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Planning
GUIDE FOR INCORPORATING LIFE RISK IN USACE FLOOD AND COASTAL STORM RISK MANAGEMENT PROJECT DEVELOPMENT

1. Purpose. This guide provides information on how the U.S. Army Corps of Engineers (USACE) incorporates life risk in the planning process for both new and existing projects, and in inland and coastal environments. Risk to human life is a fundamental component of flood and coastal storm risk management and must receive explicit consideration throughout the planning process. USACE planning studies consider and evaluate the economic, social, and environmental costs and benefits of a potential water resources project. Positive and negative impacts to life risk are considered alongside other social effects of the project.

2. Applicability. This Circular applies to all USACE Headquarters (HQUSACE) elements, major subordinate commands, districts, laboratories, centers of expertise, and field operating activities that have civil works planning, engineering, design, construction, and operations and maintenance responsibilities.

3. Distribution Statement. Approved for public release. Distribution is unlimited.

4. References. References are at Appendix A.

5. Records Management (Record Keeping) Requirements. Records management requirements for all record numbers, associated forms and reports required by this regulation are included in the Army's Records Retention Schedule - Army. Detailed information for all record numbers, forms, and reports associated with this regulation are located in the Army's Records Retention Schedule - Army at https://www.arims.army.mil/arims/default.aspx.

6. Background and Overview.

a. Consideration of life risk should be incorporated in USACE water resources project development and analysis from the beginning. The consideration of life risk in a feasibility study requires examination of concepts such as human behaviors and societal and individual life risk. Factors that influence life risk analysis for a riverine or coastal flood risk management project include, but are not limited to, the depth and velocity of flooding, flood arrival time, flood risk management infrastructure (for example, dam or levee) performance, socio-economic characteristics of the population, fatality rate thresholds, warning systems, warning time, warning effectiveness, evacuation plans, emergency response, and other physical and preparedness measures. Life risk analysis may be qualitative or quantitative, based on the severity of life risk, thus its importance in project decision making.

b. This new guide complements existing USACE guidance and handbooks which provide direction for considering life risk in the development of flood and coastal storm risk management projects. USACE staff are encouraged to use this guide as a resource in the formulation and evaluation of USACE flood and coastal storm risk management projects.

Encl
1 Appendix

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Guide for Incorporating Life Risk in USACE Flood and Coastal Storm Risk Management Project Development

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As the U.S. Army Corps of Engineers (USACE) works to improve its evaluation and decision-making, explicit consideration of the effects of flooding and coastal storms on people and communities must be at the forefront of our planning. In formulating and evaluating all water resources development projects USACE teams consider project effects across economic, environmental, and social benefit categories. Consideration of life risk falls squarely in the social benefits category.

Individuals and communities interact with the built environment and the natural environment in a multitude of combinations that influence health and safety, including life risk. USACE teams and our partners must tease apart the components that influence risk and understand how each of them interact, what components of risk can be modified, and how risk – especially life risk – can be mitigated or managed, and how the project alternatives being considered affect life risk as compared to the future without project condition.

Study teams that effectively consider and communicate risk, including life risk, in the formulation and development of USACE flood risk management and coastal storm risk management projects will find they have set themselves up to more effectively work and communicate with study and project partners, local communities, and decision-makers.

This informational Engineer Pamphlet is intended to provide context and examples of incorporating life risk in to flood and coastal storm risk management studies, to help our project development teams, partners, and stakeholders consider life risk in the decision-making process. It does not establish or add to policy – it provides a framework for understanding and implementing the concept in our familiar process.

TABLE OF CONTENTS

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"USACE has long been a risk management organization, addressing uncertainty and managing risk by various methodologies at all echelons of the organization. Consistent across USACE's broad portfolio of mission areas is the requirement to regularly execute programs and projects where risk is an inherent factor in business decisions. Assessing and communicating risks to establish effective courses of action and shared expectations for likely outcomes, both internal and external to USACE, is an essential element of good business practice."

— Risk-Informed Decision Making for Program and Project Delivery (Director's Policy Memorandum 2020-04)

INTRODUCTION

The purpose of the Guide for Using Life Risk in Flood and Coastal Storm Risk Management Project Development is to provide context and examples on the explicit incorporation of life risk during the feasibility phase of flood and coastal storm risk management projects, from setting study objectives through developing recommendations to reduce life risk.

How we analyze and incorporate life risk in planning studies is an evolving topic. When a planning study includes existing dams or levees, the district dam safety program manager or levee safety program manager and operations project manager are required participants on the study team. Study teams are encouraged to be adaptive and reach out to others to share experiences and approaches, including the Flood Risk Management and Coastal Storm Risk Management Planning Centers of Expertise, the USACE Risk Management Center, and the Dam Safety Modification Mandatory Center of Expertise.

Risk is an inherent factor in all our work. No risk is more important to consider than life risk.

BACKGROUND

Risk to human life is a fundamental component of flood and coastal storm risk management and must receive explicit consideration throughout the planning process. This guide provides information on how to incorporate life risk in the planning process for both new and existing projects, and in inland and coastal environments.

USACE planning studies consider and evaluate the economic, social, and environmental costs and benefits of a potential water resources project. Positive and negative impacts to life risk are considered alongside other social effects of the project.

Consideration of life risk should be incorporated in project analysis from the beginning. The consideration of life risk in a feasibility study requires examination of concepts such as human behaviors and societal and individual life risk. Factors that influence life risk analysis for a riverine or coastal flood risk management project include, but are not limited to, the depth and velocity of flooding, flood arrival time, flood risk management infrastructure (e.g., dam or levee) performance, socio-economic characteristics of the population, fatality rate thresholds, warning systems, warning time, warning effectiveness, evacuation plans, emergency response, and other physical and preparedness measures. Life risk analysis may be qualitative or quantitative, based on the severity of life risk and its importance in project decision making.

