



# Corps Risk Analysis Gateway Training Module

## Risk Management

Series:  
Corps Risk Analysis Online Training Modules

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## Introduction

This module was originally developed as a web-based training on the Corps Risk Analysis Gateway. The content has been modified to fit this format. Additional modules are available for download on the IWR website.

As noted throughout the Risk Analysis Gateway, there are three key tasks of risk analysis, including the following:

- Risk assessment: defining the nature of the risk, its probability, and the consequences, either quantitatively or qualitatively (or combination).
- Risk management: the actions taken to accept, assume, and manage risk.
- Risk communication: the multi-directional exchange of information to allow better understanding of the risk.

The purpose of this training module is to elaborate on the concepts and processes related to risk management.

After completing this module you will be able to do the following:

- Define and discuss risk.
- Discuss risk management concepts.
- Identify and discuss elements of the risk management model for the U.S. Army Corps of Engineers (USACE or the Corps).

You are encouraged to read through all of the examples provided in this module, which look at specific concepts in more depth.

This training is approximately one hour.

*This course includes a self-assessment; it's recommended that you be able to achieve 70% for successful course completion.*

## A BRIEF REVIEW

Risk is a measure of the probability and consequence of uncertain future events. The conceptual model of risk can be defined as the following:

$$\text{Risk} = \text{Probability} \times \text{Consequence}$$

If either element of the risk (i.e., the probability or the consequence) is zero, there essentially is no risk. In other words, if the probability of an event is very high, but there are no consequences, essentially there is no risk. Likewise, if the consequences are large, but there is no probability that they will occur, there is no risk.

The U.S. Army Corps of Engineers faces two broad categories of risk: risk of loss and risk of unrealized potential gains.

- **Risk of loss**

A risk of loss, also called a pure risk, could be a loss due to flood, storm damage, infrastructure failure, disruption of project services, bad weather, economic setbacks, or any sort of hazard. The losses could include loss of life, reductions in health and safety, property damage, or the loss of ecosystem services, transportation services, power and so on.

- **Unrealized potential gain**

The risk of an unrealized potential gain is called a speculative risk. Examples of potential gains that may not be realized include reductions in transportation cost savings, ecosystem restoration benefits, operation and maintenance efficiencies, an investment that did not produce the expected benefits, and other similar potential gains.

There are multiple dimensions to a risk that should concern to USACE. These include the following:

- **Existing and emerging risks:** current risks and risk that can reasonably be expected in the future. For example, the without-project (the condition of an area if USACE does not build a structure) expected annual damages (EAD) associated with an existing flood problem would serve as an existing risk, and estimates of EAD for the same floodplain in the future would serve as an emerging risk.
- **Risk reductions:** reductions in risk expected to result from risk management strategies; for example, the difference between with- and without-condition (with a USACE project, or without a USACE project) EAD estimates for a flood risk management (FRM) project would be a risk reduction exercise.
- **Residual risks:** risk remaining after risk management strategies are implemented; for example, the with-condition (with a USACE project) EAD associated with a FRM project would be a measurement of residual risk.
- **New risks:** creation of a risk that did not previously exist; for example, the construction of a levee brings into existence the risk of a levee failure, which would be considered a new risk.
- **Risk transformations:** any changes in the nature (i.e., consequence or probability) or source of the risk that results from a risk management strategy; for example, a levee

might transform a slow rising fluvial flood risk into a catastrophic overtopping event for flood flows in excess of the levee's capacity, transforming the nature of the risk.

- **Risk transfers:** any shifting of the burden of the risk from one group to another; for example, building a levee to protect development on the right river bank might induce additional flooding for development on the left river bank, transferring risk to another group.

## Chapter 1 - Why Risk Management?

### 1.0 WHY RISK MANAGEMENT?

The U.S. Army Corps of Engineers is a risk management organization. The Corps has been engaged in risk management since its beginnings. In its Civil Works program the Corps must manage risk over the entire life cycle of a project, from its conception during planning, through preconstruction engineering and design, construction, operation and maintenance, and the final disposition of the project. Managing risks means recognizing and addressing uncertainty to make better decisions under uncertain conditions.

Risk management is essentially making practical and effective decisions in uncertain circumstances. It requires planning, analyzing, organizing, implementing and monitoring efforts to control the effects of uncertainty. Therefore, risk management exists in all realms of the USACE's Civil Works Program.

USACE defines risk management in a white paper called *Transforming the Corps into a Risk Managing Organization*, as the following (Series: White\_Paper\_Transforming\_the\_Corps\_into\_a\_Risk\_Managing\_Organization\_Moser\_et\_al\_No v2007.pdf):<sup>[1]</sup>

*Risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The goal of risk management is scientifically sound, effective, efficient, integrated actions that reduce risks while taking into account economic, environmental, social, cultural, ethical, political and legal considerations.*

Within USACE, the desired characteristics of effective risk management include the following:

- **Universal applicability (horizontal and vertical)**  
Risk management should be practiced at all hierarchical levels of an organization.
- **Analytically-based and judgment-driven**  
Risk management is to be based on the best available objective evidence, but it is recognized that decision making will also require weighing of social preferences and values.
- **Simple and flexible**  
Risk management will be easy to understand and conduct, and it can be adapted to new or changing requirements.

- **Systematic and scalable**  
There is a specific methodology to do effective risk management; it has steps to be followed that are as applicable to one hour decisions as they are to multi-year analyses.
  - **Iterative**  
The risk management process is iterative, and as uncertainty is gradually reduced, it may be beneficial or even necessary to revisit and refine one or more steps in the process.
  - **Transparent and open**  
Risk management is to be conducted in such a way that it is easy for others to see what has been done and why. This process is open to stakeholders.
  - **Documented**  
The risk management process is to be documented in a fashion that is suitable to the communication needs of the process.
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[1] Moser, D., Bridges, T., Cone, S., Haimes, Y., Harper, B., Shabman, L. & Yoe, C. (2007 unpublished). *Transforming the Corps into a risk managing organization*.

## 1.1 EXPLORE – DEFINING RISK MANAGEMENT

Definitions for “risk management” are plentiful. The following are risk management definitions from various agencies:

**National Science Foundation:** “Risk management is the art and science of planning, assessing, and handling future events to avoid unfavorable impacts on project cost, schedule, or performance to the extent possible. The NSF also notes, “The undesirable alternative to risk management is crisis management.”<sup>[2]</sup>

**Center for Disease Control:** “Risk management planning is the practice of deciding and documenting how to conduct risk management activities such as risk identification, analysis, response planning, and monitoring, controlling and reporting.”<sup>[3]</sup>

**U.S. Environmental Protection Agency:** “Risk Management is the process which evaluates how to protect public health. Examples of risk management actions include deciding how much of a substance a company may discharge into a river; deciding which substances may be stored at a hazardous waste disposal facility; deciding to what extent a hazardous waste site must be cleaned up; setting permit levels for discharge, storage, or transport; establishing national ambient air quality standards; and determining allowable levels of contamination in drinking water.”<sup>[4]</sup>

**National Oceanic and Atmospheric Administration:** “Risk management focuses on the ability of the organization to meet objectives in the future by identifying risk and making decisions to manage these risks. Risk Management is a dynamic, ongoing assessment, decision-making and implementation process that is integrated with management activities.”<sup>[5]</sup>

