbow feature (Station 535+85). The restoration would include a low-flow meandering channel, in-channel terraces, gently sloping banks and an upland buffer.

This alternative was determined to generate a significant environmental benefit, and was therefore carried forward for additional analysis.

3.13.10 Floodplain Restoration from Oxbox (Sta. 535+85) to Clinton Keith Road

This alternative consists of restoring a more natural riparian system in the portion of Murrieta Creek between the oxbow at Station 535+85 to Clinton Keith Road.). The restoration would include a low-flow meandering channel, in-channel terraces, gently sloping banks and an upland buffer.

Although estimated to be more expensive than those alternatives discussed above on a unit cost basis, this alternative was determined to generate a significant environmental benefit, and was therefore carried forward for additional analysis.

Handout for Exercise 2 (Part f)

4.1 FLOOD CONTROL ALTERNATIVES

4.1.1 NO-ACTION ALTERNATIVE

This alternative assumes that no action is taken to alleviate flood inundation damages. This is also referred to as the "future without-project" condition. The no action alternative incorporates the most-likely future conditions in the watershed and along the creek, that no action is taken to pursue flood control other than those measures currently in place, or within the County or City's limited capabilities to pursue. In the case of Murrieta Creek, the "Murrieta Creek Floodplain Maintenance Plan" (currently in negotiation) was used as the future "without-project" scenario. Under this alternative, over 500 structures in the 500-year floodplain would continue to be at risk from flood inundation, and total equivalent annual damages would continue to accrue at a rate of $1,780,300 per year, of which $1,613,000 would be attributable to flood inundation (structural and contents) damages.

4.1.2 FLOOD CONTROL ALTERNATIVE 2: OFF-LINE MULTIPLE POOL DETENTION BASIN PLAN

This alternative, as with all the detention basin plans (Alternatives 2, 3, 4a, and 4b), are based on the concept of allowing the channel to carry as much water as possible during a flood event, but that under a condition in which breakout of floodflows would occur such that damages would occur, the excess floodwaters would be stored in a detention basin(s) until the end of the event, metering the water into the channel at a rate the downstream channel can accommodate. Initial analysis of the detention basin concepts indicated that costs for this concept were likely to exceed benefits to be derived. However, because of the limited flood protection likely to be provided by a limited channel enlargement concept, general lack of support for a floodwall concept, and the desire of the local sponsor to achieve approximately 100-year flood protection for properties adjacent to Murrieta Creek, the detention basin concept was retained for final analysis and possible inclusion as a locally-preferred plan. In anticipation of this eventuality, the local sponsor purchased land between Warm Springs Creek, Santa Gertrudis Creek, Murrieta Creek, and Jefferson Avenue. The original plans developed consisted of a 225 acre off-line, multiple pool detention basin in this area. Alternative 2 is the refinement of the local sponsor's preliminary plan for the detention basin.

The overall detention basin was segmented into five (5) separate compartments in order to preserve in place existing underground utility lines, which run through the basin. Each compartment would be excavated downward from the existing ground surface by removing a total of 2,470,000 cubic yards of material. Due to the high demand for fill material in the local area, disposal of this material would occur at sites within 10 miles of the project site. To confine floodwaters within the basin, levees would be required around the perimeter of the basin along the borders defined by Murrieta Creek, Date Street, Adams Avenue, Cherry Street, and Santa Gertrudis Creek. These levees would range in height from 1 foot to a maximum of 8 feet above the existing ground surface. In order for water to distribute throughout the basin, interior overflow weirs and reinforced concrete pipes (RCP's) would be placed between the individual compartments.

Total storage capacity of this detention basin would be 2,200 acre-feet. Functionally, this type of detention basin was determined to reduce 100-year peak flood flows from 37,000 ft^3/sec to 26,100 ft^3/sec.

Given the constraints of acreage available for detention basin construction, depth to groundwater, and other constructability requirements, there is an inadequate storage volume provided by this design to

store the excess floodwaters generated during large flood events (in excess of a 2% probability event). Utilizing the maximum storage possible with this design, there would still be storage or channel capacity increases required to accommodate a 1% exceedance flood event. In addition, analysis of this design through flood routing indicated that the benefits to be gained would be greatly exceeded by the costs of its construction. Therefore, from the standpoint of Federal justification, the detention basin alone was dropped from consideration as a NED plan component.

This alternative is less effective in reducing flood damages when compared to the other detention basin alternatives, and is also economically unjustified. Therefore, the off-line basin was not carried forward as a component of any plan.

4.1.3. FLOOD CONTROL ALTERNATIVE 3: OFF-LINE SINGLE POOL DETENTION BASIN PLAN

This alternative is similar to that discussed above, with the exception that the detention basin has no interior partitioning. This was done primarily to increase the volume of storage available within the basin at the same overall real estate requirement, but would require the removal and relocation of all utilities on the existing property. This results in a larger cost for this basin, due to increased excavation, but might also capture more floodwater volume, potentially resulting in a larger reduction in inundation damages than that of Alternative 2. Alternative 3 consists of a 225-acre single-pool off-line detention basin located on the eastern side of Murrieta Creek between the confluences of Warm Springs and Santa Gertrudis Creeks.

In this alternative the internal levees within the detention basin do not exist and the underground utilities have been relocated. Total storage capacity of this detention basin would be 2,730 acre-feet. This is slightly more volume capacity than Alternative 2 because the removal of internal levees has provided additional storage capacity. As a result of this increased capacity, this basin was determined to reduce 100-year peak flood flows from 37,800 cfs to 24,900 cfs. This represents a 1,200 cfs reduction over the basin in Alternative 2.

As with Alternative 2, hydrologic analysis indicated that this alternative was not as effective in reducing flood peaks as other alternatives. The economic analysis also indicated that the benefits to be provided by this alternative alone would not exceed the costs. Therefore, this alternative was not carried forward as part of any plan.

4.1.4. FLOOD CONTROL ALTERNATIVE 4: ON-LINE DETENTION BASIN PLANS

This alternative consists of an in-line detention basin through which the creek (or creeks) flows. Low flows are permitted to pass unaffected through the basin and then through an outflow control structure at the downstream end. As floodflows increase to a rate that the downstream channel cannot safely carry without breakout, floodwaters back up within the basin. The control structure at the downstream end of the basin is the feature which limits floodflows downstream of the basin to a rate the channel can accommodate. There is, however, a constraint to the rate of discharge that can be controlled, based on storage volume availability at this site. Therefore, it was recognized that additional measures might be needed in the downstream channel, should a high level of flood protection be desired. Based on hydrologic and hydraulic information, two separate on-line detention basins were designed. The first would capture flow from all three creeks (Warm Springs, Murrieta, and Santa Gertrudis), and the second would capture flow from only two creeks (Warm Springs and Murrieta. Both designs are discussed in greater detail in the following sections.