This guide complements existing USACE guidance and handbooks which provide direction for considering life risk in the development of flood and coastal storm risk management projects, including:

- Engineer Regulation (ER) 1105-1-100, Planning Guidance Notebook;
- ER 1105-2-101, Risk Assessment for Flood Risk Management Studies;
- ER 1110-2-1156, Safety of Dams;
- Planning Bulletin 2019-04 - Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies;
- IWR Report 09-R-4, Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning;
- IWR Report 2013-R-02, Other Social Effects: A Primer; and
- A Guide to Public Alerts and Warnings for Dam and Levee Emergencies.

UNDERSTANDING LIFE RISK: KEY DEFINITIONS

Risk is the measure of the probability (or likelihood) and consequence of uncertain future events. Risk is determined by: the hazard (what can cause harm); the performance or response of flood risk management projects; the exposure of population to the risk; the vulnerability of the population at risk to harm; and the consequences (how much harm is caused). See Figure 1: Components of Risk.

Life risk, in the context of riverine or coastal flood risk management projects, is the combination of likelihood and extent of life loss because of a hazard or lack of system performance. This can include both direct life loss from the hazard as well as indirect life loss. In the case of considering life risk for flood or coastal storm risk management projects, indirect life loss may occur from a loss of essential services such as hospitals or fire departments as a result of the hazard occurring.

Residual life risk is the life risk that remains after a proposed flood or coastal storm risk management project is implemented.

"Without project" life risk minus reduced life risk from a new project equals residual risk.

Incremental life risk is the life risk due to the risk of inundation posed by poor project performance or failure. A properly designed and constructed levee or dam can perform well for the duration of its intended life. Incremental life risk is attributed to the project when the project does not perform as intended — such as breaching prior to or

Figure 1. Components of Risk

during overtopping, malfunction, or mis-operation — and consequences occur.

Tolerable risk, in the context of USACE flood risk management projects involving levee systems or dams, is the incremental risk that society is willing to accept to secure the benefits of that project. Tolerable risk guidelines address the questions: Are the risks commensurate with the benefits? Are risks being assessed, managed, and communicated? Is the owner acting reasonably? Is there more that should be done?

FACTORS INFLUENCING LIFE RISK IN FLOOD AND COASTAL STORM RISK MANAGEMENT PROJECTS

The built environment (e.g., infrastructure, houses, roads), the natural environment (e.g., hazards, ecosystems), and the human environment (e.g., people, economy) interact in a multitude of combinations to influence life risk. The major factors influencing life risk in the flood and coastal environments are the same although their characteristics, such as type of hazard, may be distinct. Formulating and planning flood and coastal storm risk management projects also share the inherent uncertainties in each factor, whether natural, built, or human. These uncertainties often are a major influence in assessing life risk.

The Hazard: What causes harm?

The major hazard influencing life risk in the flood and coastal environments is the natural environment. The flooding hazard can also be described as flood severity, which can be boiled down to a combination of water depth and velocity. These factors must be considered in the context of the complete hazard, which can be influenced by wind and wave action, storm surge, tides, and debris load. Other factors which may be far from the location of the initial hazard can have a significant impact on the level of life risk, such as tides and rainfall with associated runoff.

Flood and coastal life risk may occur as a result of the same initial event when a hurricane moves inland and generates heavy localized rain, such as occurred with Hurricane Harvey in Texas in 2017.

Variations in physical impacts should also be considered in the context of life risk, including: levels of uncertainty in storm track and intensity; tides, waves, and storm surge; and depth and velocity of flooding.

Performance: How will the system react?

Infrastructure for the purpose of reducing flood or coastal storm risk is designed to withstand a certain limit of forces. Therefore, there is a limit on its performance. Once those limits are exceeded, infrastructure will likely no longer perform as designed. This must be acknowledged and considered in determining life risk.

In addition to the performance of the flood risk management project to prevent flood damages, consideration should be given to other types of critical infrastructure which are key to both evacuation and to recovery, particularly roads. Evacuation reduces direct and indirect life risk by removing people from the area of danger. Indirect life loss may be reduced by quick recovery, for example, ensuring safe access to restore power, water, communication systems, and other essential community elements.

Exposure and Vulnerability: Who and what are in harm's way, and how susceptible are they to harm?

Once the geographic area of impact is determined, the population and structures within the area must be examined to determine their exposure and vulnerability. Exposure refers to who or what is impacted by a hazard. This includes components of the built environment, such as houses, schools, and hospitals, as well as the people and natural environment. Exposure of people may be influenced by location (near the source of the hazard), time of day (awake to get a warning, commuting), day of the week (work, school day, or weekend), warning time (how long until the hazard will arrive), type of structure (sturdy such as a factory, second story available) and other factors. Awareness of these items is key in identifying actions to reduce life risk. Actions to reduce exposure by removing people from the path of the hazard or reducing their interaction with the hazard may be very effective, for example the ability to move to a second story and shelter in place.

Not all people who are exposed to a hazard or are in a hazard area are equally vulnerable to the hazard. Characteristics of structures, individuals, and communities can increase or decrease their vulnerability. For example, elevated homes can decrease the vulnerability of the residents to some flood or coastal storm events, whereas certain socio-economic and population characteristics may increase an individual's and the community's vulnerability to the hazard.

Socially vulnerable groups are important to consider and may warrant special considerations during the formulation and evaluation of alternatives due to their reduced ability to evacuate, potentially increased trauma due to evacuation, and longer and less complete recovery. Characteristics of vulnerable populations may include age (very young or elderly), low proficiency in English, income level, or limited access to transportation options. Census data and local information can help to identify the populations exposed to the hazard and the magnitude and location of vulnerable populations. Particular attention should be given to settings where numerous vulnerable people may be gathered, including schools, nursing homes, day care centers (child and adult), and hospitals.

Look for this symbol throughout the Guide for examples that address the components of risk: Hazard, Performance, Exposure, Vulnerability and Consequence.

Consequences: How much harm?

Combining information on hazard, performance, exposure and vulnerability results in a determination of consequences, or how much harm occurs. Potential harm, i.e. life risk, is predicted by modeling the hazard (volume and movement of water) and overlaying that with the population in the path of the hazard (exposure). Exposure is impacted by time of day in relation to the location of the population and in relation to awareness of the potential hazard. Coastal storm and flood risk management projects may reduce the amount of harm through understanding and actions to impact the causes.