**State of Washington, Office of Financial Management:** “Risk management is used to refer to the various practices an organization uses to manage risks.” This office views risk in terms of safety, liability, property, and regulatory liability.<sup>[6]</sup>

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[2] National Science Foundation. (2011). *Risk management guide for large facilities* (p. 3). Retrieved November 15, 2012 from [http://www.nsf.gov/bfa/lfo/docs/Risk\\_ManagementPartA.pdf](http://www.nsf.gov/bfa/lfo/docs/Risk_ManagementPartA.pdf)

[3] Center for Disease Control. (2006). *CDC unified process practices guide: risk management*. Retrieved November 15, 2012 from [http://www2.cdc.gov/cdcup/library/practices\\_guides/CDC\\_UP\\_Risk\\_Management\\_Practices\\_Guide.pdf](http://www2.cdc.gov/cdcup/library/practices_guides/CDC_UP_Risk_Management_Practices_Guide.pdf)



[4] U.S. Environmental Protection Agency. (No date). *Risk assessment home: basic information*. Retrieved November 15, 2012 from <http://www.epa.gov/risk#a1>

[5] National Oceanic & Atmospheric Administration/Safety and Environmental Compliance Office. (2005). *NOAA risk management*. Retrieved November 15, 2012 from [www.seco.noaa.gov/Safety/ORM/NOAA%20Risk%20Management%20Master.ppt](http://www.seco.noaa.gov/Safety/ORM/NOAA%20Risk%20Management%20Master.ppt)

[6] State of Washington, Office of Financial Management. *Risk management basics*. Retrieved November 15, 2012 from <http://des.wa.gov/sites/default/files/public/documents/RiskManagement/RiskManagementBasics.pdf>. page 2.

## Chapter 2 - Risk Management in USACE

### 2.0 RISK MANAGEMENT IN USACE

USACE has been managing risk for a long time, beginning well before risk analysis grew into prominence.

**Student Reflection:** Take two minutes and make a list of as many current USACE programs that have formal risk management as you can.

Risk management components can be found in a number of USACE programs. In the 1980s, USACE grappled with the problem of modernizing its approach to the major rehabilitation of existing **hydropower and inland navigation** projects. Efforts to objectively assess the reliability of the existing structures gave rise to the use of risk-based analytical techniques and analyses that supported decision-making. Thus, the major rehabilitation program was one of the first to intentionally adopt risk-based techniques and principles through its reliability analyses.

As another example, USACE began more managing the risks of cost estimates in water resources projects. Later, Section 2034 of the Water Resources Development Act of 2007 mandated a risk-based approach to project cost estimates which formally recognized and expanded some of USACE risk management efforts. Working through the USACE National Planning Centers of Expertise, all USACE Districts were initially required to use the Walla Walla District [Cost Engineering and Agency Technical Review Mandatory Center of Expertise](#) to perform cost engineering risk analyses on larger, highly complex and politically sensitive projects. As capability to conduct cost risk estimates continues to grow throughout USACE, more Districts are conducting their own cost risk assessments. These and other project related risks are now managed routinely as part of the project risk management function.

**New issues** continue to emerge and gain attention within USACE as risk management concerns. Climate change impacts on USACE's planning process are one example; risks associated with the introduction of aquatic nuisance species from one watershed to another are a second example.

#### Flood Risk Management Program

The [USACE Flood Risk Management Program](#) (FRMP) is a risk management program that works across the agency to focus the policies, programs and expertise of USACE toward reducing overall flood risk. This includes the appropriate use and resiliency of structures such as levees and floodwalls, as well as promoting alternatives when other approaches (e.g., land acquisition, flood proofing, etc.) reduce the risk of loss



of life, reduce long-term economic damages to the public and private sector, and improve the natural environment.

## Levee Safety Program

USACE uses the [Levee Safety Program](#) in order to better understand, manage, and reduce the flood risks associated with levees. The program focuses on the following tasks:

- Maintaining a national inventory of levee systems and making the information available in the National Levee Database.
- Inspecting and assessing about 2,500 levee systems nationwide, using the data to prioritize action.

Communicating risk-related issues and concerns, holding life safety as paramount in importance, and supporting USACE and local decisions aimed at reducing risk.



## Dam Safety Program

[USACE's Dam Safety Program](#) uses a risk-informed approach to manage its portfolio of 694 dams, with public safety as the number one priority. This robust risk-informed approach is a best practice adopted to develop balanced and informed assessments of the safety of our dams, and to evaluate, prioritize and justify dam safety decisions.

For risk management, USACE appointed Dam Safety Officers and Dam Safety Program Managers at all levels of the organization. District staff executes the program with corporately centralized prioritization, management and oversight by the senior officers at USACE's Division and Headquarter levels. USACE's laboratories and specialized field operating agencies provide technical support.

## Risk Management

The [Risk Management Center](#) (RMC) is a center of expertise under the [Institute for Water Resources](#) (IWR) for USACE. It was established in 2009 to improve management controls over infrastructure decisions, serve as an independent advisor to senior leadership, maintain and develop risk competencies, and ensure consistency in processes, application of criteria and decision-making.

The mission of the Risk Management Center is to support Civil Works by managing and assessing risks for dams and levee systems across USACE, to support dam and levee safety activities throughout USACE, and to develop policies, methods, tools, and systems to enhance those activities.

## Smart Planning

USACE's [SMART planning initiative](https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4), which aims to complete feasibility studies more quickly and cost effectively, requires the use of a risk register (<https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4>) as the primary risk management tool. Although the concept of a risk register has origins beyond the USACE, within the feasibility study process, the risk register is a tool for identifying and documenting the risks with associated with project alternatives, study outputs, and product outcomes. It allows the study team to address the uncertainty present in the feasibility planning process. Risks considered in the risk register include risks that occur in the study area (e.g., risks to life and property from floods), risks associated with project implementation (e.g., cost overruns, delays, and unanticipated implementation problems), and risks associated with the conduct of the feasibility study (failure to identify potential design problems, blown cost estimates, failure to identify the best plan).

### **SMART planning is:**

- **S:** Specific
- **M:** Measurable
- **A:** Attainable
- **R:** Risk Informed
- **T:** Timely

## EXPLORE – FEDERAL RISK MANAGEMENT AGENCIES

Risk management has become an increasingly important part of the work of many other Federal agencies. The websites of the following agencies illustrate the growing prominence of risk management in the Federal government.

U.S. Department of Agriculture, Risk Management Agency:  
<http://www.rma.usda.gov/>

U.S. Department of Commerce, Office of Program Evaluation and Risk Management:  
<http://www.osec.doc.gov/operm/>

National Oceanic & Atmospheric Administration, NOAA Risk Management:  
<http://www.seco.noaa.gov/>

U.S. Department of Education, Risk Management:  
[http://www2.ed.gov/about/offices/list/om/fs\\_po/fsa/risk-mgmt.html](http://www2.ed.gov/about/offices/list/om/fs_po/fsa/risk-mgmt.html)

U.S. Department of Energy:  
<https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-07/view;>

<http://energy.gov/oe/services/cybersecurity/cybersecurity-risk-management-process-rmp/risk-management-process-overview>

Department of the Interior, National Park Service:  
<http://www.nps.gov/orgs/1465/index.htm>

Department of the Interior, Bureau of Reclamation:  
<http://www.usbr.gov/ssle/damsafety/Risk/index.html>

U.S. Department of Transportation:  
<https://www.phmsa.dot.gov/hazmat-safety-enhancement-program/hazardous-materials-safety-enhancement-program-overview>  
<https://www.phmsa.dot.gov/safety-awareness/pipeline/safety-awareness-overview>

Federal Emergency Management Agency, Federal Insurance and Mitigation Administration:  
<https://www.fema.gov/what-mitigation/federal-insurance-mitigation-administration#4>

Federal Energy Regulatory Commission:  
<http://www.ferc.gov/industries/hydropower/safety/initiatives/risk-informed-decision-making.asp>

## 2.1 WHO ARE THE RISK MANAGERS IN USACE?

Can you name anyone in your office who is a risk manager? Where are risk managers found in USACE?

