Corps Risk Analysis Gateway Training Module

Introduction to Risk Assessment

Series:
Corps Risk Analysis Online Training Modules

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US Army Corps of Engineers

Contents

Introduction to Risk Assessment

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.

Figure 1. Risk assessment is the analytical component of the Risk Analysis Framework.

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

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

The goal of **risk assessment** is to identify and describe the risk(s) associated with a decision problem and to examine and evaluate the potential impacts of the risk. The purpose of risk assessment is to gather the information necessary to provide risk managers with the information needed to inform decisions.

In this introductory module, you will learn about activities associated with a risk assessment. Tools for conducting risk assessments, that is, the qualitative and quantitative methods for analyzing the potential risks, will be considered in the follow-on learning modules.

It is not the intent of this module to teach all of the possible methods for conducting risk analyses. Rather, the intent is to provide a broad understanding of the wide range of approaches and to provide resources to obtain more information about the various methods.

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

1. Describe the risk assessment model for the U.S. Army Corps of Engineers (USACE or Corps).
2. Identify potential risks.
3. Understand the steps taken to conduct a risk assessment.

You are encouraged to read through the examples, which look at specific concepts in more depth.

This training is approximately 30 minutes.

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

Chapter 1 - Risk Assessment Defined

1.0 Risk Assessment Defined

USACE defines risk assessment 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_Nov2007.pdf):[1]

> *Risk assessment is a broad term that encompasses a variety of analytic techniques that are used in different situations, depending upon the nature of the risk, the available data, and needs of decision makers. It is a systematic, evidence based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the same values resulting from a changed condition due to some action.*

Risk assessment is defined differently among federal agencies (see Explore), and yet there are common themes: ***defining and analyzing*** *the risk using* ***scientific/analytical techniques***.

Within the USACE risk management model, risk assessment is comprised of two key steps: identifying risks and analyzing risks (see Figure 2). Risk assessment is where the evidence is gathered, organized, analyzed, and used to support decision making. The process identifies and addresses uncertainty, which is then conveyed to decision makers for their consideration.