The level of consequences is impacted by the original conditions and actions to adjust these factors. Population characteristics (e.g., elderly or low income) and exposure (e.g., in the path of the event or in low lying areas) are major impacts on evaluating life risk. Taking a holistic view of the interaction of factors and identifying effective actions can reduce life risk.

Warning systems, evacuation plans, emergency response, community education and outreach, and other preparedness measures influence the life risk consequences of flooding. In most coastal and riverine communities where there is known flood risk, there are systems and plans in place to promote preparedness. These measures are developed by each community to manage risk. These preparedness measures share the same fundamental components, whether coastal or riverine, and are adapted to local conditions. Reducing the exposure of the population, especially socially vulnerable populations, is critical in reducing life risk. Overall, the most reliable way to reduce life risk is for people to not be in the path of the hazard, i.e., evacuation and selected shelter-in-place scenarios. Effective floodplain management programs can facilitate wise use of floodplains and thus reduce life risk.

Warning time is a critical factor in potential life risk. There is usually significantly more warning time for coastal storms than riverine floods. Evacuation orders are typically issued days before a coastal storm is expected to make landfall and impact a coastal area. However, the specific location of landfall may be difficult to predict or change less than 24 hours before impact, putting additional people at risk with minimal time to prepare and not enough time to evacuate. In riverine flooding situations, there can be significantly less warning time, which increases the life risk. Although there are some riverine flood risk situations where the hazard can be known days or weeks in advance, such as along the Ohio and Mississippi Rivers, this is not common. The lack of warning time is likely to increase life risk, and this can be compounded in high-velocity situations such as flash floods.

Warning effectiveness is dependent on many factors. Effective evacuation programs include well-planned warning procedures and plan clear, informative evacuation messages across the full range of local, regional, state, and federal government agencies. Clear risk messages are presented to reinforce the need for evacuation well in advance of threatening weather. Messages are presented by trusted parties such as local broadcasters and meteorologists. Local officials then lay out the process and steps to be taken in the event of an evacuation—phasing by geographic area with most at risk first; preparations to make before evacuation; destination shelters; provisions for pets; and accommodations for those without transportation, including a registry of those requiring assistance. Lastly, the community is informed of the consequences of not evacuating, i.e., at an established threshold, emergency services including fire, police, and ambulance will not answer calls or provide assistance due to danger to their employees.

In addition to bringing focus to the direct consequences of flooding on the population, the consequences to critical infrastructure should be carefully identified and evaluated. For example, if electrical power and potable water are not available, life risk will rapidly increase. Lack of fire, ambulance, and hospital services will also increase life risk — possibly dramatically.

INCORPORATING LIFE RISK IN THE USACE PLANNING PROCESS

The risk-informed planning process includes four steps: scoping, plan formulation, deciding, and implementation. Evidence gathering and stakeholder involvement are ongoing tasks that occur throughout the study. The risk-informed planning process is meant to be iterative, which is reflected by the circular flow of the tasks in the planning process graphic below.

Figure 2. Risk-Informed Planning Process

The following sections step through the risk-informed planning process, focusing on the language and tasks directed at assessing life risk in flood and coastal storm risk management studies, formulating alternatives that are explicit regarding life risk, evaluating plan effects on life risk, and incorporating life risk into decision making.

SCOPING

In the first step of the planning process, scoping, a planning study team defines the problem, identifies the purpose of the study, and determines the complexity and focus of the study. The study team should gather and use readily available information to inform initial scoping efforts: details from recent flood events; risk assessments for existing levees and dams; the last hydrologic and hydraulic (H&H) analyses in the study area; and status of local emergency management/emergency planning. The initial scoping of a study should result in information that can be used to complete the first iteration of the planning process with a baseline understanding of the life risk.

As additional information is acquired and analysis is completed in subsequent iterations of the planning process, the level of detail will increase and uncertainty will be reduced. During scoping, the study team develops an understanding of the life risk that exists in the study area, and this is incorporated into the planning process. Important facets of risk to consider and document during scoping include:

- Does the hazard allow adequate time for a warning to be issued?
- If a warning is issued, does the public know what actions to take? Are plans in place to guide evacuations, who should evacuate, where, how?
- Do existing dams and levees have risk assessments?
- Is the condition of existing infrastructure understood? At what frequency does it overtop? Is overtopping likely to be forecast with enough time to evacuate?

With a basic understanding of the hazard, performance, exposure, vulnerability, and consequences, the study team can dig deeper to understand the type and magnitude of life risk. These considerations are similar for riverine and coastal areas, although the geography will impact the specifics.

- What type(s) of life risk exist: incremental life risk, residual life risk, or both?
- Are the drivers/contributing factors to the type(s) of life risk identified: the hazard itself, the performance of existing dams and levees, the exposure and vulnerability of the population, or the consequences of flooding?
- What is the magnitude of the life risk(s)?
- What is the impact of evacuation?
- Does the type and/or magnitude of the life risk remain consistent into the future, or does it increase or decrease as compared to the existing condition?
- Are there vulnerable populations of special concern in the study area?

What to Do When Your Study Includes an Existing Levee or Dam

If your study includes the evaluation of an existing levee or dam, all USACE-owned and operated dams and levees, and most federally authorized levee systems, have a risk assessment available. The District dam or levee safety program manager can share the background and findings on existing risk assessments, and the District Chief of Operations and Asset Manager can provide additional information related to the history and performance of existing infrastructure. USACE Dam Safety and Levee Safety Program risk assessments include levee screenings (screening level risk assessments), higher level risk assessments (semi-quantitative and quantitative risk assessments), and periodic assessments.

These risk assessments will provide you a head start in understanding the life risk in your study area.

HAZARD – The existing risk assessment will have a hazard defined. These flood events may be less frequent, so the project delivery team will need to consider if they need to develop more frequent storm modeling.

PERFORMANCE – The design or geologic conditions that could lead to failure, along with their probability, will be identified.