"Risk manager" is an increasingly common job title found in government agencies. It is not yet so common in USACE, but most managerial positions throughout the agency have some amount of responsibility for risk management. So, it is convenient to think of risk manager as one of the roles most managers assume as part of their job description. Thus, risk managers are found vertically and horizontally throughout the agency.

It is important to note that all the risk managers for a risk management activity are not always USACE personnel. There need to be many risk managers for some problem solutions. Who they are depends on who *owns* what part of the risk. For example, in a planning study the risk managers are found in USACE and among its planning partners and collaborators. In a construction project, risk managers are from USACE and its contractors. For operation and maintenance of a project, the local sponsor may be the risk manager. When citizens and industry have personal responsibility to respond to risky situations, as they do in floods, they act as risk managers too.

The USACE Flood Risk Management Program promotes the concept of "shared responsibility" (<http://www.iwr.usace.army.mil/Missions/FloodRiskManagement/FloodRiskManagementProgram/PartnersinSharedResponsibility.aspx>) for flood risk management. Effective

risk management is achieved when all stakeholders take action to reduce risk. The graph below shows an initial flood risk on the left and subsequent steps conceptually show how actions by different risk managers contribute to reducing (*buying down* or *driving down*) the risk.

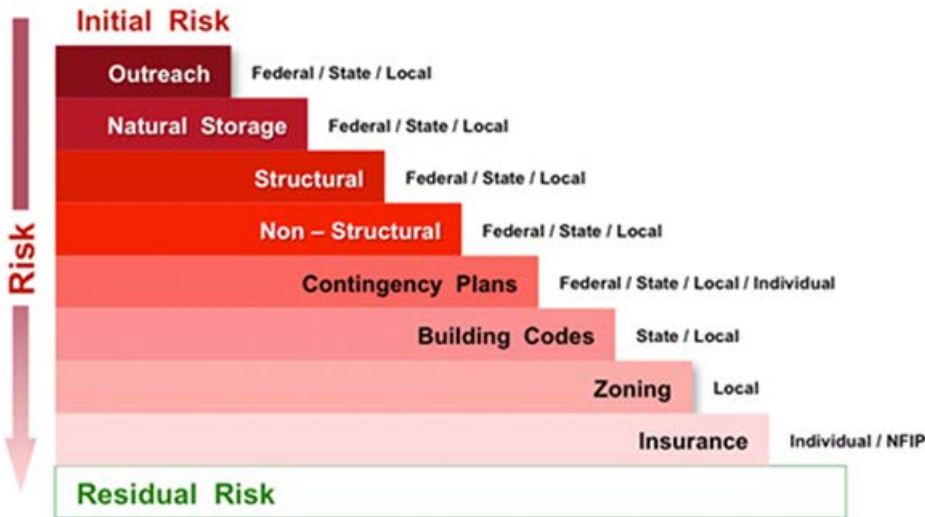


Figure 1. Shared responsibility for flood risk management.

Responsibility for flood risk management in the United States is a **shared responsibility** between multiple Federal, state, and local government agencies with a complex set of programs and authorities. Nationally, the U.S. Army Corps of Engineers (USACE), Federal Emergency Management Agency (FEMA), and many other Federal agencies, have programs to assist states and communities in reducing flood damages and promoting sound flood risk management

Local interests help manage risk through zoning regulations. States can proscribe building codes that reduce risk. Outreach efforts may be initiated by State and local governments or any number of non-governmental organizations. Evacuation plans can begin at the building manager level, but evacuation routes are likely to require State or local governments.

Individual property owners join the ranks of risk managers by buying flood insurance and taking steps to make their homes more flood resistant. One of the last *buy downs* comes in the form of a levee in this graphic. This is where USACE would join the growing circle of flood risk managers. Very importantly, this graphic also carries the message that some risk will remain no matter what measures are in place, demonstrating the way that residual risk is inevitable.

The Great Lakes and Mississippi River Interbasin Study (GLMRIS) (<http://glmris.anl.gov/>) is charged with preventing the spread of aquatic nuisance species from one basin to the other. It provides another excellent example of shared risk management responsibility. The Corps is

identifying alternatives the Federal government can implement as departments of the environment and natural resources of many states continue a multiplicity of efforts to control these risks. Private interests like the navigation industry (control of bilge water) and individual boating enthusiasts (hull scraping) and anglers (bait bucket management) must all be aligned in a singular effort to manage these risks.

## Chapter 3 - USACE Risk Management Model

### 3.0 USACE RISK MANAGEMENT MODEL

The following graphic is a generic model that describes how USACE manages risk. This model is an adaptation of the International Organization for Standardization's (ISO) risk management model.<sup>[7]</sup>