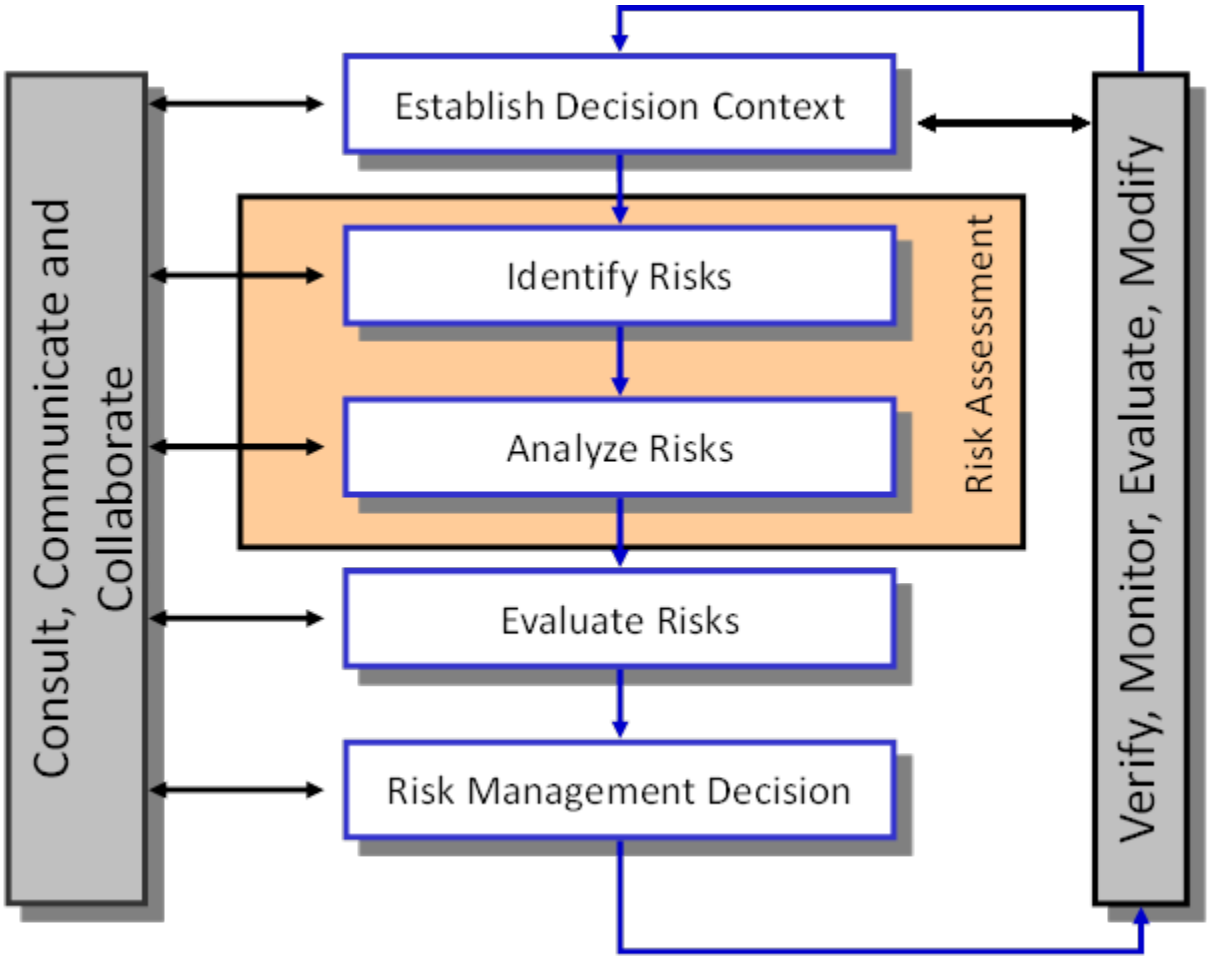

Figure 2. USACE Risk-Informed Decision Making Model

[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.*

EXPLORE – RISK ASSESSMENT AT FEDERAL AGENCIES

U.S. Environmental Protection Agency (EPA)[2]

EPA uses risk assessment to characterize the nature and magnitude of health risks to humans (e.g., residents, workers, recreational visitors) and ecological receptors (e.g., birds, fish, wildlife) from chemical contaminants and other stressors that may be present in the environment.

At EPA, environmental risk assessments typically fall into one of two areas:

- *Human Health*
- *Ecological*

Risk assessment is, to the highest extent possible, a scientific process. In general terms, risk depends on the following factors:

- *How much of a chemical is present in an environmental medium (e.g., soil, water, air).*
- *How much contact (exposure) a person or ecological receptor has with the contaminated environmental medium.*
- *The inherent toxicity of the chemical.*

Following a planning and scoping stage where the purpose and scope of a risk assessment is decided, the risk assessment process usually begins by collecting measurements that characterize the nature and extent of chemical contamination in the environment, as well as information needed to predict how the contaminants behave in the future.

Federal Drug Administration (FDA)[3]

Risk assessors provide information risk managers need to make science-based policy decisions.

Risk profiles are comprehensive descriptions of a hazard, the supply and consumption chains of the foods it affects, and potential interventions. These types of risk assessments don't include models that estimate outcomes and comparisons of interventions.

Quantitative risk assessments are mathematical models into which risk assessors enter information from risk profiles and other sources. The outcomes are estimates of risk, usually measured as the likelihood of illness from consuming a serving of food, and number of illnesses, per year, among a population that eats the food. Risk assessments also estimate and compare reductions in contamination and/or illness that would be generated by specific interventions applied at specific points of the farm-to-fork continuum.

Quantitative risk assessments may consider:

- *One hazard in relation to one food; also called product-pathway risk assessments.*
- *One hazard in relation to multiple foods.*
- *Multiple hazards in relation to multiple foods.*

Decision-analysis tools under development by FDA consider the kinds of data and information above in a larger context, to increase the likelihood that proposed policies will be both adoptable and effective in real-world settings. In considering which interventions would result in the greatest public-health gains when evaluating a specific risk scenario, the tools take into account other factors; for example, the cost-effectiveness and feasibility of the interventions and the likelihood that industry or consumers would apply them. The tools consider the various elements collectively and generate solution sets of optimized priorities and choices.

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[2] U.S. Environmental Protection Agency. (No date). Risk assessment home: basic information. Retrieved January 2, 2013 from http://www.epa.gov/risk#a1).

[3] U.S. Food and Drug Administration. (December 18, 2012). Risk analysis at FDA: food safety. Retrieved January 2, 2013 from: http://www.fda.gov/Food/ScienceResearch/ResearchAreas/RiskAssessmentSafetyAssessment/ucm243439.htm.

Chapter 2 - Risk Assessment Model

2.0 Risk Assessment Model

In its most basic form, risk assessments are conducted in order to answer one or more of the following questions:[4]

- What can go wrong?
- How can it happen?
- What are the consequences?
- How likely is it to happen?

These informal questions can be addressed by a vast array of definitions, process, models, or tools that are available to conduct the basic work of risk assessment. This module will only scratch the surface of the wide range of possible analytic tools. Figure 3 presents a model that currently meets USACE needs for a more formal expression of the risk assessment process.

Figure 3. Conceptual Risk Assessment Model

This is the same risk assessment that is conducted in the *identify risk* and *analyze risk* steps of the risk management model (of Figure 2). The generic risk assessment concepts are identified

more explicitly in this conceptual model. Ideally, any specific risk assessment conducted by USACE would include each of these steps.

Risk Assessment Steps

Look for Hazard or Opportunity
Identify the hazards that can cause harm or the opportunities for gain that are uncertain.

Consequence Assessment
Decide who or what may be harmed or benefited in what ways. Gather and analyze the relevant data. Characterize the consequences and their uncertainty qualitatively and quantitatively.