EXPOSURE – The risk assessment will have developed a category of the study area described as the "population at risk," identifying those who are exposed to the hazards.

VULNERABILITY – There will be some assumptions about the population's ability to mobilize, but considerations of social vulnerability will likely need to be explored in greater detail.

CONSEQUENCES – There will be an annualized characterization of the life loss, which will be a subset of the population at risk.

This risk assessment will be for the existing condition, so project delivery teams will need to ask when looking at the "future without project" condition: "Does the type and/or magnitude of the life risk remain consistent into the future, or does it increase or decrease as compared to the existing condition?"

What To Do When You're Considering New Infrastructure

When considering a new coastal storm risk management or flood risk management project, the project delivery team can find relevant information that can inform early characterizations of life risk in each of the areas of the conceptual risk model of hazard, performance, exposure, vulnerability, and consequence:

HAZARD – FEMA Floodplain maps, USGS stream gage information, prior flood studies

PERFORMANCE – risk assessments for levees or dams near the study area may inform design considerations

EXPOSURE – National Structure Inventory, local land use maps

VULNERABILITY – CDC Social Vulnerability Index

CONSEQUENCES – Typically calculated by a life risk assessment

Table 1 shows a side-by-side comparison of developing a life risk assessment versus developing economic damages. Many of the inputs and tools are similar in both methodologies. Project delivery teams should consider from the scoping phase how the two overlap and what tasks may be necessary to fully develop the life risk assessment.

Identify Problems and Opportunities

Key questions for a study team during scoping are: "What is the level of life risk in the study area? Which problems contribute to the life risk in a study area and are there opportunities to reduce the risk to human life?"

Once a study team identifies that certain problems exist in the study area, the first step in understanding them is to identify the cause or hazard at the root of each problem. Next, the study team must identify the specific harm or negative outcome associated with the identified hazard.

Thinking About Life Risk

The study team should develop a narrative of the sequence of events leading to life risk, with discussion of hazard, performance, exposure, vulnerability, and consequences.

HAZARD

Flood Frequency: Generally, more frequent flooding can impact annualized life loss more than less frequent flooding. However, the less frequent (larger) floods will tend to have higher event life loss.

Type of Hazard: Long-forming hurricanes and flash floods have different speeds of onset.

Flood Velocities: Higher velocities usually result in higher life risk.

Flood Arrival Times: Shorter flood arrival times usually result in higher life risk.

Flood Depths: Greater depths are typically associated with higher life risk.

PERFORMANCE – Flood risk management features that have less reliable performance have higher life risk than more reliable features.

EXPOSURE – Areas with lower levels of emergency preparedness have higher potential life risk consequences than those implementing preparedness best practices. Highly developed areas have higher potential life risk consequences than undeveloped areas. Critical infrastructure (fire, police, hospitals) and how they are impacted in a flood event can plan a key role in life risk.

VULNERABILITY – Older populations tend to be more vulnerable than younger populations. Economically disadvantaged communities tend to be more vulnerable than economically advantaged communities.

CONSEQUENCES – If vulnerable populations cannot evacuate, there will likely be higher life risk.

Sample Problem Statements

HAZARD PROBLEM STATEMENT

- The city of Omaha, NE experiences seasonal flooding of the Missouri River that damages residential and commercial property and creates life risk.
- The city of Savannah, GA may experience a hurricane which damages property and infrastructure, and creates life risk.

PERFORMANCE PROBLEM STATEMENT

- The flood diversion system may fail during a flood with little or no warning, resulting in economic damages and life loss.
- The beach nourishment project may provide limited reduction of damage if a large storm is experienced.

EXPOSURE PROBLEM STATEMENT

- Critical infrastructure in the Florida Keys, including fire stations, airports, hospitals, etc., are vulnerable to damage from inundation caused by coastal storm surge, and this impact on emergency and human services contributes to life risk.

VULNERABILITY PROBLEM STATEMENT

- Low income communities may lack transportation and require assistance with evacuation.

CONSEQUENCES PROBLEM STATEMENT

- The structure inundation caused by coastal storm events creates life safety risks to the population of the Florida Keys.

Sample Opportunity Statements

- Improve critical infrastructure functionality during flood and/or coastal storm events to better maintain emergency and critical services to the population in the study area.
- Improve resilience of the study area to flood/coastal storm events.
- Reduce the vulnerability of U.S. Route 1, the primary and only evacuation route from the Florida Keys, to the effects of coastal storms, including limited vehicle travel and damage to the roadway structure.

Identify Objectives and Constraints

Teams must identify and consider objectives that are responsive to national, state, and local concerns, including public safety and community resilience, when undertaking studies.

Objectives and constraints are used to define plan success. Planning objectives specify what the recommended project should accomplish. Good planning objectives are specific and measurable. Constraints related to life risk are going to be about avoiding increases to residual or incremental life risk.

When a plan addresses one or more study objectives and avoids constraints, there should be a measurable level of benefit or risk reduction in the future “with project condition” as compared to the “future without project.” When writing objectives or constraints for life risk, keep in mind whether your problem involves residual life risk, incremental life risk, or both.

Sample Objective Statements

- Reduce the residual life risk related to flood events in the study area through the period of analysis.
- Reduce the incremental life risk at the dam over the period of 50 years.
- Reduce the risk to human life, health, and safety to the population in the Florida Keys that is caused by the inundation of development and critical infrastructure and the reduced evacuation efficiency that is associated with coastal storm events over the 50-year period of analysis.

Sample Constraint Statements

- Do not increase the residual risk with the existing levee system within the study area over the period of analysis.
- Do not recommend a plan that increases life risk.
- Do not recommend a plan that transfers life risk to other locations within and/or outside of the study area.

Plan performance questions may be important to identify unintended effects of alternatives; for example, some measures may reduce economic damage but also create or exacerbate life risk.

Identify Key Uncertainties

A strategy in risk-informed planning is to reduce uncertainty strategically to enable the study team to effectively and efficiently identify the "tentatively selected plan" (TSP). The goal of this task during the first iteration of the risk-informed planning process is to identify the major sources of uncertainty that exist, as understood at the start of the study. At the beginning of a flood or coastal storm risk study, there is often a significant amount of uncertainty surrounding the likelihood and consequence components of life risk.