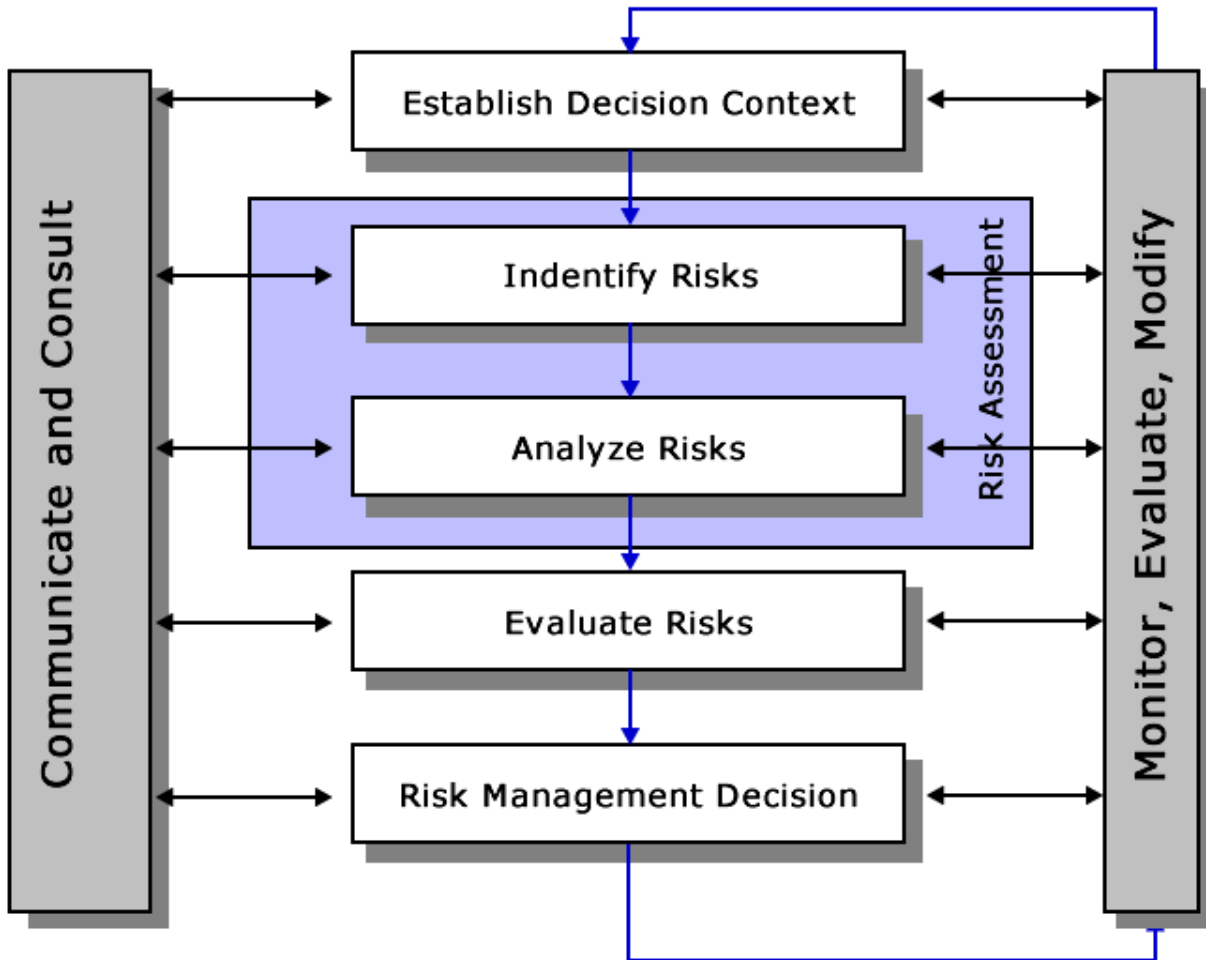


Figure 2. USACE Risk-informed decision making model

Risk management involves attempting to answer the following questions:<sup>[8]</sup>

- What is the problem?
- What information do we need to solve the problem? (i.e., what questions do we want risk assessment to answer?)
- What can be done to reduce the impact (consequence) of the risk?
- What can be done to reduce the likelihood (probability) of the risk?



- What are the tradeoffs of the available options?
- What is the best way to address the risk?
- (Once implemented) Is it working?

In order to answer these questions, USACE's risk management model identifies **five risk management tasks** and **two ongoing processes**. The tasks include the following:

1. Establish the decision context.
2. Identify risks.
3. Analyze risks.
4. Evaluate risks.
5. Risk management decision.

Decision making is the beginning and ending focus of the model. That decision making is especially challenging because it involves uncertainty. The ongoing processes of the model include the following:

1. Consultation, communication, and collaboration.
2. Verification, monitoring, evaluation, and modification.

Each of these seven elements is considered on the following pages.

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[7] International Organization for Standardization. *ISO 31000 – Risk management*. Retrieved November 15, 2012 from: <http://www.iso.org/iso/iso31000>

[8] Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty*. CRC Press: Boca Raton, FL., pg. 7.

### 3.1 CONSULT, COMMUNICATE AND COLLABORATE

At the beginning of any risk management activity, it is important to identify and engage the stakeholders who have an interest in the problem, opportunities, and potential outcomes. Getting input from stakeholders can potentially help reduce uncertainties in outcomes (e.g., how the public might react to a particular outcome). This process should be a critical component of all of the risk management analytical processes and activities.

Consultation with experts and interested parties, active risk communication, and appropriate levels of collaboration with agency partners and stakeholders are to be ongoing activities **throughout the risk management process**, as appropriate to the decision context. In some situations, this process will be wholly contained within USACE. An example might include risk management activities dealing with the allocation of budget resources within the District. In other situations there will be varying degrees of shared responsibility for conducting the risk management steps, the risk assessment, risk communication and decision making. The Great Lakes and Mississippi River Interbasin Study (GLMRIS) (<http://glmris.anl.gov/>) risk management effort involves multiple states and numerous stakeholders. The consultation, communication, and collaboration processes can vary markedly among different situations.

Key activities associated with this process may include the following:

- Identify a preliminary list of internal and external stakeholders.
- Prepare and execute a public involvement plan, including provisions for risk communication.
- Prepare and execute a formal agreement documenting the shared responsibility for this risk management process.
- Develop a standard operating procedures or memoranda of understanding for activities that do not involve a broader base of the public or stakeholders.

### 3.2 ESTABLISH DECISION CONTEXT

The risk management process begins by establishing the decision context: *What is the problem (or opportunity)? What do you want to know? What information is needed?* Essentially, this step should identify the questions to be answered during the rest of the risk management process, and these questions need to be understandable to all stakeholders involved in the process.

Documentation of every risk management activity is an important aspect of a transparent process. The outputs of this step include the following:

- A written problem and opportunity statement.

- A written statement of the risk management activity's objectives.
- A written list of all the unique decision information questions.
- A written list of the decision criteria.
- A written list of the key uncertainties.

## Decision Context

The primary elements of a decision context include the following:

- Define the management problem or opportunity.
- Identify the objectives.
- Request specific information needed to make a decision.
- Identify the decision criteria.
- Preliminary identification of the key decision uncertainties.
- Initiate consultation, communication, collaboration activities.

## Problem & Opportunity

Defining a problem or opportunity (substitute opportunity for problem below) consists of several specific tasks including the following:

- **Problem identification:** Recognizing a risk problem exists and understanding what it is.
- **Problem acceptance:** Deciding to focus attention and resources on the problem.
- **Problem representation:** Articulating the risk problem in an evidence-supported narrative for USACE and others while linking the problem to possible solutions.

For example, periodic damage-causing floods on an urban creek are a **problem**. Reconnecting the urban community with the natural ecosystem is an **opportunity**.

## Identifying Objectives

The next task is to identify what USACE would like to see happen and when. An objective is a clear statement of a desired outcome. **Objectives** define what success will look like. They are not specific options for solving problems or attaining opportunities. Reducing flood damages to residential properties is an **objective**. Raising structures and levees are risk management **options**. Examples of objectives include the following:

- Protecting human life, health and safety.
- Providing more reliable navigation services.
- Providing a more predictable flow of budget resources.
- Minimizing the costs of facility operations subject to an acceptable level of service.

A good objective is...

- **Specific:** It is clear and free from ambiguity.
- **Flexible:** It can be adapted to new or changing requirements.
- **Measurable:** Its achievement can be documented by some objective means.
- **Attainable:** It can be reached at the end of a course of action.
- **Congruent:** It is in harmony with other objectives
- **Acceptable:** It is welcome or pleasing to key stakeholders

A good objective is not...

- **An absolute target:** It does not specify a particular level of achievement.
- **Prescriptive:** It is not management options with a specific course of action.
- **Political:** It is not a government goal or objective.
- **Developing risk assessment tasks:** Developing a dose-response curve is not an objective.
- **Resource constraints:** It does not address time, money, or expertise.

The simple relationship between problems, opportunities and objectives should be such that when the objectives are realized, the problems are solved and the opportunities are realized.

## Decision Information

Part of establishing the decision context is the **identification of the specific kinds of information** that are necessary to achieve the objectives. This means asking staff the right questions. For well-established USACE programs, like flood risk management, inland navigation, reservoir reallocation, and the like, the information needs are long established and well known (e.g., estimating annual damages, how to conduct navigation analyses, etc.). However, consideration should be given to any unique information requirements for the problem context.