4.1.4.1 FLOOD CONTROL ALTERNATIVE 4A: THREE CREEK DETENTION BASIN PLAN

In this alternative, the detention basin captures flow from Murrieta Creek, Warm Springs Creek, and Santa Gertrudis Creek. By placing a control structure downstream of the confluence of Murrieta and Santa Gertrudis Creeks, floodflows from all three creeks might be reduced. In order to obtain an adequate volume of storage, an embankment would be constructed around the perimeter of the basin. The embankment would extend along the western side of Murrieta Creek between the creek and Diaz Road, along the southern side of Santa Gertrudis Creek between the creek and the businesses adjacent the creek along Enterprise Circle North. Additional embankment would be placed along Jefferson Avenue, Cherry Street, Adams Avenue, and approximately 400 feet north of the Warm Springs confluence with Murrieta Creek. Because the portion of Santa Gertrudis Creek between Jefferson Avenue and Murrieta Creek currently consists of a soft-bottomed trapezoidal channel with concrete side slopes, locating the embankment along on the south side of Santa Gertrudis Creek also presents the opportunity to eliminate the concrete side slopes.. Total size of the detention basin area required for this alternative would be 285 acres. Due to this design, Date Street would have to be eliminated from the basin area and would as a result terminate at Adams Avenue. Total storage capacity of this detention basin would be 4,140 acre-feet. This design has somewhat more storage volume available than Alternatives 2 and 3 due to the larger footprint afforded by expanding the levees outward. As a result of this increased capacity, this basin was determined to reduce 100-year peak flood flows from 37,800 cfs to 24,100 cfs.

This alternative provides greater opportunity for ecosystem restoration benefit than either of the above off-line concepts due to its incorporation of a sizable reach of channel. This would allow continuity between the basin acreage and the riparian zone, wildlife migration, permitting greater flexibility for the creek to meander, form water-generated topographic features, and respond to fluctuations in water availability and changing geomorphic trends.

As with the off-line detention basin alternatives, this plan did not appear to be justified as a stand-alone feature in NED plan selection, nor in combination with other added features. In addition, this alternative provided a minimal advantage in reducing flood peaks over that of Alternative 4B, at a higher cost. Therefore, this alternative was not carried forward as part of any plan.

4.1.4.2 FLOOD CONTROL ALTERNATIVE 4B: TWO CREEK DETENTION BASIN PLAN

In this alternative, a flow control structure is located on Murrieta Creek just upstream of the confluence with Santa Gertrudis Creek, and would only control flows downstream of Warm Springs Creek, and that of Murrieta Creek upstream of Santa Gertrudis Creek. Flows from Santa Gertrudis Creek would remain uncontrolled, with its peak discharge passing unaffected through the downstream channel. The potential advantage of not gathering flows from Santa Gertrudis Creek is that the peak discharge from Santa Gertrudis was determined to arrive at its confluence with Murrieta Creek before the peaks of Murrieta and Warm Springs arrive. As a result, by allowing the peak flow from Santa Gertrudis to bypass the detention basin, the overall net effect is to reduce the combined peak flow in the downstream, floodprone areas.

To confine floodwaters within the basin, an embankment would also be constructed around the perimeter of the basin. Total size of the detention basin area for this alternative would be 270 acres. This would require the removal 3,700,000 cubic yards of material from the basin, resulting in a total storage capacity of 3,860 acre-feet. This is less volume capacity than Alternatives 4a, but larger than Alternatives 2 and 3. Running the hydrologic model indicated that this basin would reduce 100-year flood flows from

37,800 cfs to 22,400 cfs. As with Alternatives 3 and 4a, Date Street would have to be eliminated from the basin area and would as a result terminate at Adams Avenue.

This alternative proved to be the most effective of any of the detention basin plans in reducing peak discharges in the downstream channel, based on the cost per unit discharge reduced. Economic analysis of this alternative indicated, however, that this alternative was not economically justified. Regardless, as this alternative was capable of achieving the level of protection desired by the local sponsor, and had potential to be combined in a multi-purpose configuration, it was carried forward as a component of a Locally Preferred Plan.

4.1.5 FLOOD CONTROL ALTERNATIVE 5: FLOODWALL PLAN

This alternative consists of constructing concrete floodwalls along the edges of the existing channel of Murrieta Creek from Winchester Road down to the southern end of Old Town Temecula. A wide range of alternative floodwall heights were evaluated in order to determine which height of floodwall would maximize benefits over costs. A total of 6 floodwall heights were evaluated, ranging from heights necessary to contain flows from a 25-year event to heights necessary to contain a 1000-year event. Based on analysis of various design levels, it was determined that wall heights ranging from 7.5 feet maximum/1 foot minimum to 19 feet maximum/1 foot minimum height (depending on location along the creek and the local surface contours) would control large flood events, but were economically infeasible. The floodwall concept was not supported by the local sponsor or residents of the watershed. It was, however, determined that a more limited floodwall might be economically feasible in concert with a channel widening effort, and was thus carried forward as a potential component of an NED plan. Construction of a floodwall would require a temporary construction easement of approximately 20 feet outside of the floodwall and a permanent maintenance easement of 12 feet inside (on the creek side) of the floodwall. These easements would all occur within the existing right of way owned by RCFC&WCD between Winchester Road and Rancho California Road. However, additional right-of-way would need to be purchased between Rancho California Road and the U.S.G.S. gage. Installation of a floodwall could result in excavation and disposal of up to 450,000 cubic yards of material. All of this material would be disposed of in the local disposal sites discussed in Section 4.1.2.

Because floodflows accommodated in the design of these floodwalls also exceed the flow capacity of Rancho California Road Bridge, additional modifications in the area of this bridge would be required. These modifications include a drop structure designed to lower the invert at the Rancho California Road Bridge, which would increase its flow capacity. This drop structure is described in Section 4.1.8 in the discussion of the channel widening alternative. In addition, as floodflows would still exceed capacity at Rancho California Road Bridge, for larger events, the design would allow the bridge to overtop. To prevent breakouts of floodwaters as they pass over the bridge, a temporary “gate”, or “stop log” would be installed at the ends of the bridge. This consists of a series of removable “boards” that slide into place within a permanent set of racks, and would only be used during large events, being removed when floodwaters recede. Temporary traffic impacts would be experienced when placing the anchors into Rancho California Road for the stop logs as well as when the stop log is actually erected during flood events. In addition to the above modifications, removal and reconstruction of the Main Street Bridge would be required. This is feature would not be necessary for smaller floods, and in fact, was determined to be unnecessary for a combination channel widening/floodwall concept.

Because the larger floodwalls were not found to be economically feasible, and are not supported by the local sponsor, this concept was dropped from further consideration. Despite this, as a small floodwall in limited areas might add an additional increment on a channel widening concept, the use of a small floodwall was retained as a possible element of a NED plan.