Questions that focus on the characterization of life risk and development of problem statements might address the uncertainty surrounding the likelihood and/or magnitude of future flood or coastal storm events, distribution or amount of population at risk in the study area, and how vulnerable the population is.

When considering objectives and constraints, questions should identify the information needed to determine whether plans meet the objective to reduce life loss and/or avoid constraints established to reduce life risk.

Acknowledging and displaying uncertainty, when appropriate, is important when using life risk as a criterion in evaluation or decision-making. What inputs are the most sensitive in the model being used? What happens when those inputs are changed?

Forecast Future without Project Conditions

Life risk is a critical aspect of the future without project condition and may or may not share the same risk drivers as those that generate economic damage and other study problems. The future is inherently uncertain and conditions change over time, so teams should consider how the type and/or magnitude of the life risk may change from the existing condition in the future. For example, risk may change if there is upstream development or watershed restoration that can affect flood frequency, flood elevations, and flow velocities.

Available data, local and regional plans, and zoning and other evidence should be used to identify the most likely future scenario. The future without project forecast should include any projects or initiatives that will be completed by others that affect the level of risk in the study area.

Examples of Future Conditions that may Impact Life Risk

- Population growth trends.
- Planned development and projected rate of growth.
- Projected sea level change or relative sea level change.
- Climate change and associated changes in rainfall and runoff.
- Projected changes to hydrology.
- Projects and/or initiatives by others, both within the study area and outside of it (ex. upstream) that would impact conditions that contribute to life risk.

- Expected performance of existing projects in the future/throughout the period of analysis.
- Expected legal responsibilities of the non-Federal partner, including operation, maintenance, repair, replacement, and rehabilitation responsibilities.

Identify Decision Criteria

The study team must identify the list of criteria that will be used to evaluate alternatives and identify the tentatively selected plan. Specific metrics should be established to facilitate decision making throughout the planning process. In identifying decision criteria for life risk, the study team must determine how life risk is best characterized or quantified in an objective way throughout the study. This means the study team must have a good understanding of their problem – is the problem residual life risk or incremental life risk? Is the problem more related to the hazard, performance, or consequences? Can the hazard occur suddenly, or is there a long warning time? Is the population disadvantaged and more vulnerable to harm?

Establishing metrics for qualitative assessments of life risk requires critical thinking and should be chosen carefully based on key risk drivers identified in your flood system.

Early in the study, during initial screening of measures, the uncertainties will be higher and criteria may be more general and qualitative, while the evaluation of plans includes a more detailed quantitative analysis if life risk is a significant concern.

Sample Life Risk Screening and Evaluation Criteria

LIFE RISK (OVERALL)

Average annual life loss – Similar to traditional economic risk assessments, residual life risk can be represented as through an “expected” or “average annual” value, in this case Average Annual Life Loss (AALL). AALL describes the average annual life loss that would be expected considering the full range of potential events and their likelihood to occur. It is the long-term average life loss for the assessed conditions. AALL is used to describe residual life risk and show how it changes between different project conditions.

HAZARD – Flooding depth

PERFORMANCE – Flood velocity

EXPOSURE – Evacuation rates, warning time/ flood arrival time

VULNERABILITY – Vulnerable populations - low income, lack transportation, elderly, hospitalized

CONSEQUENCES – Anticipated life loss based on single events

PLAN FORMULATION

The use of strategies to formulate measures and combine measures into alternative plans is good practice.

When developing formulation strategies for life risk, keep in mind the components of risk. Think about measures that could be combined to reduce the risk associated with the hazard, performance, exposure, vulnerability, or consequences.

Sample Plan Formulation Strategies

- Improve the performance of existing project . *(Strategy focused on Performance)*
- Reduce impacts flooding and coastal storms have on critical infrastructure. *(Strategy focused on Vulnerability)*
- Maximize the ability to evacuate the population (including vertical evacuation). *(Strategy focused on Consequences)*
- Reduce the exposure to a specific hazard associated with the flood or coastal storm event, e.g., focusing on plans that would address the life risk associated with wave and erosion vs. storm surge flooding. This can be useful if there are multiple drivers contributing to the overall hazard and different measures are better suited to address each of the drivers. *(Strategy focused on Hazard)*

- Improve evacuation plans. *(Strategy focused on Exposure)*
- Reduce life risk to the most vulnerable populations. *(Strategy focused on Vulnerability)*

Communities and facilities may have emergency plans in place. Critical elements of these emergency plans should be considered in relation to the alternatives developed. Consider evacuation timing, evacuation routes, and reliance on electrical power if sheltering in place.

Identify Measures

The first formulation task is to identify measures that meet one or more planning objectives. When identifying measures, consider which ones would meet the objective to reduce life risk. Again, a good place to begin is to consider the components of life risk, measures that could reduce the hazard, performance, exposure, vulnerability, or consequences. Try to identify measures for each component; many of the sample measures listed may impact multiple components of the risk equation.

Sample Measures to Reduce Life Risk

- Flood bypasses *(Measure primarily impacts Hazard/ Exposure)*
- Beachfill (for berm and/or dune improvement) *(Measure primarily impacts Performance)*
- Channel Improvements *(Measure primarily impacts Performance/Exposure)*
- Flood walls/Sea walls *(Measure primarily impacts Performance/Exposure)*
- Levees *(Measure primarily impacts Performance/ Exposure)*
- Dams *(Measure primarily impacts Performance/ Exposure)*
- Surge barriers/tide gates *(Measure primarily impacts Performance/Exposure)*
- Buyouts/Acquisition *(Measure primarily impacts Exposure/Vulnerability)*
- Floodplain Management/Zoning Changes *(Measure primarily impacts Exposure)*
- Emergency Action Plans, including shutting down/ limiting access to inundated roads *(Measure primarily impacts Consequences)*
- Warning Notification such as Reverse 911 or warning sirens *(Measure primarily impacts Consequences)*
- Evacuation Route Signage *(Measure primarily impacts Consequences)*
- Elevation of structures *(Measure primarily impacts Consequences)*
- Dry floodproofing *(Measure primarily impacts Consequences)*

Combine Measures to Build Plans

The plan formulation strategies identified offer guides on combining the screened measures into alternative plans. Alternatives that are formulated according to a plan formulation strategy for reduced life risk may include different measures than an alternative that is formulated to reduce risk to structures in order to reduce damage.