Likelihood Assessment
Assess the benefit of various adverse and beneficial consequences. Characterize these likelihoods and their uncertainty qualitatively and quantitatively.

Risk Characterization
Estimate the probability of occurrence, the severity of adverse consequences and the magnitude of potential gains, including attendant uncertainties, of the hazards and opportunities identified based on the evidence in the preceding steps. Characterize the risk qualitatively or quantitatively with appropriate attention to baseline and residual risks, risk reductions, transformations and transfers.

Each of these steps is discussed in the following sections.

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

2.1 IDENTIFY RISKS (LOOK FOR THE HAZARD OR OPPORTUNITY)

The primary elements of the hazards or opportunity step include:

- Identifying risk.
- Profiling risk.
- Deciding whether to complete a risk assessment or not.

Step 1 in any risk assessment phase is to identify the risks of interest. **Risk identification** is the process of finding, recognizing and describing risks in a narrative fashion. Informally, this is done by asking and answering the questions, *what can go wrong* and *how can it happen*? This is done by looking for the hazards that can cause harm and the opportunities for potential gains that are uncertain.

USACE faces two broad categories of risk: risk of loss and risk of unrealized potential gains.

- **Risk of loss**: Also called a pure risk, risk of loss 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, health, safety, property damage, ecosystem services, transportation services, power and additional losses.
- **Unrealized potential gain:** 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 be of 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.

There are potential risks in every one of the Corps' business lines:

- **Hydropower:** Risks associated with potential dam failures (new risk).

- **Navigation:** Risks associated with lock improvements and unintended consequences (new risk).

- **Flood risk management:** Potential risks to life, health, safety, and property, both in coastal and riverine areas (risk reductions, existing risks, risk transformations).

- **Recreation:** Risks associated with unrealized gains from the construction of a recreational facility (new risk).

- **Environmental restoration:** Comparative ecological risks associated with remedial action alternatives (risk transfers or risk transformations).

Planning, regulatory, project management, construction and operation life cycles all face unique risk situations. Note that in USACE planning studies, there are potential risks associated both with project and without project (no change) conditions.

After the potential risks are identified, a **risk profile** can be prepared. In its simplest form, this is a description of what is currently known about the identified risks. This is the equivalent of a scoping process for risks. A risk profile clearly identifies what is and what is not known about the identified risks.

The risk profile can be used to decide whether a more detailed risk assessment is needed or not. There will be times when the risk profile provides 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), a more formal effort to obtain that information must be undertaken in a risk assessment.

USACE developed a **risk register** template for use in feasibility studies (https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4). This template is also applicable for use in risk assessments. 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.

Table 1 and 2 on the next two pages show some of the information that is collected in the risk register; other types of information are dependent on the type of hazard/opportunity being reviewed (e.g., economics, real estate, hydraulics and hydrology, cost, engineering, etc.). A detailed video about the USACE risk register, titled "SMART Planning – The Risk Register (June 2012)," is available at the Corps online *Planning Community Toolbox* (https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=9&Step=1).

Table 1. USACE Risk Register Selected Parameters
Sheet 1. Define Project Risks

Column	Parameter	Parameter Description
A	Item	ID number.
B	Date	Date of entry (record each date entry was modified).
C	Assessors	Name(s) of person(s) assessing the task.
D	Action	Identify the action you propose to take (i.e., things you will do or not do) in order to accomplish the strategy and develop the information identified in the decision management plan.
E	Risk	Briefly identify the risk associated with the action you are taking, i.e., considering the entry in column D, what can go wrong and how can it happen?
F	Consequence	Describe the consequence of the column E risk. If things do "go wrong" in the way described, what are the specific consequences for: i) the study, ii) implementing the project or iii) project outcomes? (List the most significant consequence first if more than one.)
G	Consequence rating	If the most significant consequence in column F occurs, what is its potential magnitude?
H	Evidence for consequence rating	Enter specific evidence used to support the consequence rating in column G.
I	Likelihood rating	What is the likelihood that the most significant consequence in column F will occur?
J	Evidence for likelihood rating	Enter specific evidence used to support the likelihood rating in column I.
K	Confidence rating	Of the consequence and likelihood ratings, choose the one you have the least confidence in and rate your level of confidence in that rating.
L	Risk rating	Qualitative risk rating from lookup table.
M	Risk management options	Enter alternatives to the action you proposed in column D. If you can identify the cost or schedule impacts of the alternatives please do so.
N	Recommendation	Identify the preferred course of action for managing the risk you have identified. “Tolerate the risk associated with the action” in column D is the default option for this. You may recommend something other than the column D entry.
O	Study tasks affected	For study risks, identify any other study tasks that could be affected by the outcome of the risk identified for this entry.
P	Outcome	Describe the effect of your recommended course of action on the study or project outcomes.
Q	Notes	Make note of any significant information not provided in the other cells.