4.1.6 FLOOD CONTROL ALTERNATIVE 6: CHANNEL WIDENING PLAN

The existing channel of Murrieta Creek is largely incised into the surface of the floodplain. Therefore, additional channel capacity can be realized by enlarging the existing channel in order to accommodate larger flood events than can be currently carried. Because Murrieta Creek is a natural channel (i.e., both bed and banks are primarily comprised of natural soils), and is in a general "equilibrium" state in regards to inflow and outflow of sediment, there is no opportunity to excavate the channel below its existing grade without the channel refilling during each flood event and reducing the capacity to its "without-project" condition. Therefore, enlargement of the channel to accommodate larger flood events must be achieved through channel widening alone. This alternative would consist of enlarging by widening the creek to the maximum possible, as well as other less extensive options which would not reach the same capacity, but would require less real estate. The smaller channel widening options were developed while ensuring that encroachment on existing properties, particularly structures, was minimized. Although it was recognized that unlimited enlargement of the channel might eliminate the need for upstream detention, it was also recognized that added real estate costs associated with that plan might also prove to be economically infeasible. In addition, if an extensive widening plan proved to not be in the Federal interest, this plan would also not be supported as an LPP due to the fact that this plan would be forced to eliminate many of the very same structures it was formulated to protect. In more detailed analysis of the larger widening plans, it was recognized that this plan proved to have numerous significant impacts, including the potential removal of a large moderate-income apartment complex with its attendant parking facilities. Given that the costs of the larger plan appeared to exceed the benefits to be derived from it, and was not supported by the local sponsor, it was not investigated further. The smaller channel widening plans proved to be both cost-effective and supportable by the local sponsor, so were carried forward as potential components of both a NED Plan, and/or LP Plan.

The channel-widening plan, would consist of excavation of the side slopes of Murrieta Creek from Winchester Road downstream to the U.S.G.S. gage. The widening from Winchester Road to Rancho California Road would consist of widening within the current right-of-way owned by the RCFC&WCD. On the eastern side of the creek, widening would occur up to approximately 10 feet from the edge of the existing right-of-way in order to ensure sufficient area at the top of the creek sideslope for maintenance activities. This is to prevent the need to acquire construction and/or maintenance easements from adjacent landowners. On the western side of Murrieta Creek, widening would occur up to within approximately 50 feet of Diaz Road. This land could also be used to provide a bike and/or equestrian trail alongside the creek for recreational purposes. Sideslopes of the widened channel would be excavated to a 3:1 (H:V) slope. Between Rancho California Road and First Street, the channel would need to be widened right up to the edge of several privately owned properties and in some cases would require purchase of all or large portions of other properties. These land requirements are described in more detail in the Real Estate Appendix. Sideslopes right at Rancho California Road would be at a 3:1 (H:V) slope but would increase to a 0.5:1 slope within 800 feet downstream. Sideslopes in the steeper segment would be reinforced using gabbions. This high angle slope is necessary to maximize floodflow capacities in the downstream reaches. Downstream of First Street, the creek channel would be widened further. The 0.5:1 slope would gradually decrease to reach a 5:1 slope within 500 feet downstream.

A small drop structure would be located in Murrieta Creek 300 feet upstream of the Rancho California Road Bridge. This drop structure would lower the creek bed elevation by three (3) feet over a distance of ten (10) feet, resulting in a drop slope of just over 3:1 (H:V). The drop structure would consist of a grouted stone surface with grouted stone aprons on either side of the creek and a grouted stone surface extending for a distance of fifty (50) feet downstream. The purpose of this drop structure is to lower the creek bed at the Rancho California Bridge in order to increase the flow capacity at the bridge. As discussed earlier, Rancho California bridge currently has a limited flow capacity, only allowing a

maximum of approximately 19,000 cfs to pass beneath. The option of removing this bridge and rebuilding it was determined to be problematic due to the high costs associated with destruction of the old bridge and constructing a new one. Also, Rancho California Road across Murrieta Creek is a primary traffic artery for numerous businesses on the western side of the creek. Even a temporary closure of this bridge would result in significant adverse traffic impacts.

In order to maximize floodflow capacities for this alternative, and due to its extremely low floodflow carrying capacity, removal of the Main Street Bridge was determined to be necessary in any plan to increase carrying capacity. Raising the bridge to a new elevation proved to be infeasible due to the construction of the bridge. Therefore, the existing Main Street Bridge would need to be demolished and a new bridge of the same configuration constructed in its place. Once completed, the new bridge would be longer to accommodate the wider channel dimensions, and somewhat wider to meet existing bridge standards. Since the existing bridge was built in 1948, it does not meet current design and safety standards. The new bridge would meet all current standards for bridge design.

Excavation material from this widening would result in the generation and disposal of 1.1 million cubic yards of earth material. Analysis of local disposal sites in the area indicated that there is an existing capacity of 1.5 million cubic yards; all this earth material can be disposed of in these local sites.

The channel widening plan, for any level of protection examined, did not generate sufficient economic benefits to be justified. In addition, even with bridge replacement, a widening plan alone cannot accommodate floodflows generated during a 1% exceedance flood event, which is a requirement of the local sponsor. It was recognized, however, that this plan, with inclusion of a detention basin alternative, would provide a level of protection acceptable to the local sponsor, and was therefore carried forward as a potential element of a Locally Preferred Plan. It was also noted that with the addition of a limited floodwall on the west bank of the creek, this alternative did prove to be economically justified. This is discussed in greater detail as Alternative 7, below.

4.1.7 FLOOD CONTROL ALTERNATIVE 7: CHANNEL WIDENING WITH FLOODWALL PLAN

This alternative would consist of the channel widening discussed above and smaller floodwalls as necessary to accommodate a larger flood event. The principle difference between this alternative and the one described above would be the heights and locations of the floodwalls. Floodwalls were considered along all reaches of the Murrieta Creek from Winchester Road to the U.S.G.S. gage downstream of Old Town Temecula. Based on analysis of the various floodwall locations, it was determined that limited channel widening, as discussed above, in concert with floodwalls only on the western side of Murrieta Creek from Winchester Road to Rancho California Road were economically justifiable. Floodwalls along the eastern side of the creek were found not to be economically justifiable due a problem draining floodflows from Long Canyon Creek and Empire Creek into Murrieta Creek in such a way not to cause breakout in that area. Due to the volume of water in Long Canyon and Empire Creeks at the peak of their individual hydrographs, small storage basins outside the floodwalls would need to be constructed to capture these waters. Once peak flows would diminish, these waters would then need to be pumped into Murrieta Creek. Constructing of these small storage basins was determined to be cost prohibitive. Floodwalls on either side of Murrieta Creek downstream of Rancho California Road were also found to be economically unjustifiable due to the determination that costs of construction and maintenance of these walls exceeded the benefits to be gained through a reduction of flood inundation damages.