It is also important to remember that some flood or coastal storm risk management measures may reduce economic damage to structures, but have life risk consequences. When building alternative plans, complimentary measures need to be considered. The plans below are samples showing what measures may be included in a plan that meets one of the example plan formulation strategies discussed above.

	EXAMPLE INPUTS TO ECONOMIC BENEFIT CALCULATIONS	EXAMPLE INPUTS TO LIFE LOSS CALCULATIONS
HAZARD	▪ Peak water surface elevation for range of inland/riverine flood events ▪ Range of coastal storm events that vary in track and intensity causing storm surge flooding, erosion, and/or wave attack ▪ Duration of events	▪ Peak water surface elevation for range of inland/riverine flood events ▪ Range of coastal storm events that vary in track and intensity ▪ Duration of events
PERFORMANCE	▪ Existing infrastructure performance ▪ Potential failure modes analysis (system response curves)	▪ Existing infrastructure performance ▪ Potential failure modes analysis (system response curves)
EXPOSURE	▪ Structure inventory ▪ Critical facilities ▪ Road infrastructure	▪ Population at risk ▪ Critical facilities ▪ Structure inventory ▪ Road infrastructure
VULNERABILITY	▪ Type of structure ▪ Expected performance of structure ▪ Location of structure ▪ Building materials ▪ First floor elevation	▪ Characteristics of the population affecting their ability and likelihood to respond to the hazard or warnings ▪ Public awareness and ability to act ▪ Housing/sheltering characteristics ▪ Expected performance of structure ▪ Location of structure ▪ First floor elevation
CONSEQUENCES	▪ Structure damage ▪ Agriculture damage ▪ Emergency costs ▪ Vehicle transportation delays/impacts	▪ Evacuation disruption ▪ Life loss

Table 1: Example Inputs to Evaluating Economic and Life Loss Calculations

Sample Alternative Plans

Maximize the ability to evacuate the population (including vertical evacuation)

- Emergency Action Plans
- Warning Notification such as Reverse 911 or warning sirens
- Evacuation Route Signage

Reduce the exposure to a specific flood hazard, in this example riverine flooding

- Flood bypasses
- Elevation of structures
- Buyouts/Acquisition

Reduce impacts flooding and coastal storms have on critical infrastructure in a coastal city at the confluence of a river

- Floodwalls/seawalls
- Flood bypasses
- Levees
- Surge barriers/tide gates
- Beachfill
- Dry floodproofing
- Building codes to require elevated infrastructure; elevate infrastructure

Improve performance of existing infrastructure for a coastal storm risk management project

- Beachfill to increase size of existing beach berm and dune
- Breakwaters to maintain beachfill and reduce wave energy

Change or Reformulate Plans as Necessary

Once the study team formulates an array of plans and completes the deciding phase of the planning process, there is usually at least one plan that does not meet study objectives but can be improved upon to do so. Reformulation may add or reduce the measures included in a plan to improve it. Reformulation may be necessary if the study team realizes that there are life risk consequences generated by a plan, or perhaps if there are life safety benefits that could be increased by reformulating a plan.

Measures and plans need not be limited to those USACE could implement directly under current authorities. Plans may include specific measures or multiple measures that could be implemented under authorities of other federal agencies, state and local entities, and non-government interests.

DECIDING

During a feasibility study, the project delivery team identifies the criteria necessary to evaluate and compare alternatives to identify a plan that best meets study objectives. In this "Deciding" phase, evaluation and comparison of plans is informed by what is driving the life risk.

When the objective is to reduce residual life risk, project delivery teams will focus on cost-effective risk reduction. When the objective is to reduce incremental life risk, project delivery teams rely heavily on cost-effectiveness and whether or not the alternatives address or meet the USACE Dam Safety and Levee Safety Programs' tolerable risk guidelines.

Evaluate the Benefits of the Alternatives

Table 1, above, compares the inputs to the typical calculation of economic benefits and life risk for flood and coastal storm risk management studies. The intent is to show that calculations of life risk are similar and that data generated for the required economic ("national economic development," NED) calculations likely can be used in life risk calculations.

Plan evaluation includes forecasting and displaying the outputs of your decision criteria – which should include life risk. This future with project scenario is compared to the future without project scenario to determine the magnitude of risk reduction provided by each alternative. This comparison is key to understand what is driving your life risk when deciding how to evaluate your plans.

Completing a qualitative evaluation matrix is one way to evaluate the factors that either contribute to life risk or reduce it. The team should include criteria they consider important in the evaluation of a plan for life risk effects, but must take care not to double count the same impact. The team must describe the scoring method, how each term is defined (e.g., minor, moderate, significant or low, medium, high), and the assignment of each score. Table 2 is an example of this kind of evaluation.

MEASURE	FACTORS		
	Warning Time	Evacuation Rates	Reduced Impact on Vulnerable Population
No Action	Medium	Low	Low
Relocations	High	Low	High
Home Raises	Medium	High	Medium
Levee	High	Medium	High
Bypass	High	Medium	High
Building Codes	Medium	High	Low
Evacuation Planning	High	Medium	Low
Warning Time	*Based on hazard forecasting ability. High would improve warning time to greater than 24 hours, Medium warning time would be expected to be between 6 and 24 hours, Low would be warning time less than 6 hours*		
Evacuation Rates	*Based on evacuation rates. High would represent evacuation of all except those who cannot or will not evacuate, Medium would represent evacuation of greater than 90% of the population at risk, Low would represent evacuation of less than 90% of the population at risk*		
Reduced Impact on Vulnerable Population	*Based on structure inventory and census data. High would have less than 25% of the population at risk considered vulnerable, Medium would have 26-50% of the population at risk considered vulnerable, Low would have greater than 50% of the population at risk considered vulnerable*		
Note: When using qualitative evaluations it is important to base your evaluations on evidence of some kind.			