In unique situations, risk managers may have to be extremely specific about the information they need to make a decision. Identifying the information needs may require considerable original effort. The Great Lakes and Mississippi River Interbasin Study (GLMRIS) (<http://glmr.is.anl.gov/>) presented USACE with a unique problem: managing the risks associated with the establishment of aquatic nuisance species (ANS) in a new water basin. There were no prior studies to emulate. No one knew at first what kinds of information would be needed. As new and unique situations like this emerge, identifying data needs becomes a critically important part of the risk management process. What information do managers need to make a decision? They need to ask for what they need when the need is not otherwise obvious.

Examples of decision information questions might include are listed below:

- What is the District's dredging priorities?
- Which flood risk management measures will be most effective for this community?
- When should the engineering structure be rehabilitated?
- Which structures should we inspect first?
- Does the navigation channel need modification?
- Are there significant environmental impacts associated with this permit application?
- What is the community's current flood risk?
- What is our exposure to a construction cost overrun?
- What is the probability of a catastrophic loss of aquatic wildlife due to a marine casualty in the channel?
- What are the consequences of continued subsidence for the project's integrity?
- How much hard bottom is adjacent to the channel?
- What is the potential for improving this ecosystem?

## Decision Criteria & Uncertainty

Every risk management activity ultimately requires some mixture of balancing risks, costs, benefits and other social and political values. This means the nature of the relevant benefits, costs, and values, i.e., **the decision criteria**, must be explicitly identified early in the risk management process so appropriate information is gathered. For example, in flood risk management, decision criteria might include flood damage reductions, project costs or negative environmental consequences. With a navigation management activity, the decision criteria might include transportation cost savings, project costs, and negative environmental consequences. The decision criteria used to make decisions must be explicitly identified early in the risk management process so appropriate information is gathered.

As the decision context is determined, a preliminary decision can be made as to what information already exists and what information is still needed. Information needs are uncertainties at this point in the activity. Some will be successfully reduced during the analysis while others will not.

In fact, new information needs and uncertainties may arise as the activity progresses. The uncertainties are the greatest potential concern for decision making. That is, those uncertainties that can influence risk management outcomes and decision making need to be identified by decision makers and analysts at the earliest possible point in the process. See the **Uncertainty module** of the *Risk Analysis Gateway* for further information.

## EXPLORE – PROBLEMS AND OPPORTUNITIES

### Example: Problems and Opportunities <sup>[9]</sup>

#### Problems

- Loss of fish habitat due to urbanization
- Flood damages in the industrial section of Central City
- Stream bank erosion along Campus Park
- Saltwater intrusion in the estuary
- Loss of coastal wetlands

#### Opportunities

- Increase wildlife habitat along Campus Park
- Restore indigenous fish species in upper basin
- Provide increased recreational opportunities along the waterfront

## EXPLORE – STUDENT ACTIVITY – PROBLEM OR OPPORTUNITY

**Student Activity:** Indicate whether each of the following is a problem or an opportunity.

- Navigation causes adverse environmental impacts at Ft. Sumter, Crab Bank, Castle Pinckney, Folly Beach.
- Current dimensions of Charleston Harbor do not meet the needs of the current and near future fleet serving the East Coast.
- Container port capacity of the Nation is limited.
- Handle fully loaded Super Post Panamax vessels.
- Reduce the cost of international imports and exports.
- Beneficial uses of dredged material.

## Explore – Student Activity – Problem or Opportunity - ANSWERS

- Navigation causes adverse environmental impacts at Ft. Sumter, Crab Bank, Castle Pinckney, Folly Beach. **PROBLEM**
  - Current dimensions of Charleston Harbor do not meet the needs of the current and near future fleet serving the East Coast. **PROBLEM**
  - Container port capacity of the Nation is limited. **PROBLEM**
  - Handle fully loaded Super Post Panamax vessels. **OPPORTUNITY**
  - Reduce the cost of international imports and exports. **OPPORTUNITY**
  - Beneficial uses of dredged material. **OPPORTUNITY**
- 

[9] Source: Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty*. CRC Press: Boca Raton, FL.

### 3.3 IDENTIFY RISKS

The essence of risk management is recognizing and understanding the risks. This is the initial step in a risk assessment; more detailed guidance on the risk assessment steps (i.e., identifying risk and analyzing risks) can be found in another training module on the *Risk Analysis Gateway*. The primary elements of this step include the following:

- Identifying risk.
- Developing a risk profile.
- Deciding whether to complete a detailed risk assessment or not.

**Risk identification** is the process of finding, recognizing and describing risks. Informally, this is done by asking and answering the questions, “*What can go wrong?*” and “*How can it happen?*” At this stage in the process, the relevant risk consequences (positive or negative) and their likelihoods should be identified, but not yet quantified. Examples include the following:

- Asian carp could become established in the Great Lakes.
- Floods from Richards Creek could take lives and destroy property.
- Channel deepening may not induce more cargo to move through Edith Grove Harbor.

A **risk profile** is a description of what is currently known about the identified risks, and can be considered the equivalent of a scoping process for risks. The profile clearly identifies what is and what is not known about the identified risks.

Managers will use the profile to decide whether a detailed **risk assessment** is needed or not. There will be times when the risk profile provides the risk manager with all the information needed to make a decision. In that case, a risk assessment is not needed. However, if there is insufficient information about the risk(s) that is readily available, a formal effort to provide that information must be undertaken in a risk assessment, which may be qualitative or quantitative.

USACE has developed a **risk register** (<https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4>) template for use in feasibility studies. The initial risk profile (i.e., what is known about the risk and their causes, and the consequences of that risk) can be documented in the risk register. The risk register can be updated and populated as one works through the decision making model of a planning feasibility study.

The outputs of this step include the following:

- A narrative description of the risks identified.
- A completed risk profile.
- A decision whether or not to pursue a risk assessment.



## EXPLORE – RISK PROFILES

**Question:** Make a list of three things you might expect to find in a risk profile. Then check your list against the list below.

## Explore – Risk Profiles - ANSWERS

### **Answer: Information you might find in a risk profile...**

- The most recent problem statement.
- A description of the hazard or opportunity involved.
- How assets are exposed to the hazard.
- Frequency, distribution and levels of occurrence of the hazard.
- Identification of possible risks.
- Nature of values at risk (human health, economic, cultural, etc.).
- Distribution of the risk and benefits from the risky activity.
- Characteristics of available risk management options.
- Current risk management practices relevant to the issue.
- Public perceptions of the potential risks.
- Information about possible risk management (control) measures.
- Preliminary identification of important scientific data gaps that may prevent or limit a risk assessment.
- International implications of risk management.
- Risk management objectives.
- Decision to pursue a risk assessment.
- Questions to be answered by a detailed risk assessment.

### 3.4 ANALYZE RISKS

The essence of a **risk assessment** is the analysis of the risks. The primary elements of this step include the following:

- Completing a risk assessment.
- Characterizing each risk.
- Providing answers to the risk managers' questions.
- Characterizing the decision critical significance of relevant uncertainties.

In the most basic form, this step of the risk assessment answers the following questions:

1. What are the consequences of the risk?
2. How likely is it that the risk will happen?<sup>[10]</sup>

If the risk profile does not provide sufficient information to make a decision, then this step will be used to complete the risk assessment. The **risk assessment characterizes the consequences and likelihood of the risks** identified in the preceding step. Any uncertainty that attends those answers is characterized here. Most of the data gathering and analysis are completed in this step.