Floodwall heights between Winchester Road and Rancho California Road in this alternative were optimized through examining many different wall heights. As a result of this optimization process, it was determined that the floodwall which provided the greatest net benefits were 3.5 feet in height though the entire reach.

This alternative, in addition to the floodwall on the western side of Murrieta Creek from Rancho California Road to Winchester Road, would include the channel widening, a small drop structure, and the replacement of the Main Street Bridge, all described in previous sections.

With the inclusion of a small floodwall with the channel widening concept, bridge replacement, and drop structure, this plan possesses a positive benefit-cost ratio, and thus appeared to be economically justified. Although not supported as a "stand-alone" project by the local sponsor, primarily because of its inability to produce the desired level of protection, this plan was carried forward into the final array as a potential NED plan for flood control.

Upstream flood damage reduction alternatives were found to be infeasible, primarily on NED grounds.

SINGLE PURPOSE ECOSYSTEM RESTORATION ALTERNATIVES

4.2.1 NO-ACTION ECOSYSTEM RESTORATION ALTERNATIVE

The No-Action alternative, assuming a lack of active maintenance or enhancement of the environmental resources of the creek, would incur a net loss of functional capacities over the 50-year period of analysis. The baseline condition for all reaches analyzed has a functional capacity of 338.7 units. The "future without-project" condition for all reaches has a functional capacity of 326.6 units. The net loss of functional capacities would amount to 12.1 units over the period of analysis. This assumes that natural and human-induced forces would both cause destruction of resources at some level in the creek during the period of analysis, but that those losses would be minimal in comparison to the capacity that both exists and would exist in the "without-project" condition. Flood events, particularly large ones, which have a tendency in natural systems to cause large degrees of environmental damage, are often offset by the natural tendency of the system to reestablish vegetation, clear out sediment deposited, and regain environmental value during the remainder of the period of analysis. This would result in an overall balance of gain and loss in most areas. Another key assumption in this analysis is that whatever activities occur in the watershed, any deleterious effects to the channel system would be fully mitigated.

Details on the functional capacities of the various study reaches are contained in the restoration plan (Appendix VI-B).

4.2.2 ECOSYSTEM RESTORATION ALTERNATIVE A: TWO-CREEK RIPARIAN AREA

The objective of this alternative would be to create a natural riverine system on County-owned land beginning immediately upstream of Santa Gertrudis Creek and extending upstream past Warm Springs Creek to approximately Jefferson Ave. The alternative would include low-flow channels, natural backwaters and ponded areas, a transition zone from freshwater marsh to willow riparian habitat, and an upland buffer zone of mulefat scrub and/or coastal sage scrub. It

would also integrate a series of seasonal wetlands/ponds that provide additional habitat functions for herptefauna, fish, birds, mammals, and invertebrates. Santa Gertrudis Creek would not be incorporated in this alternative. The land on which this alternative would be constructed, other than that within the existing creekbed is currently separated from the creek by a small levee constructed from material dredged from the existing channel. The channel bed is minimally vegetated with emergent wetland vegetation. The upland area "outside" the levees is occupied by native and non-native grasses, disturbed mulefat scrub, graded and disked areas, and otherwise disturbed areas. The upland area would be excavated to that width necessary to reestablish a meandering stream course with backwater areas. The flood prone area would be expanded considerably from the existing condition. The excavated area would be lowered by approximately 10 feet to a depth generally matching that of the existing channel invert. Excavation would remove approximately 2,120,000 cubic yards of material to allow for restoration of a riverine ecosystem in this area. The site would be sloped to drain the area, particularly that of the area farther from the channel centerline at a rate slower than that of the existing invert, and with the surficial contouring, would provide areas of slow-moving water and ponding. Incorporation of the confluence of Warm Springs Creek would provide additional area for increasing in-channel habitat. Recontouring would create floodplain terraces to promote a natural succession within the riparian plant community. Nursery bars and benches next to the active channel would provide the means for seedling establishment. Benches would be gently sloped (4:1 to 6:1 slopes), averaging 30-40 feet in width. Farther from the centerline of the active channel, secondary benches would be established for species that prefer less frequent flooding, promoting more structurally diverse habitat. Natural flooding would be expected to scour and rejuvenate the habitat to encourage distribution of annuals, seedlings, and allow channel migration.

The on-line nature of this feature would receive channel inflow at all times that this would be available, from both Warm Springs and Murrieta Creek. This will increase infiltration compared to the existing condition. Channel embankments confining Warm Springs on both sides from its confluence, and Murrieta Creek on its east side, would be removed. Flows above that maintained in the low-flow channel(s) would have the opportunity to flood back channels and ponded areas. Approximately 109 acres of wetlands habitat would be created in this alternative. Initial contouring would create two low-flow channels, one on Murrieta Creek, and one on Warm Springs Creek. Average width of the channels would range between 10 and 15 feet, with an average depth of 3 feet. Low-flow channel beds would slope at 3:1 to 4:1 into the adjoining benches. Nine acres of freshwater ponds would be created which would receive flows at more frequent intervals, and also by groundwater infiltration. Water stored in these ponds would exfiltrate, draining through the surrounding soils during drier periods (periods of lower groundwater elevation). The two ponds would average 4.8 and 4.4 acres, with a maximum depth of 6 and 8 feet, respectively, with gradually sloped perimeters to facilitate establishment of hydrophytic vegetation.

An upland buffer would be created contiguous to the riparian zone to minimize effects of adjacent land use and create a more diverse ecotone. The buffer would be at a greater elevation to support more drought resistant species. The average width of the buffer would be 150 feet, encompassing an area of approximately 11 acres. Revegetation would be utilized to accelerate

and ensure native plant establishment. This will minimize the establishment of non-native species, such as salt cedar and arrundo donax. Revegetation will involve the use of pole cuttings, containerized plant materials, and native seed mixes. Further detail on revegetation is contained in the EIS/EIR.

Due to the widening of the channel, a control structure at the downstream end would be needed to ensure that flow would reenter the downstream channel. During the 12-month establishment period, irrigation would be maintained, as well as on-site maintenance efforts to prune trees, replace lost and damaged plants, apply fertilizer, apply soil amendments where needed, and prepare status/progress reports.

Estimated costs for this alternative are $21,980,000. Under the without-project condition, the area proposed for restoration has a functional capacity of 23 units. Under the with-project condition, this area would achieve a functional capacity of 367 units, for a project benefit of 344 units. The total average annual cost is $1,518,000. The unit cost per FCU is $63,900 for an average annual cost of $220,100 per FCU.