Table 2: Example Qualitative Evaluation Matrix Comparing Measures to the "No Action" Alternative

SPECIAL CONSIDERATION FOR LEVEES AND DAMS: TOLERABLE RISK GUIDELINES

When a levee or dam is part of an existing flood risk management system, or additional measures are being considered to further manage risk, special consideration needs to be given to the potential performance and associated consequences for existing infrastructure. This special consideration is referred to as incremental risk.

To guide understanding of the significance of the incremental risk, USACE has developed tolerable risk guidelines for levees and dams. At its most basic, tolerable risk guidelines ask the questions: Are the risks commensurate with the benefits?; Are risks being assessed, managed, and communicated?; Is the owner acting reasonably?; and Is there more that should be done?

The USACE Dam Safety and Levee Safety Programs provide additional guidance and explanation for the use of tolerable risk guidelines when conducting a risk assessment to inform the formulation and design of flood risk management projects including levees and dams. There are four areas (or guidelines) used by USACE in evaluating levees and dams:

TOLERABLE RISK GUIDELINE 1 – Understanding the Risk (Risk Assessment). The first tolerable risk guideline asks: Is the incremental life risk commensurate with the benefits when considering life safety, economic, and environmental benefits? To answer this question, there must be an understanding of the incremental risk associated with the project.

TOLERABLE RISK GUIDELINE 2 – Building Risk Awareness (Risk Communication). The second tolerable risk guideline involves determining if there is a continuation of recognition and communication of the residual risk (awareness) in the community.

TOLERABLE RISK GUIDELINE 3 – Fulfilling Daily Responsibilities (Risk Management). The third tolerable risk guideline involves determining if the risks associated with the project are being monitored and managed properly by those responsible for managing the risk.

TOLERABLE RISK GUIDELINE 4 – Actions to Reduce Risk (Risk Management). The fourth tolerable risk guideline is determining if there are cost effective, socially acceptable, or environmentally acceptable ways to reduce risks from an individual or societal risk perspective.

If you have any questions about how these tolerable risk guidelines are evaluated in the context of a dam or levee risk assessment, seek out your district's dam or levee safety program manager.

ALTERNATIVE	ALTERNATIVE PLAN DESCRIPTION	AVERAGE ANNUAL COST (1000S)	AVERAGE ANNUAL LIFE LOSS REDUCED	COST EFFECTIVE
Alt 1	No Action	$0	0	Best Buy
Alt 2	Non-Structural	$1,000	0.2	Best Buy
Alt 3	Levee 3	$2,000	0.3	Cost Effective
Alt 4	Levee 3 + Non-Structural	$3,000	0.5	Best Buy
Alt 5	Levee 5	$5,000	0.4	Non-Cost Effective
Alt 6	Levee 6	$6,000	0.3	Non-Cost Effective
Alt 7	Levee 7	$7,000	0.7	Cost Effective
Alt 8	Levee 5 + Non-Structural	$6,000	0.6	Cost Effective
Alt 9	Levee 6 + Non-Structural	$7,000	0.5	Non-Cost Effective
Alt 10	Levee 7 + Non-Structural	$8,000	0.9	Best Buy
Alt 10b	Levee 7b + Non-Structural	$10,000	0.9	Non-Cost Effective
Alt 11	Levee 11 + Non-Structural	$16,000	1	Best Buy

Table 3. Cost Effectiveness Analysis for Alternative Plans

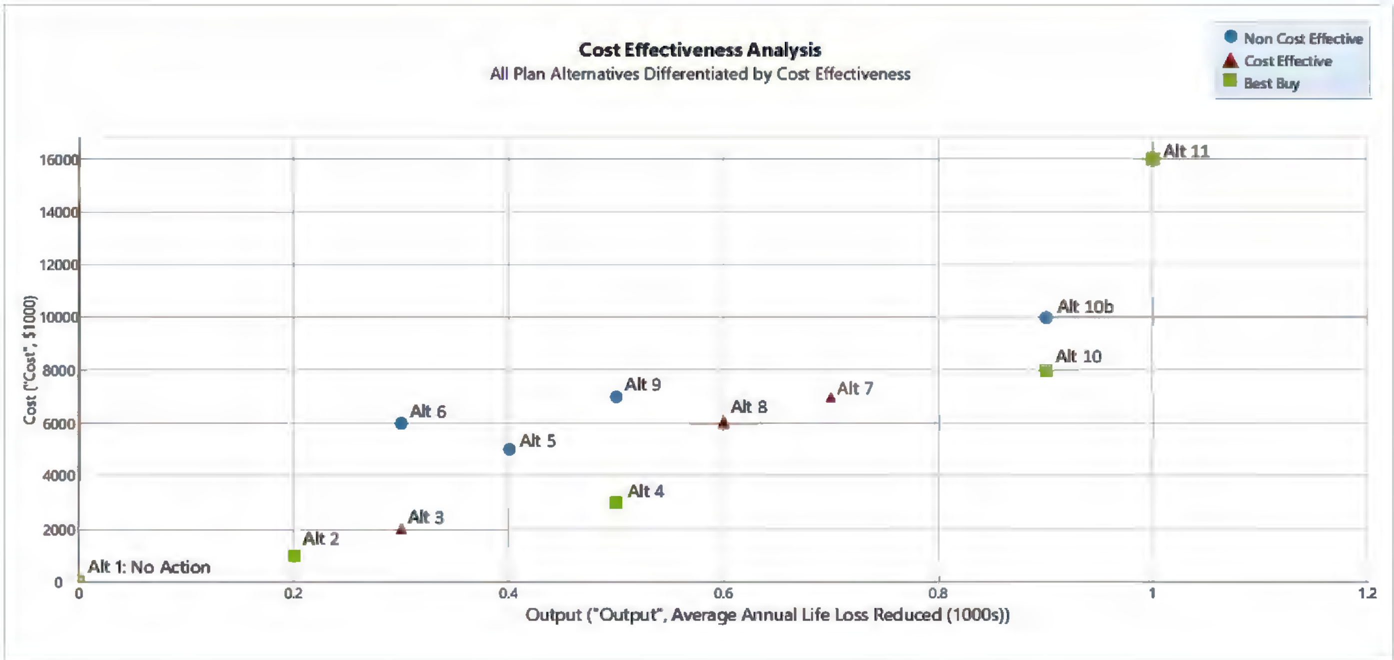

Figure 4. Cost Effectiveness Analysis for Alternative Plans

Comparing Alternatives

Plan comparison can be described as a reiteration of the evaluation step, but with each of the plans compared to each other instead of the future without project scenario. The quantitative and qualitative evaluations are presented in the study's decision document in graphical or tabular forms, with an accompanying explanatory narrative.