This step is used to complete the risk assessment when one is needed for making a decision. Risk assessments may be **qualitative, quantitative, or some mix of the two**. A completed assessment will present a characterization for each identified risk. The risk characterization includes the following:

- **One or more estimates of each risk:** This includes estimates of the magnitude of the adverse effects and/or potential gains as well as their likelihoods. These estimates must also identify and characterize the most significant uncertainties. Quantitative estimates are numerical in nature, while qualitative estimates are narrative. Expected annual damages (EAD) estimates are an example of a risk estimate. There can be many estimates for a single risk.
- **A risk description:** This is a narrative that bounds and defines a risk for decision making purposes. This would be the paragraph(s) that put an EAD estimate in context by describing the numbers and types of flooded buildings, the depth and frequency of flooding, and the like.
- **Estimate changes in risk attributable to the management options:** This would involve comparing estimates of risk based on having, or not having a risk management option. The estimate may not be accurate in the first iteration of this step. Reductions in EAD attributable to channel improvements or levees would be examples.

All the information requested in the decision context step that is directly related to risk decision making is gathered and analyzed in this task. When this task is completed, the bulk of the analytical work is done, and the nature and extent of the remaining uncertainty should become

clearer. Decision makers need to be fully informed about what is known and what is not known about the decision problem. A comprehensive list of relevant sources of uncertainty should be prepared.

As noted previously, the USACE **risk register** (<https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4>) identified in the previous step can be used to summarize the outputs of the risk assessment in feasibility planning studies.

The suggested outputs of this step include the following:

- A completed risk assessment, if required.
- A characterization of each significant risk with a focus on relevant remaining uncertainties.
- Written answers to the risk managers' questions with a focus on the decision critical significance of relevant uncertainties.

Most risk assessments will be completed as an integral part of a larger decision making process. For example, it is part of feasibility planning, construction management, the budget process, cost estimation, and the like. More rarely, it will be necessary to complete a more detailed risk assessment. A few examples follow, but relatively few of these have been completed by USACE to date.

Some examples of risk assessments include the following:

- Risk assessments were conducted as part of the *Great Lakes and Mississippi River Interbasin Study* (GLMRIS (<http://glmris.anl.gov/>)). Only Interim Products (<http://glmris.anl.gov/documents/interim/index.cfm>) have been released at this time.
- *Overview of Risk Assessments Methods for Levee Systems*. Retrieved February 1, 2013.

Risk assessments done by other government agencies may be found at:

- Food Safety Inspection Service of the U.S. Department of Agriculture (<http://www.fsis.usda.gov/wps/portal/fsis/topics/science/risk-assessments/risk-assessments>)
- Center for Food Safety and Applied Nutrition, U.S. Department of Health and Human Services (<http://www.fda.gov/Food/FoodScienceResearch/RiskSafetyAssessment/default.htm>)
- U.S. Environmental Protection Agency (<http://www.epa.gov/risk#g>)

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[10] Source: Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty*. CRC Press: Boca Raton, FL. Page 7.

### 3.5 EVALUATE RISKS

Once the risks have been assessed, the emphasis in risk analysis shifts back to deliberation, discernment, and decision making. The primary elements of the risk evaluation step include the following:

- Judging whether or not the risks are acceptable to the decision makers and/or to the affected stakeholders.
- Formulating risk management options for unacceptable risks.
- Evaluating risk management options to determine which solutions are viable.
- An adaptive management strategy when warranted.

The suggested outputs of this step include the following:

- Deciding whether or not each identified risk is acceptable.
- Formulating alternative risk management options to address each risk that is not acceptable.
- Evaluating each alternative risk management option to determine whether or not it is a viable solution.
- Including an adaptive management strategy in the risk management option when warranted.

#### Determine Acceptable Risks

The **first evaluation decision** after the risk assessment is completed is to determine whether the characterized risks are acceptable or not. Unacceptable risks must be managed to an acceptable level, if possible, and to a tolerable level if not. To do so, alternative risk management options must be formulated.

The **second evaluation decision** involves identifying which of the multiple risk management options formulated is a viable solution. Both these evaluation decisions require consideration of the risks, risk management objectives, and decision criteria previously identified.

Each identified existing risk is evaluated in light of the risk management objectives, decision criteria and other relevant social values to determine whether it is acceptable or not. The risk characterization developed in the previous step provides the basis for this evaluation. A risk is acceptable, tolerable, or unacceptable. Acceptable risks require no further management. Unacceptable risks must be managed and tolerable risks can either be further managed or left as is. Communicating tolerable risks is explored further in the **Risk Communication** module.

## Risk Management Options

When the existing or future risk is not acceptable it may be appropriate to formulate risk management options to manage the risk further. The available risk management options vary for risk reduction and risk taking.

**Risk taking** means to take an action and accept the risk that the opportunities will not be fully realized.

**Risk creation** involves bringing opportunities that did not previously exist into being (dredging a navigation channel where one did not exist).

**Risk enhancement** means taking measures to increase the likelihood of desired outcomes (making the channel deep).

**Risk exploitation** options increase the desired consequences, i.e., increase the potential gains (make the channel wide to avoid marine casualties).

**Risk sharing** requires partners in the risk taking activities (cost sharing).

**Risk ignoring** is refusing to take any risks where the gain is speculative (the do nothing option).

**Risk reduction** means to take an action to lessen a potential loss.

**Risk avoidance** options eliminate the risk by avoiding it all together. If the dam is not built there is no risk of dam failure.

**Risk prevention** options reduce the likelihood of the risk (reservoirs reduce flood risk probabilities).

**Risk mitigation** options reduce the consequence of the risk (levees reduce flood risk consequences).

**Risk transfers** outsource or insure management of the risk (as flood insurance transfers flood risk).

**Risk retention** means managers accept and budget for the risk.

**Risk management options** are formulated in this step if they have not been identified earlier in the risk management process. Once a risk is found to be unacceptable, risk management options that will meet the risk management objectives should be identified and formulated in an attempt to solve the problems and attain the opportunities identified in the decision context.

Ideally, multiple risk management measures will be formulated for each risk identified. Measures can then be combined to create risk management options or plans that treat the whole of the decision problem. Once the risk management options have been formulated they need to be evaluated. This is done by estimating the effects of each risk management option on the relevant risk metrics, risk management objectives and the decision criteria identified in the first step using a comparison of without and with risk management scenarios.

## Residual Risk

**Residual risk**, the risk remaining after a risk management option is implemented, must receive special attention in the evaluation. If the residual risk is not acceptable or tolerable, additional risk management features need to be developed by USACE or other risk managers with the ability to enact the measures USACE cannot. In a similar fashion, risks transferred to other parties need to be explicitly identified and the affected parties engaged in the evaluation process. Transformed risks should, likewise, not be overlooked.

## Uncertainty

**Uncertainty** is presumed to be a major factor in every risk management activity. It is essential that risk managers and other decision makers be effectively informed about the nature and identity of key uncertainties as well as their effects on decision making outcomes. This information should include a description of the possible range of critical decision variables, the assessor's level of confidence in the various metrics to be considered in the decision making, and any options that might be effective in further reducing uncertainty.