This alternative proved to be the next least costly alternative on the basis of cost per functional capacity unit (FCU), of all those examined. It was recognized, however, that this plan as a "stand-alone" plan, was not supported by the local sponsor, primarily due to the need by the local sponsor for a multi-purpose project at this site. Therefore, this plan was only carried forward as a component of the NER plan for ecosystem restoration. In addition, the concept plan was carried forward into the final array of alternatives as the basis for cost sharing by the Federal government, and as a conceptual component at this site in the Locally Preferred Plan.

4.2.3 ECOSYSTEM RESTORATION ALTERNATIVE B: THREE-CREEK RIPARIAN AREA

The objective of this alternative was also to create a natural riverine system on County-owned land extending from just downstream of the confluences of Murrieta and Santa Gertrudis Creeks upstream to approximately Jefferson Avenue. This alternative would encompass the downstream-most reaches of both Santa Gertrudis and Warm Springs Creeks. The alternative would include low-flow channels, natural backwaters and ponded areas, a transition zone from freshwater marsh to willow riparian habitat, and an upland buffer zone of mulefat scrub and/or coastal sage scrub. It would also integrate a series of seasonal wetlands/ponds that provide additional habitat functions for herptefauna, fish, birds, mammals, and invertebrates.

The land on which this alternative would be constructed is also currently separated from the creek by a levee that confines the creek during most flow conditions. The channel bed is minimally vegetated with emergent wetland vegetation. The upland area "outside" the levees is occupied by native and non-native grasses, disturbed mulefat scrub, graded and disked areas, and otherwise disturbed areas. The upland area would be excavated to the depth of the channel bed, and to that width necessary to reestablish a meandering stream course with backwater areas. Santa Gertrudis Creek is currently lined with concrete from the confluence upstream to past

Jefferson Avenue. The concrete would be removed in this alternative. The flood prone area would be expanded considerably from the existing condition. The excavated area would be lowered by approximately 10 feet to a depth generally matching that of the existing channel invert. Excavation would remove approximately 2,714,100 cubic yards of material to allow for restoration of a riverine ecosystem in this area. The site would be sloped to drain the area, particularly that of the area farther from the channel centerline (thalweg) at a rate slower than that of the existing invert, and with the surficial contouring, would provide areas of slow-moving water and ponding. Incorporation of the confluence of Warm Springs Creek would provide additional area for increasing in-channel habitat. Recontouring would create floodplain terraces to promote a natural succession within the riparian plant community. Nursery bars and benches next to the active channel would provide the means for seedling establishment. Benches would be gently sloped (4:1 to 6:1 slopes), averaging 30-40 feet in width. Farther from the centerline of the active channel, secondary benches would be established for species that prefer less frequent flooding, promoting more structurally diverse habitat. Natural flooding would be expected to scour and rejuvenate he habitat to encourage distribution of annuals, seedlings, and allow channel migration. The on-line nature of this feature would receive channel inflow at all times that this would be available, from both Warm Springs and Murrieta Creek. This will increase infiltration compared o the existing condition. Channel embankments confining Warm Springs on both sides from its confluence, and Murrieta Creek on its east side, would be removed. Flows above that maintained in the low-flow channel(s) would have the opportunity to flood back channels and ponded areas. Approximately 143 acres of wetlands habitat would be created in this alternative. Initial contouring would create two low-flow channels, one on Murrieta Creek, and one on Warm Springs Creek. Average width of the channels would range between 10 and 15 feet, with an average depth of 3 feet. Low-flow channel beds would slope at 3:1 to 4:1 into the adjoining benches. Nine acres of freshwater ponds would be created which would receive flows at more frequent intervals, and also by groundwater infiltration. Water stored in these ponds would exfiltrate, draining through the surrounding soils during drier periods (periods of lower groundwater elevation). The two ponds would average 4.8 and 4.4 acres, with a maximum depth of 6 and 8 feet, respectively, with gradually sloped perimeters to facilitate establishment of hydrophytic vegetation.

An upland buffer would be created contiguous to the riparian zone to minimize effects of adjacent land use and create a more diverse ecotone. The buffer would be at a greater elevation to support more drought resistant species.

Revegetation would be utilized to accelerate and ensure native plant establishment. This will minimize the establishment of non-native species, such as salt cedar and arrundo donax. Revegetation will involve the use of pole cuttings, containerized plant materials, and native seed. Further detail on revegetation is contained in the EIS/EIR.

During the 12-month establishment period, irrigation would be maintained, as well as on site maintenance efforts to prune trees, replace lost and damaged plants, apply fertilizer, apply soil amendments where needed, and prepare status/progress reports.

Estimated costs for this alternative are $33,196,800. Under the without-project condition, the area proposed for restoration has a functional capacity of 25 units. Under the with-project condition, this area would achieve a functional capacity of 480 units, for a project benefit of 455 units. The total average annual cost is $2,292,000. The unit cost per FCU is $73,000. The average annual cost per FCU is $252,000. This plan does not produce as effective a cost per functional capacity as the alternative discussed above, although it does produce the greatest increase in habitat of any of the alternatives analyzed. However, due to its higher cost, and potential interference with flood control use of this site, it is not supported by the local sponsor. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.4 ECOSYSTEM RESTORATION ALTERNATIVE C: SANTA GERTRUDIS CREEK CORRIDOR RESTORATION

This alternative would restore the reach of Santa Gertrudis Creek between its confluence with Murrieta Creek, upstream to Jefferson Avenue. Removal of the concrete side slopes and bed currently protecting the creek from erosive forces would allow reestablishment of a corridor between the headwaters area and lower portions of Murrieta Creek. The concrete lining would be demolished and disposed of off-site. Slopes would be lessened where possible, and scarified to promote vegetation establishment. Number of acres restored under this alternative is 9.

Estimated costs for this alternative are $2,039,000. Under the without-project condition, the area proposed for restoration has a functional capacity of 2 units. Under the with-project condition, this area would achieve a functional capacity of 12 units, for a project benefit of 10 units. The total average annual cost is $141,000. The unit cost per FCU is $204,000. The average annual unit cost per FCU is $704,000.

This plan produces the least increase in FCUs of any alternative examined, due to the high cost of the concrete removal and rehabilitation (as reflected in the number of functional capacities produced per dollar spent). In addition, due to its high cost, it is not supported by the local sponsor. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.5 ECOSYSTEM RESTORATION ALTERNATIVE D: EXOTIC SPECIES MANAGEMENT

This restoration measure would increase habitat value by active management of exotic species. The focus of this alternative would be on removal of exotics from the upper project reaches. Target species include, but are not limited to: giant reed, salt cedar, tree tobacco, cocklebur, and castor bean. These species tend to crowd out and replace more desirable native species that have higher resource value and provide better habitat to wildlife. These measures can be undertaken anywhere in the project area, and can be done in combination with any of the other measures. This measure might include a combination of chemical, biological and/or mechanical means to remove the exotic species.