Table 2. USACE Risk Register Selected Parameters
Sheet 2. Define Economic Parameters

Column	Parameter	Parameter Description
A	Item	ID number.
B	Date	Date of entry (record each date entry was modified).
C	Assessors	Name(s) of person(s) assessing the task.
D	Action	Identify the action you propose to take (i.e., things you will do or not do) in order to accomplish the strategy and develop the information identified in the decision management plan.
E	Risk and its cause	Briefly identify the risk associated with the action you are taking, i.e., considering the entry in column D, “what can go wrong and how can it happen?”
F	Consequence	Describe the consequence of the column E risk. If things do "go wrong" in the way described, what is the specific consequence for: i) the study, ii) implementing the project or iii) project outcomes? (List the most significant consequence first if more than one.)
G	Consequence rating	If the most significant consequence in column F occurs, what is its potential magnitude?
H	Evidence for consequence rating	Enter specific evidence used to support the consequence rating in column G.
I	Likelihood rating	What is the likelihood that the most significant consequence in column F will occur?
J	Evidence for likelihood rating	Enter specific evidence used to support the likelihood rating in column I.
K	Confidence rating	Of the consequence and likelihood ratings, choose the one you have the least confidence in and rate your level of confidence in that rating.
L	Risk rating	Qualitative risk rating from lookup table.
M	Risk management options	Enter alternatives to the action you proposed in column D. If you can identify the cost or schedule impacts of the alternatives, please do so.
N	Recommendation	Identify the preferred course of action for managing the risk you have identified. “Tolerate the risk associated with the action” in column D is the default option for this. You may recommend something other than the column D entry.
O	Study tasks affected	For study risks, identify any other study tasks that could be affected by the outcome of the risk identified for this entry.
P	Outcome	Describe the effect of your recommended course of action on the study or project outcomes.
Q	Notes	Make note of any significant information not provided in the other cells.

2.2 Assess Consequences and Likelihoods

Throughout the *Risk Analysis Gateway*, risk is described by a simple equation:

Risk = Probability x Consequence

These two elements comprise the **next two steps (Step 2 and Step3)** in the risk assessment model.

In the consequence assessment (**Step 2**), the potential **consequences** of both hazards and opportunities must be identified and described. This activity might be described as the *cause-effect* link in the risk assessment. Questions to consider include:

- What undesirable effects do the hazards have?
- What desirable effects might the opportunities offer?
- Who might be impacted by the hazard or opportunity?

In a flood risk management planning study, the consequence assessment would include the estimation of a stage-damage curve (Figure 4). This curve shows the consequences of various levels of flooding on property damage in a floodplain reach.

Concurrently or sequentially with the consequence assessment, the **likelihood** of the various negative or positive consequences will need to be assessed (**Step 3**). This likelihood assessment is often called an exposure assessment in other risk assessment models. Once the possible undesirable consequences of hazards or the desirable consequences of opportunities are defined, then the likelihoods of the sequence of events that produce these outcomes can be considered.

Most risks cannot be directly observed or measured because they are potential outcomes that may or may not occur. Uncertain occurrence is a necessary condition for risk. Certain events are not risks.

Probability is the language of uncertainty and qualitatively or quantitatively assessing the likelihoods of the various adverse and beneficial consequences associated with the identified risks. Probabilities need to be considered during risk assessment.

Continuing with a flood risk management study example, these likelihoods are captured in part by the stage-discharge and discharge-frequency curves (Figure 4). These two curves together enable the estimation of the likelihood that the varying levels of flooding and their associated damages will occur. (See the Flood Risk Management National Economic Development Manual (Series: 2013-R-05.pdf) for more information about this example.)