The risk management options are evaluated by examining and weighing differences in risk and other important social values attributable to the risk management options. Evaluation is restricted to a single option at a time. The outcome of this evaluation process is to judge each option as a viable solution or a non-viable solution. All viable options are later compared to one another in the final risk management step.

Because both the risk and the efficacy associated with a risk management option are uncertain, it may not be possible to formulate risk management options that ensure successful management of the risk in the future. When the uncertainty is especially troublesome for decision making it may make sense to formulate plans that incorporate adaptive management strategies.

## EXPLORE – TOLERABLE RISKS

Acceptable risks and tolerable risks are not the same thing. An **acceptable** risk is one that can be accepted *as is* without major impacts. Acceptable risks are often negligible; when they are not, the benefits are large enough to make the non-negligible risk acceptable. Acceptable risks are not managed explicitly. An acceptable **opportunity risk** is one with a sufficiently large positive consequence to warrant the acceptance of the chance that those gains will not be realized. Alternatively, an acceptable opportunity risk might also include those risks that can also be a risk with a sufficiently low chance of the desired benefits not being obtained

A **tolerable risk** is considered as having more potential risks than risks that are widely acceptable. A tolerable level of risk is one which is grudgingly accepted in order to secure certain benefits. It is not a negligible risk or something that should be ignored. A tolerable risk is to be monitored, kept from increasing and reduced further if possible.

An **unacceptable risk** may be reduced to a tolerable level, but not an acceptable level. This may be because the technological means to reduce it further do not exist or the costs of doing so would outweigh the benefits of further risk reduction.

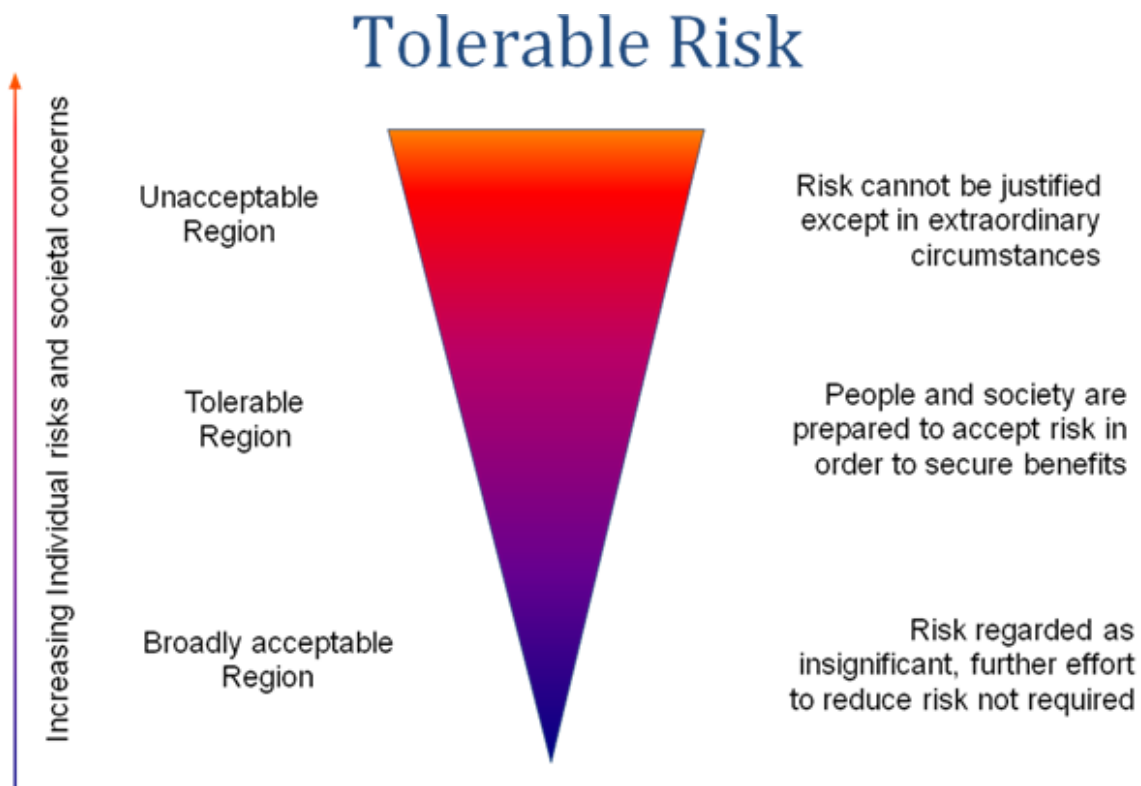


Figure 3. Levels of intolerable risk



### 3.6 RISK MANAGEMENT DECISION

When the risk management options are reduced to a set of viable options, it is time for decision making. The primary elements of the risk management decision step include the following:

- A comparison of the viable options and selection of the best risk management option.
- The identification of measurable desired outcomes to monitor the option's efficacy.
- An adaptive management plan, when appropriate.
- An implementation plan.
- An implemented risk management option.

All viable options must be compared to one another in order to identify the best available option. Comparing risk management options highlights the trade-offs among competing objectives, such as residual risk and cost. Balancing trade-offs in either an informal or a formal process is very often the essence of risk management decision making. To ensure the selected risk management option is grounded in the best available evidence, uncertainty must be explicitly considered while comparing risk management options.

The choice of a risk management option is equivalent to establishing a tolerable level of risk. Because there is almost always unresolved uncertainty attending a decision, one or more desired and measurable outcomes of the risk management strategy must be identified. These outcomes provide the foundation for monitoring the success of the decision. The roles and responsibilities of everyone involved in managing the identified risk(s) must also be specified. There may be significant uncertainty in the analysis that could influence the formulation of the eventual risk management solution. The risk management strategy will include an adaptive management plan to reduce such uncertainties over time and, as needed, to modify the execution of the actions taken.

Once a risk management option is chosen, an implementation plan should be developed. The risk management strategy must, of course, be implemented, ideally by those best equipped to manage the risk. Risk management responsibility in practice is often shared by USACE and its stakeholders. An implementation plan needs to be explicitly developed so that all risk management roles and responsibilities are clearly defined. When uncertainties are great, the plan should include adaptive management strategies as appropriate.

The outputs of this step include the following:

- Comparison of the pros and cons of all viable solutions that includes consideration of the relevant uncertainties.
- Selection of the best risk management option.
- Identification of a measurable desired outcome to monitor the option's efficacy.
- Development of an adaptive management plan when appropriate.

- Development of an implementation plan.
- Implementation of a risk management option.

### 3.7 VERIFY, MONITOR, EVALUATE, MODIFY

There are several purposes of post implementation monitoring. One is to **verify** that the risk management option has been implemented as intended and that all parties with a responsible risk management role are doing what they are required to do.

Another is to collect targeted data to ensure **progress** is being made toward achieving the desired outcomes of the implemented risk management strategy. A related purpose might include collecting targeted data to test hypotheses required to reduce analytical uncertainties identified in the initial risk management process when an adaptive management process is needed.

A third purpose is to scan the overall setting for the activity to **identify opportunities, hazards or changes** in socioeconomic preferences or conditions that may not have been recognized during the initial risk analysis process, or that may have changed in their significance. Monitored data will be evaluated on a regular basis and the risk management strategy may be modified in accordance with what is learned.

Verification ensures a risk management option is being properly implemented. Monitoring the measurable outcome(s) identified in the preceding step ensures the desired risk reductions are being obtained. If the desired gains have not been realized, managers must decide whether a change is in order to help them be realized, or the activity could be abandoned or deauthorized. If the residual risk is greater than expected, a decision must be made as to whether to tolerate the residual risk or to reiterate the risk management process to further lower the risk.