The absolute locations of each target species are beyond the scope of this report, bit in general includes the channel area from Warm Springs Creek confluence upstream to Clinton Keith Road. Subsequent to weed eradication, all exotic plant materials will be disposed of off-site. The costs given for this alternative include equipment, supplies, field coordination, preparation of the access plan, and disposal fees. Approximately 129 acres would be treated and monitored, with a higher annual cost for years 1 and 2, and a lesser annual cost for years 3 through 10, for a total cost of $1,458,000.

Under the without-project condition, the area proposed for restoration has a functional capacity of 187 units. Under the with-project condition, this area would achieve a functional capacity of 203 units, for a project benefit of 16 units. The total average annual cost is $101,000. The unit cost per FC is $91,000, for an average annual cost of $336,000 per FC.

Although this plan does produce a valuable environmental benefit (as reflected in the number of functional capacities produced per dollar spent) when compared to the alternatives discussed above, it was not supported by the local sponsor, except as a potential mitigation measure. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.6 ECOSYSTEM RESTORATION ALTERNATIVE E: FLOODPLAIN RESTORATION FROM TENAJA TO CALLE DEL OSO ORO

This alternative would widen the flood prone area, enhance existing vegetation in the corridor, and lessen side slopes of the channel. The reach of channel in this alternative is approximately 6,075 feet long, and is located in and upstream of the City of Murrieta. This reach has historically been straightened, with meanders eliminated, and earthen berms installed. Channel widening in this reach would result in the creation of 1.19 acres of invert habitat. The new channel would have an average width of 40 feet for a length of 1150 feet. The lessened side slopes and wider invert would reduce potential for erosion, and increase habitat value and accessibility. In-channel contouring would create topographic features conducive to increased habitat diversity. Slowing of runoff due to creation of micro-topographic highs and lows would increase infiltration and enhance soil moisture. Softening of bank slopes will allow a toehold for vegetation. Once vegetated, the slopes would function as a buffer, and provide important wildlife habitat and water filtration for overland flow entering from upland areas. Approximately 36 acres of habitat would be restored in this alternative.

Estimated costs for this alternative are $4,627,000. Under the without-project condition, the area proposed for restoration has a functional capacity of 55 units. Under the with-project condition, this area would achieve a functional capacity of 100 units, for a project benefit of 45 units. The total average annual cost is $320,000. The unit cost per FCU is $103,000. The average annual cost per FCU is $355,000.

This plan does not produce as significant an environmental benefit (as reflected in the number of functional capacities produced per dollar spent) as the alternatives discussed above. In addition, due to its high cost and inability to be combined as an element of a multi-purpose

plan in this reach, it is not supported by the local sponsor. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.7 ECOSYSTEM RESTORATION ALTERNATIVE F: FLOODPLAIN RESTORATION FROM CALLE DEL OSO ORO TO UPSTREAM OF OXBOW

This alternative consists of restoring a more natural riparian system in the upstream portions of Murrieta Creek between Calle del Oso Oro upstream to the large oxbow feature (Station 535+85). The restoration would include a low-flow meandering channel, in-channel terraces, gently sloping banks and an upland buffer. This alternative would produce approximately 29 acres of restored habitat.

Estimated costs for this alternative are $282,000. Under the without-project condition, the area proposed for restoration has a functional capacity of 41 units. Under the with-project condition, this area would achieve a functional capacity of 52 units, for a project benefit of 11 units. The total average annual cost is $19,400. The unit cost per FCU is $25,600. The average annual cost per FCU is $97,000.

Although this alternative is the smallest of those analyzed, this plan produces the best unit cost to benefit (as reflected in the number of functional capacity units produced per dollar spent) of all the alternatives discussed above. As such, it was indicated as the first-added component of the NER plan. However, this alternative is sited in the reach of Murrieta Creek upstream of the project, in an area deemed by the resource agencies to be more suited to purchase and preservation than restoration. This area was identified as a mitigation site for the project, and is thus, not implementable. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.8 ECOSYSTEM RESTORATION ALTERNATIVE G: FLOODPLAIN RESTORATION FROM UPSTREAM OF OXBOW TO CLINTON KEITH ROAD

This alternative consists of restoring a more natural riparian system in the portion of Murrieta Creek between the oxbow at Station 535+85 to Clinton Keith Road.). The restoration would include a low-flow meandering channel, in-channel terraces, gently sloping banks and an upland buffer. This alternative would produce approximately 20 acres of restored habitat.

Estimated costs for this alternative are $3,519,100. Under the without-project condition, the area proposed for restoration has a functional capacity of 29 units. Under the with-project condition, this area would achieve a functional capacity of 67 units, for a project benefit of 38 units. The total average annual cost is $243,000. The unit cost per FCU is $92,600. The average annual cost per FCU is $304,000.

This plan does not produce as significant an environmental benefit (as reflected in the number of functional capacities produced per dollar spent) as the alternatives discussed above. In addition, due to its high cost and inability to be combined as an element of a multi-purpose plan in this reach, it is not supported by the local sponsor. Therefore, this alternative was not carried forward into the final array of alternatives.

4.2.9 ECOSYSTEM RESTORATION ALTERNATIVE H: FLOODPLAIN RESTORATION ALONG THE EAST BANK OF MURRIETA CREEK AT THE LOWER END OF OLD TOWN TEMECULA

This alternative consists of restoring a more natural riparian system in the portion of Murrieta Creek between Station 27+00 and Station 35+00 in the Old Town area of the City of Temecula. The restoration would include widening the channel, removing fill material, and re-contouring to create a natural riparian channel. The restored channel would widen the channel from an average of 160 feet to an average of 236 feet. With increased bank and terrace areas, the future width of habitat would increase considerably from the existing condition. This alternative would produce approximately 5 acres of restored habitat.

Estimated costs for this alternative are $1,348,000. Under the without-project condition, the area proposed for restoration has a functional capacity of 3 units. Under the with-project condition, this area would achieve a functional capacity of 16 units, for a project benefit of 13 units. The total average annual cost is $93,000. The unit cost per FCU is $104,000. The average annual cost per FCU is $232,500.

This plan does not produce as significant an environmental benefit (as reflected in the number of functional capacity units produced per dollar spent) as alternatives A and F discussed above. In addition, due to its cost and inability to be combined as an element of a multi-purpose plan in this reach, it is not supported by the local sponsor. Therefore, this alternative was not carried forward into the final array of alternatives.