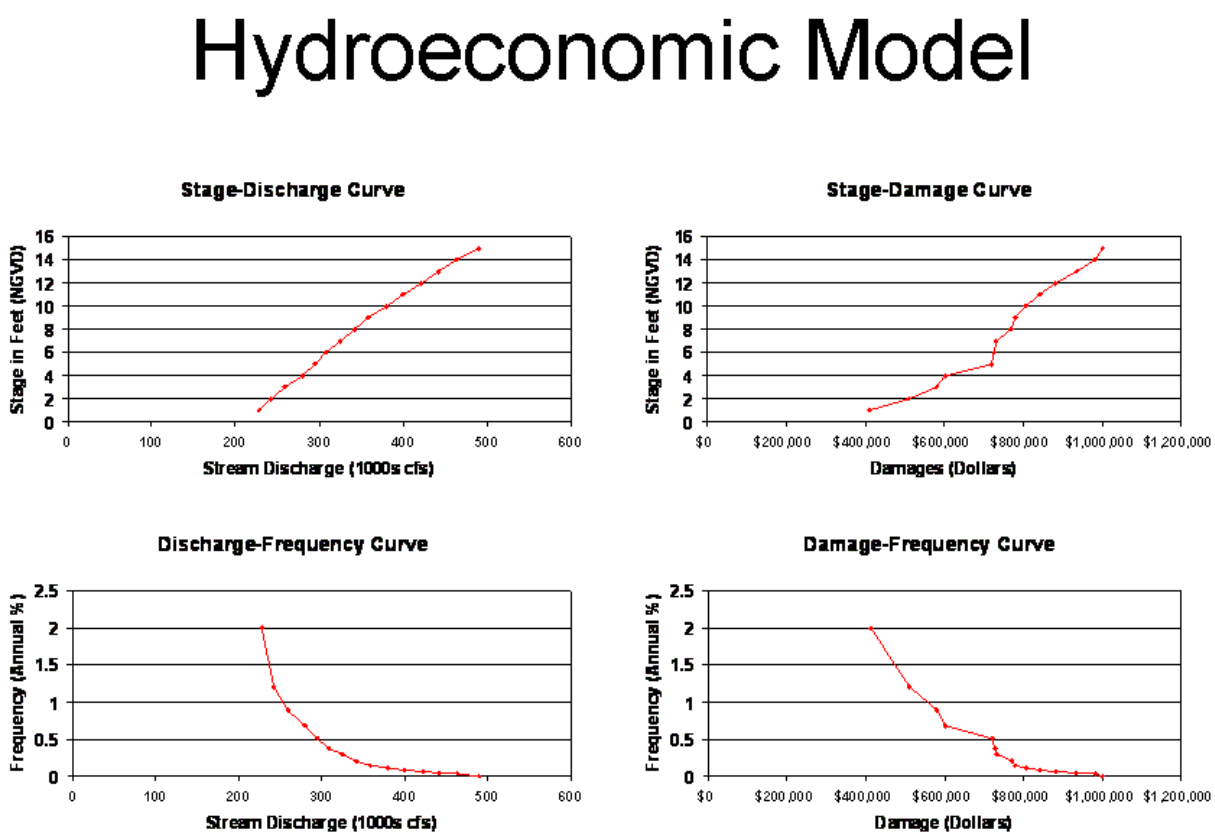

Figure 4. Consequence assessment, likelihood assessment, and risk characterization

Such information about the consequence and likelihood assessments for a specific action can be input into the risk register initiated in Section 2.1**.**

2.3 CHARACTERIZE RISKS

Step 4 in the risk assessment model is the risk characterization. Characterizations include one or more estimates of risk and a narrative description of the risk.

The risk characterization estimates the likelihood and severity of the adverse effects or the potential gains from opportunities. The estimate also addresses key attending uncertainties. Risk characterizations can be quantitative or qualitative. Risk estimates should include all the relevant aspects of the risk, which may encompass existing, future, historical, reduced, residual, new, transformed or transferred risks. A risk description is a narrative explanation and depiction of a risk that bounds and defines a risk for decision making purposes. It's the story that accompanies the risk estimate. It places each risk in a proper context for decision makers and others to understand.

A good risk characterization converts the scientific evidence base and the remaining uncertainty into a statement of risk. During the risk characterization, the overall importance of the various uncertainties encountered throughout the risk assessment is brought into focus. Risk characterization should include sensitivity analysis or formal uncertainty analysis commensurate with the nature of the risk assessment.

This step draws on the analytical work completed in the other steps to characterize the risks. In the flood risk management example, the damage frequency curve (Figure 4) integrates the consequence and likelihood assessments and enables planners to use expected annual damages to estimate the risk of flooding.

The elements of the risk assessment model are not always so easy to separate in every risk assessment. Every risk assessment will not include all four steps. In some instances it may be more efficient to conduct a detailed analysis of the *likelihood* of an event--for example, if there is some evidence to suggest imaginable potential consequences may never occur. For example, demonstrating that a potential flood cannot reach a piece of critical infrastructure, like an airport, makes it unnecessary for a damage survey and a risk characterization.

Information from the risk characterization for a specific action(s) can be entered into the risk register initiated in Section 2.1**.** The following sections provide more specific information about various types of methods and tools that can be used to facilitate the risk assessment.

Chapter 3 - Risk Assessment Toolbox

3.0 Risk Assessment Toolbox

Varying levels of risk assessment can be completed depending on the circumstances and the nature of the problem. As previously noted, risk assessments are conducted in order to answer one or more of the following questions:[5]

- What can go wrong?
- How can it happen?
- What are the consequences?
- How likely is it to happen?

Risk assessment can be described as the process of compiling, combining and presenting evidence to support a statement about the risk of a particular activity or event. There are a number of defined processes, techniques, tools and models that can be used to support the assessment. Risk assessments can be qualitative, quantitative or a combination of both. The approach selected in any one case generally depends on the level of information available, the intended use of the results and the level of analysis required.

In **qualitative** assessments, the risk characterization produces non-numerical estimates of risk. Often times, qualitative risk assessments are undertaken due to lack of funding, time or expertise to tackle the problem quantitatively. Descriptive or categorical treatments of information are used in lieu of quantitative numerical estimates. Qualitative assessments can still be analytical evidence-based characterizations of risk that provide consistency and transparency in the way risks are handled.