The suggested outputs of this step include the following:

- Development of a plan for verifying, monitoring, reviewing and modifying the implemented solution.
- Implementation of that plan.

## Chapter 4 - Summary and Conclusions

### 4.0 SUMMARY AND CONCLUSIONS

Risk management is one of the three essential tasks of risk analysis. Risk management involves attempting to answer the following questions:<sup>[11]</sup>

- What is the problem?
- What information do we need to solve it? (i.e., what questions do we want risk assessment to answer?)
- What can be done to reduce the impact (consequence) of the risk?
- What can be done to reduce the likelihood (probability) of the risk?
- What are the tradeoffs of the available options?
- What is the best way to address the risk?
- (Once implemented) Is it working?

The USACE model focuses on five key tasks and two ongoing processes. These include the following:

- Establish the decision context.
- Identify risks.
- Analyze risks.
- Evaluate risks.
- Risk management decision.
- Consultation, communication, and collaboration.
- Verification, monitoring, evaluation, and modification.

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[11] Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty*. CRC Press: Boca Raton, FL., pg. 7.

## Chapter 5 - Resources

### 5.0 RESOURCES

**USACE programmatic resources are listed below:**

Conflict Resolution & Public Participation Center of Expertise and Directory of Expertise  
(<http://www.iwr.usace.army.mil/About/TechnicalCenters/CPCXConflictResolutionPublicParticipation.aspx>)

Dam Safety Program  
(<http://www.usace.army.mil/Missions/CivilWorks/DamSafetyProgram.aspx>)

Flood Risk Management Program (<http://www.nfrmp.us/>)

National Levee Safety Program  
(<http://www.usace.army.mil/Missions/CivilWorks/LeveeSafetyProgram.aspx>)

Risk Management Center  
(<http://www.iwr.usace.army.mil/About/TechnicalCenters/RMCRiskManagementCenter.aspx>)

**Other website resources include the following:**

Collaborative Planning Toolkit  
(<http://www.sharedvisionplanning.us/CPToolkit/Default.asp>): USACE, Institute for Water Resources website for information about processes, tools, and techniques for collaborative planning (i.e., to be used in the consultation, communication, and collaboration process).

Risk Register (<https://planning.erd.c.dren.mil/toolbox/smart.cfm?Section=8&Part=4>): USACE spreadsheet tool for documenting risks association with the study outputs and project outcomes.

Risk Register webinar  
(<https://planning.erd.c.dren.mil/toolbox/webinars/risk%20register%20for%20smart%20planning.htm>): provides an introduction to the Risk Register tool.

Shared Vision Planning (<http://www.sharedvisionplanning.us/>): USACE, Institute for Water Resources website for information about collaborative planning processes (i.e., to be used in the consultation, communication, and collaboration process).

Society for Risk Analysis (<http://www.sra.org/index.php>): the Society for Risk Analysis is a multidisciplinary, interdisciplinary, scholarly, international society that provides an open forum for all those who are interested in risk analysis.

**Reference materials:**

Bridges, T. (ND). *Risk-informed decision making*. U.S. Army Engineer Research and Development Center. Retrieved December 5, 2012 from [https://dots.el.erdc.dren.mil/workshops/08apr-doer/3\\_Risk%20Mgmt\\_Bridges.pdf](https://dots.el.erdc.dren.mil/workshops/08apr-doer/3_Risk%20Mgmt_Bridges.pdf).

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U.S. Environmental Protection Agency. (2000). *Risk characterization handbook*. Retrieved December 8, 2012 from <http://www.epa.gov/spc/pdfs/rchandbk.pdf>

Yoe, C., & Orth, K. (1996). *Planning manual*. U.S. Army Corps of Engineers, Institute for Water Resources. Retrieved December 5, 2012 from: <http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/96r21.pdf>

Yoe, Charles. (2012). *Principles of risk analysis: decision making under uncertainty*. CRC Press: Boca Raton, FL.

## Chapter 6 - Self Assessment

### 6.0 SELF ASSESSMENT

1. Risk management is the process of identifying and eliminating risks. T/F
2. What is the primary risk management tool that USACE uses for documenting the risks associated with a feasibility planning project?
  - a. Risk register
  - b. Risk communicator
  - c. Risk tracker
3. Within USACE, risk management is only the responsibility of the identified risk manager? T/F
4. Which of the following is not a risk reduction strategy?
  - a. Risk Avoidance
  - b. Risk Control
  - c. Risk Transfer
  - d. Risk Mitigation
5. Which of the following risk management tasks comprise the risk assessment steps?
  - a. Decision context and identify risk
  - b. Identify risk and evaluate risk
  - c. Identify risk and assess risk
  - d. Identify risk and analyze risk
6. Which expression best describes the relationship between acceptable and tolerable risk?
  - a. Acceptable risk = tolerable risk
  - b. Acceptable risk > tolerable risk
  - c. Acceptable risk < tolerable risk
  - d. Acceptable risk ? tolerable risk

## SELF ASSESSMENT - ANSWERS

1. Risk management is the process of identifying and eliminating risks. T/F  
False. **CORRECT**. Risk management strives to alter levels of risk.
2. What is the primary risk management tool that USACE uses for documenting the risks associated with a feasibility planning project?
  - a. Risk register **CORRECT**. *The risk register is the primary risk management tool, and can be found at: <http://planning.usace.army.mil/toolbox/smart.cfm?Section=8&Part=4>*
  - b. Risk communicator **INCORRECT**
  - c. Risk tracker **INCORRECT**
3. Within USACE, risk management is only the responsibility of the identified risk manager? T/F  
  
False. **CORRECT**. Anyone that owns a piece of the risk may be a risk manager. In most instances some of the people involved will be outside the USACE.
4. Which of the following is not a risk reduction strategy?
  - a. Risk Avoidance **INCORRECT**. This is a strategy for risk reduction.
  - b. Risk Control **CORRECT**. Risk control is a term used to describe a risk management measure or option.
  - c. Risk Transfer **INCORRECT**. This is the strategy that underlies the national flood insurance program.
  - d. Risk Mitigation **INCORRECT**. This strategy aims to reduce the consequence of a risk.
5. Which of the following risk management tasks comprise the risk assessment steps?
  - a. Decision context and identify risk **INCORRECT**. These are the first two tasks.
  - b. Identify risk and evaluate risk **INCORRECT**. These are not adjacent tasks. However, tasks 2, 3, and 4 are considered the risk assessment tasks by the International Organization for Standardization.
  - c. Identify risk and assess risk **INCORRECT**. There is no assess risk task
  - d. Identify risk and analyze risk **CORRECT**. These two tasks comprise the risk assessment in the USACE risk management model.
6. Which expression best describes the relationship between acceptable and tolerable risk?
  - a. Acceptable risk = tolerable risk **INCORRECT**. An acceptable risk is less than a tolerable risk.
  - b. Acceptable risk > tolerable risk **INCORRECT**. An acceptable risk is less than a tolerable risk.

- c. Acceptable risk < tolerable risk **CORRECT**. A tolerable risk has not yet been reduced to an acceptable level.
- d. Acceptable risk ? tolerable risk **INCORRECT**. An acceptable risk is less than a tolerable risk.