Table 5.1-1
Project Benefits and Costs Flood Control Alternatives
(October 1999 price levels, in $1,000's)

	Flood Control Alt. 2	Flood Control Alt. 3	Flood Control Alt. 4a	Flood Control Alt. 4b	Flood Control Alt. 5	Flood Control Alt 6	Flood Control Alt 7
Reduction of Structure & Content Damages	**>$1,364.3**	**>1364.3**	**$1364.3**	**1,409.0**	**$1,280.0**	**$640.9**	**$1,106.7**
Bridge Replacement Benefit	**$112.3**	**$112.3**	**$112.3**	**$112.3**	**$112.3**	**$112.3**	**$112.3**
Other Benefits	$119.0	$119.0	$119.0	$119.0	$119.0	64.6	$81.0
Total Annual Benefits	>$1,595.6	>1,595.6	$1,595.6	$1,640.3	$1,511.3	$817.8	$1,298.0
Total Annual Cost	**$3,194.9**	**$2,335.0**	**$2,727.4**	**$2,488.2**	**$2,071.3**	**$1,064.5**	**$1,199**
Net Annual Benefits	**($1,599.3)**	**($739.4)**	**($1,131.8)**	**($847.9)**	**($560.0)**	**($246.7)**	**$94.3**
B/C Ratio	**.50**	**.68**	**.59**	**.66**	**.73**	**.77**	**1.1**

FCA Alt.2 Offline Detention Basin Multi-Compartments
FCA Alt 3 Offline Detention Basin Single Compartment
FCA Alt 4a On-line Three Creek
FCA Alt 4b On-line Two Creek
FCA Alt 5 500-year Floodwall
FCA Alt 6 Channel Widening
FCA Alt 7 Channel Widening and Floodwall

	Alt A	**Alt B**	**Alt C**	**Alt D**	**Alt E**	**Alt F**	Alt G	**Alt H**
Number of Acres Restored In Future	**109**	**143**	**9**	129	36	29	**20**	5
Projected Total Gain in Functional Capacities Units over 50 years	344	455	10	16	45	11	**38**	13
Projected Average Functional Capacity Units	**6.9**	**9.1**	.2	.3	.9	.2	**.8**	.4
Real Estate Costs ($)	$2,123.8	$5,523.4	$0	$870.0	$1,340.4	$139.4	**$600.8**	$700.0
Basin and Creek Construction Costs ($)	$5,572.4	$7,742.8	$900	$0	$217.8	$0	**$517.0**	$37.8
Revegetation Costs ($)	$8,458.6	$11,509.2	$624.0	$0	$1,907.0	$0	**$1,481.6**	$399.7
Monitoring, Irrigation, and Maintenance ($)	$2,264.8	$3,304.9	$167.1	$461.2	560.9	$113.7	**$403.8**	$131.0
All other Additional Costs (PED, S&A, and IDC) ($)	$3,560.8	$5,116.5	$347.7	$126.7	$601.2	$28.5	**$515.9**	$131.7
Total Costs ($)	$21,980.3	$33,196.8	$2,038.8	$1,457.9	$4,627.3	$281.6	**$3,519.1**	$1,347.5
Average Annual Cost ($)	$1,517.6	$2,292.0	$140.8	$100.7	$319.5	$19.4	**$243.0**	$93.0
Annual Cost OMRR&R ($)	$1.3	$1.3	$0	$0	$0	$0	**$0**	$0
Total Average Annual Costs ($)	$1,518.9	$2,293.3	$140.8	$100.7	$319.5	$19.4	**$243.0**	$93.0
Unit Cost Per RFCU ($)	$63.9	$73.0	203.9	91.1	$102.8	$25.6	**$92.6**	$103.7
Average Annual Cost per RFCU ($)	**$220.1**	**$252.0**	**$704.0**	**$335.7**	**$355.0**	**$97.0**	**$303.8**	**$232.5**

Table 5.2-1
Cost Effectiveness Analysis of Ecosystem Restoration Alternatives National Ecosystem restoration Account
(October 1999 price level, in $1,000's)

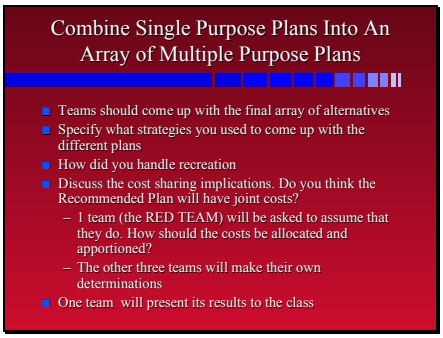
APPENDIX E-3

CLASS EXERCISE 3

MODULE MX – HANDS ON EXERCISE BASED ON MURRIETA CREEK, FLOOD CONTROL, ENVIRONMENTAL RESTORATION AND RECREATION, FINAL FEASIBILITY REPORT, AUGUST 2000

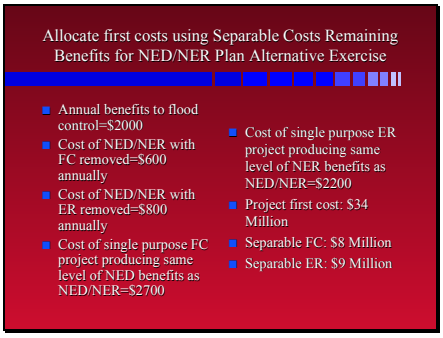
Slide 1

Slide 2



Slide 3

Slide 4



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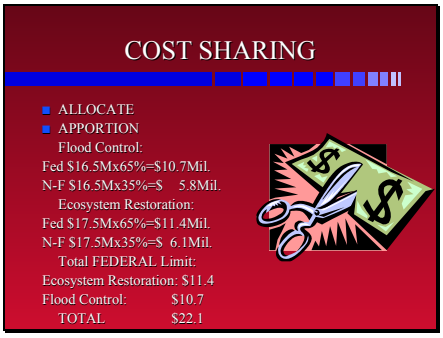
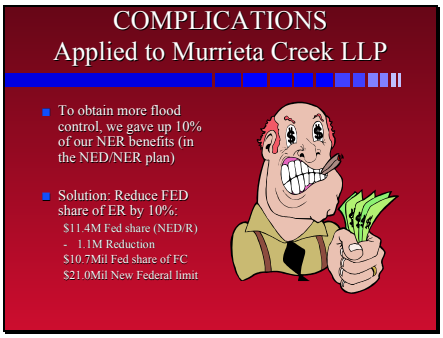
Slide 6

Slide 7



Slide 8



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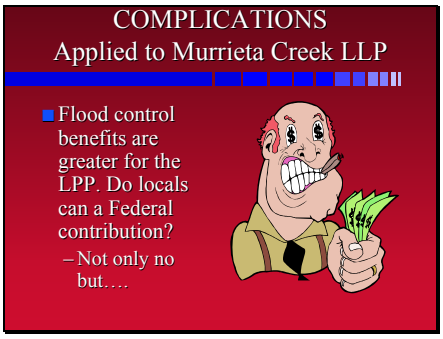