Quantitative tools rely on numbers to express the level of risk. Typically, quantitative risk assessments have more transparency and the validity of the analysis can be more easily determined. Quantitative risk assessment relies on models and can range from simple to complex.

The type and level of analysis to be conducted during the risk assessment is driven in some cases by the level of uncertainty and the consequences of being wrong. This assessment has evolved into a paradigm for decision making under uncertainty. It recognizes that there may be uncertainty about one or more aspects of the likelihood or the consequence of a risk of concern. Consequently, risk assessment is intentional in the way it directs analysts and decision makers alike to base their decisions on the available science while paying appropriate attention to the remaining uncertainty.

Risk analysis is for decision making under **uncertainty**, which is a separate training module in the *Risk Analysis Gateway*. When there is little to no uncertainty in decision making, risk analysis is not needed. However, many management and mission critical decisions do involve

significant uncertainty and the consequences of a wrong decision are more serious. When uncertainty is great and the consequences of a wrong decision are serious, risk analysis is needed. When there is little uncertainty and the consequences of a mistake are minor, other decision paradigms will work as well. Figure 5 summarizes this idea.

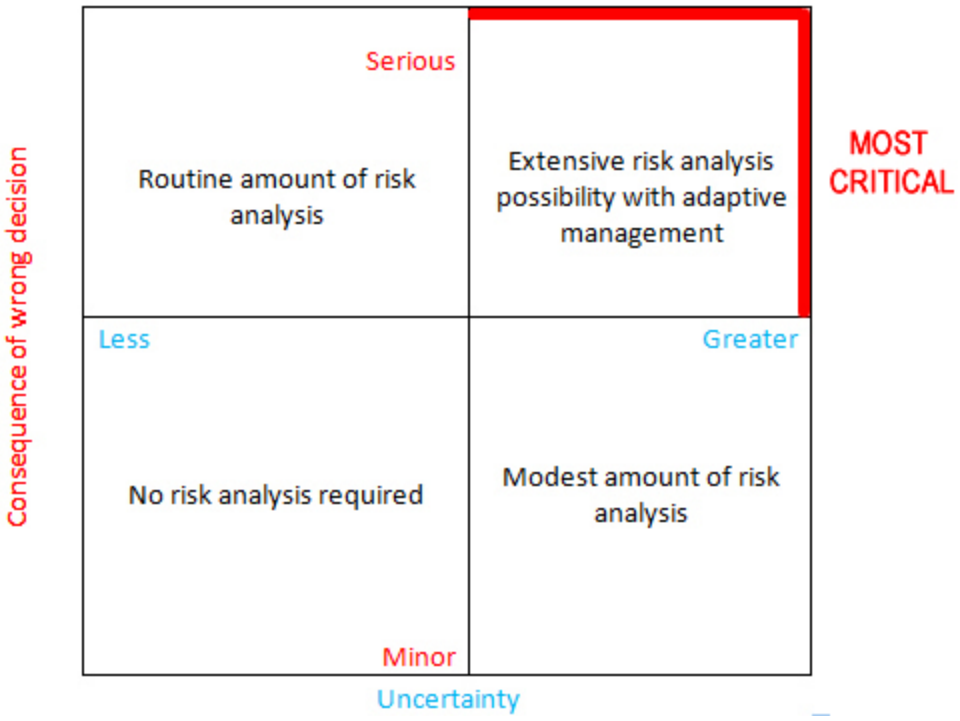

Figure 5. Considerations for risk analysis

The lower left quadrant where the consequence of the wrong decision is little and uncertainty is minor tends to describe activities like personnel assignments, routine purchases, data collection, some permit applications, routine coordination activities, administrative activities, budget updates and the like. These are routine tasks with little uncertainty or situations where a wrong decision will have trivial or easily reversed consequences.

The lower right quadrant holds classes of decision problems where there may well be significant amounts of uncertainty, but the consequence of a decision mistake are relatively minor. These situations require a modest amount of risk analysis. That might mean at least enough analysis to reassure decision makers that the consequences of a mistake are indeed slight. Examples of such decisions could include some routine or recurring aspects of project design, routine emergency management activities, management of construction projects, allocation of operation and maintenance resources within the District, and so on.

As the consequences of a mistake grow more serious, the need for more rigorous risk analysis grows as well. The presumed normal situation for USACE decision making is described as one

with relatively less uncertainty but serious consequences for a decision error. Thus, risk analysis is presumed to be a routine part of such decision making processes. Ideally, it will be the dominant decision making paradigm. Examples of such areas include recurring and always unique situations like lake siltation, reservoir reallocation, maintenance dredging, reconnaissance studies, feasibility studies, dam and levee safety programs, managing the annual budget of the Corps, programs management, allocating inspection resources, and so on.

The greater need for the detailed analyses of risk occurs for those decisions with both a lot of uncertainty and potentially severe consequences for a decision error. When the uncertainty is great enough, adaptive management techniques may be needed to reduce the uncertainty to support decision making.

Regardless of the method of the risk analysis, the risk register (https://planning.erdc.dren.mil/toolbox/smart.cfm?Section=8&Part=4) noted in Section 2.1 is a tool that has been specifically developed for USACE feasibility studies. This risk register can be used to organize data and information about the risk assessment and to document the analysis.

The basic characteristics of qualitative and quantitative methods for assessing risk are discussed in the following learning modules on the Corps Risk Analysis Gateway site:

- Assessing Risk Using Qualitative Methods
- Assessing Risk Using Quantitative Methods

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

EXPLORE – TIPS FOR A GOOD RISK ASSESSMENT

Dr. Charles Yoe, a recognized expert in both risk analysis and USACE planning processes, provides the following suggestions for conducting a good risk assessment.

1. A good risk assessment must begin with the questions that need to be answered by the risk assessment to support decision making. Get these questions right, and then answer them clearly and concisely.

2. Keep risk assessment functionally separated from the risk management task. If possible, have different people perform these two tasks. Make sure they communicate early and often.

3. Corps risk assessment is best accomplished as a team activity. Evidence-based analysis requires subject matter experts. It is unusual for a single person to possess all the knowledge required to complete a risk assessment. Good teams are at least multidisciplinary. Better teams are interdisciplinary. The best teams are trans-disciplinary.

4. The magnitude of the effort is commensurate with the resources available and in proportion to the seriousness of the problem. Risk analysis in general and risk assessment in particular are perfectly scalable processes. A good risk assessment process can be completed in an hour if that is all the time you have, or in a couple of years.

5. The process is often as important as the result. Following the risk assessment process aids the understanding of the problem and its solutions.

6. A good risk assessment assumes an independent point of view. It is not the assessor's job to protect lives, save or create jobs, or to punish or reward anyone. Assessors only need to provide objective evidence-based answers to the questions they have been asked.

7. A good risk assessment separates what we know from what we do not know. It then focuses special attention on what we do not know. Good risk assessment gets the right science into the assessment and then it gets that science right. Assessors use science to answer the risk manager's questions. Honesty about uncertainty provides the confidence bounds on those answers.

8. Good science, good data, good models and the best available evidence are integral to good risk assessment. The analysis must be tied to the evidence.

9. It is the way that risk assessment addresses the things we do not know that makes it such a useful and distinctive decision making paradigm. In a good risk assessment, all assumptions are clearly identified for the benefit of other members of the assessment

team, risk managers and anyone else who will read or rely upon the results of the risk assessment.

10. Sensitivity analysis should be a part of every risk assessment. Testing the sensitivity of assessment results including the answers to the risk manager's questions is a minimum requirement for every assessment qualitative or quantitative.

11. To distinguish risk assessment from safety analysis, we need to consider risk broadly and focus on the risks of interest (e.g., existing risk, future risk, historical risk, risk reductions, new risks, residual risk, transferred risk, transformed risk). It's not always necessary to consider each of these kinds of risk, but it is rarely adequate to consider only one dimension of a risk

12. Good risk assessments are unbiased and objective. They tell the truth about what is known and not known about the risks. They are as transparent and as simple as possible, but no simpler. Practicality, logic, comprehensiveness, conciseness, clarity and consistency are additional qualities desired in a risk assessment.

13. Risk assessments usually produce more estimates and insights than scientific facts. The assessment provides information; they do not produce decisions. Risk managers make decisions.

14. Risk assessments can have educational value. They often identify the limits of our knowledge and in doing so, guide future research. Completed risk assessments may be conducive to learning about similar or related risks.

15. Documentation is an important part of the risk assessment process. Effective documentation tells a good story well. It lays out the answers to the risk manager's questions clearly, well, and simply.

Chapter 4 - Summary and Conclusions

4.0 Summary and Conclusions

The level of risk assessment to be undertaken may be driven by the consequence of making a wrong decision and the level of uncertainty in the outcomes. However, there are practical matters that also drive the level of risk assessment chosen including the time and resources available to conduct the analysis. There may be cases where risk assessments are conducted through a combination of various approaches, including both qualitative and quantitative methods.

There are five key points to take away regarding risk assessment overall, including the following:

1. Risk assessment is the science-based component of risk analysis that answers the risk manager's questions about the risks.
2. The Corps generic risk assessment model has four steps: hazard/opportunity identification, likelihood assessment, consequence assessment and risk characterization.
3. Communicating uncertainty effectively is a critical task of risk assessment.
4. Good risk assessment begins with the questions risk managers need to be answered to support their decision making.
5. Risks can be assessed qualitatively or quantitatively.

Chapter 5 - Resources

5.0 RESOURCES

The following additional resources regarding risk assessment approaches are available.

Risk Assessment

Davis, D., Faber, B. and Stedinger, J. (2008). USACE experience in implementing risk analysis for flood damage reduction projects. Journal of Contemporary Water Research and Education. Issue 140, pps. 3-14.