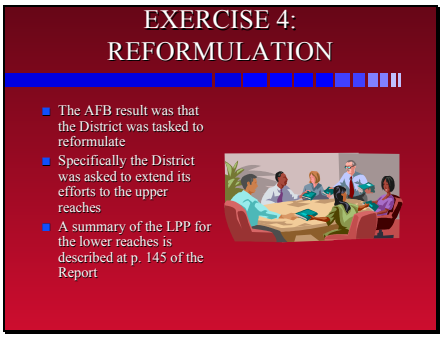
APPENDIX E-4

CLASS EXERCISE 4

MODULE MX – HANDS ON EXERCISE BASED ON MURRIETA CREEK, FLOOD CONTROL, ENVIRONMENTAL RESTORATION AND RECREATION, FINAL FEASIBILITY REPORT, AUGUST 2000

Slide 1

Slide 2



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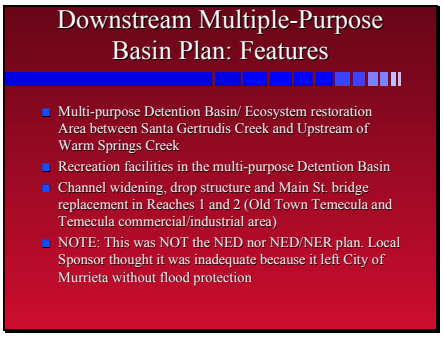


Slide 4

Assignment

- Reformulate to accommodate local sponsor concerns
- What other concerns are you going to consider?
- Don't forget the Planning Objectives and Constraints
- Don't forget the concept of Federal Interest
- Don't forget agency and stakeholder concerns
- We are looking for your approach here: your criteria

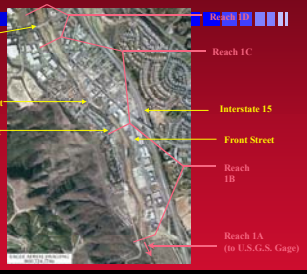
Slide 5

Mid Exercise Correction

- The Plan recommended by the District is described in the next 14 slides and at p. 149 of the Report
- It adds Upstream protection to the original Locally Preferred Plan and does not change the NED, NER nor NED/NER plan

Slide 6

Recommended Plan (Reach 1)



Slide 7

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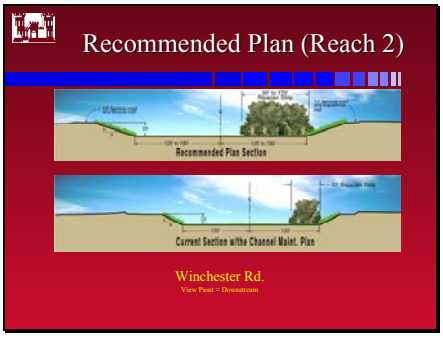
Slide 9

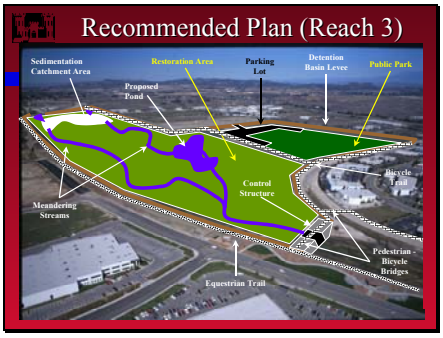
Slide 10



Slide 11

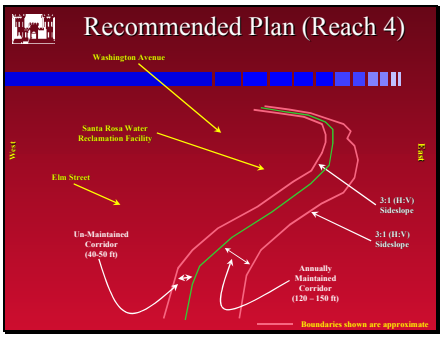
Slide 12

Slide 13



Slide 14

Slide 15



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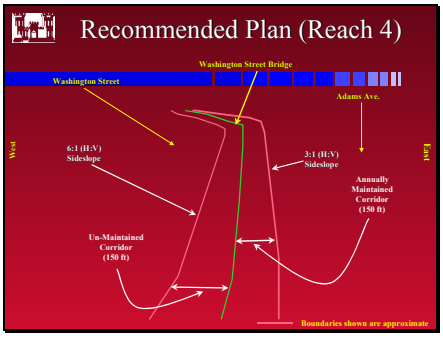

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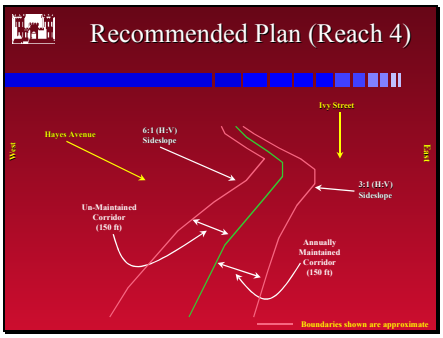

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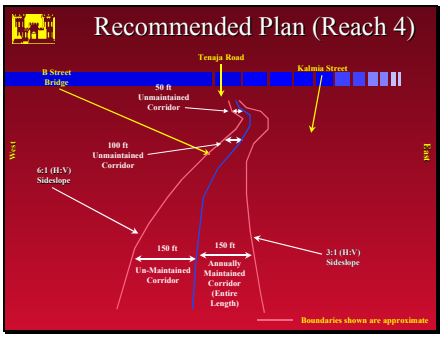

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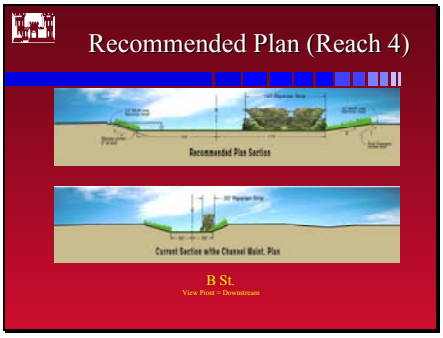
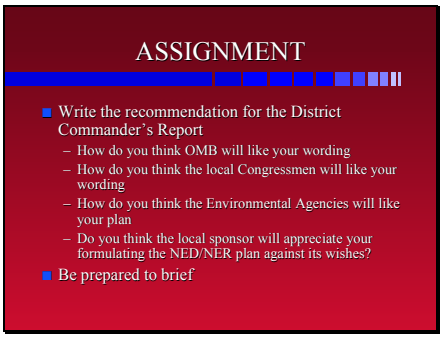


Slide 20

Costs of Recommended Plan

	Corps	Local	Total
Recommended Plan			
Downstream (Below Elm Street)	$23,330,000	$22,427,000	$45,757,000
Recreation Plan	$2,225,000	$2,225,000	$4,450,000
Upstream (Above Elm Street)	$0	$40,659,000	$40,659,000
Total Contribution	$25,555,000	$65,311,000	$90,866,000

Slide 21