Information Systems Audit and Control Association (ISACA). (n.d.). Risk assessment tools: a primer. Retrieved May 16, 2013 from: http://www.isaca.org/Journal/archives/2003/Volume-2/Pages/Risk-Assessment-Tools-A-Primer.aspx.

International Electrotechnical Commission (IEC)/International Organization for Standardization (ISO). (2009). *ISO 31000:2009, Risk management—risk assessment techniques.* Retrieved January 13, 2013 from http://www.iso.org/iso/iso31000.

Moser, D., Bridges, T., Cone, S., Haimes, Y., Harper, B., Shabman, L. & Yoe, C. (2007 unpublished). *Transforming the Corps into a risk managing organization*.

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U.S. Environmental Protection Agency. (No date). *Risk assessment home: basic information.* Retrieved January 2, 2013 from http://www.epa.gov/risk_assessment/basicinformation.htm#a1).

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Chapter 6 - Self Assessment

6.0 Self Assessment

1. Risk assessment is the actions taken to accept, assume, and manage risk. T/F

2. Which of the following is NOT one of the four steps in the risk assessment process?
    a. Identify risks
    b. Publicize the risk
    c. Assess consequences of risk occurrence
    d. Assess likelihood of risk occurrence
    e. Characterize risks

3. Risk characterization can only be properly defined in quantitative terms. T/F

4. The risk of unrealized potential gain is called a speculative risk. T/F

5. Residual risks are the 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. T/F

6. If you are trying to answer the following questions, are you assessing the probability or consequences of the risk?

    What undesirable effects do the hazards have?
    What desirable effects might the opportunities offer?
    Who might be impacted by the hazard or opportunity?

    a. the probability of the risk
    b. the consequences of the risk

7. If the consequence of the wrong decision is serious and the uncertainty of risk is great, which of the following levels of risk analysis should be conducted?
    a. Extensive risk analysis with adaptive management
    b. Routine levels of risk analysis

8. What tool can be used in USACE feasibility studies to organize data and information about the risk assessment and to document the analysis?
    a. Risk Ware
    b. Risk Register
    c. Risk Communicator
    d. Risk Log

9. Risk assessments generally produce scientific facts. T/F

10. Within the Corps, a risk assessment is best accomplished by a single individual. T/F

6.0 SELF ASSESSMENT - ANSWERS

1. Risk assessment is the actions taken to accept, assume, and manage risk. T/F

   False. **CORRECT**. The statement above is the definition of risk management. Risk assessment is defining the nature of the risk, its probability, and the consequences, either quantitatively or qualitatively (or combination).

2. Which of the following is NOT one of the four steps in the risk assessment process?
   a. Identify risks INCORRECT
   b. Publicize the risk **CORRECT**. This is not one of the four steps of risk assessment
   c. Assess consequences of risk occurrence INCORRECT
   d. Assess likelihood of risk occurrence INCORRECT
   e. Characterize risks INCORRECT

3. Risk characterization can only be properly defined in quantitative terms. T/F

   False. **CORRECT**. Risks can be characterized both qualitatively and quantitatively.

4. The risk of unrealized potential gain is called a speculative risk. T/F

   True. **CORRECT**. 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.

5. Residual risks are the 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. T/F

   False. **CORRECT**. Residual risks are the risks remaining after risk management strategies are implemented; for example, the with-condition (with a USACE project) expected annual damages associated with a flood risk management project would be a measurement of residual risk.

6. If you are trying to answer the following questions, are you assessing the probability or consequences of the risk?

   What undesirable effects do the hazards have?
   What desirable effects might the opportunities offer?
   Who might be impacted by the hazard or opportunity?

   a. the probability of the risk INCORRECT
   b. the consequences of the risk **CORRECT**

7. If the consequence of the wrong decision is serious and the uncertainty of risk is great, which of the following levels of risk analysis should be conducted?
    a. Extensive risk analysis with adaptive management **CORRECT**. The need for the greatest amount of risk analysis occurs for those decisions with both a lot of uncertainty and potentially severe consequences for a decision error.
    b. Routine levels of risk analysis INCORRECT

8. What tool can be used in USACE feasibility studies to organize data and information about the risk assessment and to document the analysis?
    a. Risk Ware INCORRECT
    b. Risk Register **CORRECT**
    c. Risk Communicator INCORRECT
    d. Risk Log INCORRECT

9. Risk assessments generally produce scientific facts. T/F

    False. **CORRECT**. Risk assessments usually produce more estimates and insights than scientific facts. The assessment provides information; they do not produce decisions. Risk managers make decisions.

10. Within the Corps, a risk assessment is best accomplished by a single individual. T/F

    False. **CORRECT**. Corps risk assessment is best accomplished as a team activity. Evidence-based analysis requires subject matter experts. It is unusual for a single person to possess all the knowledge required to complete a risk assessment. Good teams are at least multidisciplinary. Better teams are interdisciplinary. The best teams are trans-disciplinary.