The key metric for life risk in plan comparison is reduction in life risk. Again, there are no targets for reducing residual life risk. As with other non-monetary decision criteria, a good way to compare life risk across plans is by using cost-effective, incremental cost analysis (CE/ICA) with reduction in average annual life loss and economic cost of the alternative plans as inputs.

ALTERNATIVE	ALTERNATIVE PLAN DESCRIPTION (BEST BUY PLANS)	INCREMENTAL AVERAGE ANNUAL COST (1000S)	INCREMENTAL AVERAGE ANNUAL LIFE LOSS REDUCED	AVERAGE ANNUAL COST PER AVERAGE ANNUAL LIFE LOSS REDUCED (1000S)
Alt 1	No Action	$0	0	$0
Alt 2	Non-Structural	$1,000	0.2	$5,000
Alt 4	Levee 3 + Non-Structural	$2,000	0.3	$6,667
Alt 10	Levee 7 + Non-Structural	$5,000	0.4	$12,500
Alt 11	Levee 11 + Non-Structural	$8,000	0.1	$80,000

Table 4. Incremental Cost Analysis for Best Buy Alternative Plans

CE/ICA are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative plan's output cannot be produced more cost effectively by another alternative. "Cost effective" means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a "best" level of output within the limits of both the sponsor's and USACE's capabilities. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of non-monetary benefits. Those most efficient plans are called "Best Buy" plans.

Table 3 shows the outputs of a cost effectiveness analysis comparing the economic cost of alternatives to the reduction in residual life risk, measured in the reduction in average annual life lost (AALL). Figure 4 is a graphical representation of Table 3. Note that some alternatives are identified as non-cost effective and are not included in the subsequent incremental cost analysis.

Table 4 shows the results of the incremental cost analysis for the Best Buy alternatives. The incremental cost per unit is equal to the change in cost divided by the change in AALL reduced for each subsequent alternative. Figure 5 is a graphical representation of Table 4.

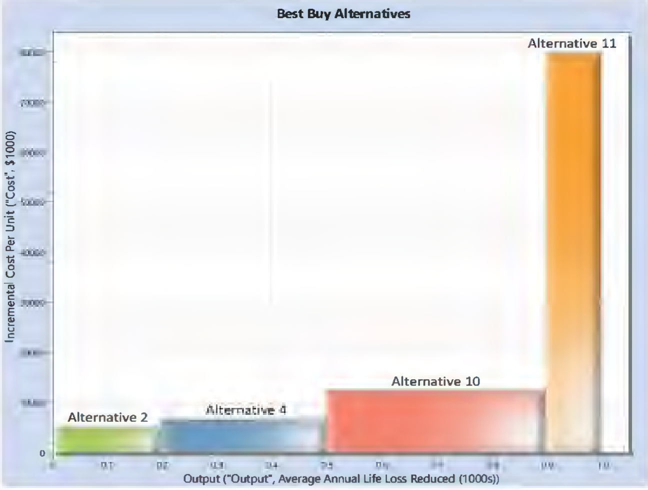

Figure 5. Incremental Cost Analysis for Best Buy Alternative Plans

Alternatives that include dams or levees are also evaluated against the tolerable risk guidelines established by the USACE Dam Safety and Levee Safety Programs, and are compared against each other with respect to how each alternative meets or does not meet the guidelines. Primary consideration should be given to evaluating alternatives against tolerable risk guidelines for Understanding the Risk (risk assessment), and Actions to Reduce Risk (risk management), although best practice would evaluate across all four guidelines.

For evaluating a plan against USACE's tolerable risk guidelines, questions like the following help evaluate and even influence plan formulation for plans that will address life risk.

ALTERNATIVE	COST*	RISK REDUCTION *(ORDER OF MAGNITUDE)***	TRG: UNDERSTANDING THE RISK *(F/P/N)****	TRG: ACTIONS TO REDUCE RISK *(F/P/N)****	REAL ESTATE IMPACTS *(L/M/H)*	ENVIRONMENTAL IMPACTS *(L/M/H)*
No Action	$0	0.0	N	P	L/M	L
Filtered Berm with Toe Drains *(RECOMMEND TSP)*	$150M	3.0	P	F	L/M	L
Full Cutoff Wall	$390M	2.5	P	F	H	H
Residential Buyout	$300M +	2.5	F	F	H	H

** Cost is a Class 4 Cost Estimate*

*** Average Annual Life Loss is often expressed in scientific notation and plotted on logarithmic scales. A change in an order of magnitude refers to a change in a factor of ten (i.e. from 10 to 100, or 1,000 to 10,000)*

**** TRGs - Fully Met (F); Partially met (P); and Not met (N)*

Table 5: Incorporating Life Risk Criteria in Comparing Alternative Plans

- Does the levee sponsor(s) have access to and are they aware of the best available levee risk information?
- Has the local emergency management agency in the leveed area been provided the best available risk information associated with the levee system?
- Have flood risk (residual risk) and potential changes to flood risk over time been communicated to the community?
- Is USACE or the levee district acting as reasonable dam or levee owners?
- Have appropriate actions been taken to reduce risks?
- Could any actions reasonably be taken that would reduce risks further?

Table 5 evaluates alternatives for a levee project on incremental life risk (measured by order of magnitude reduction), and whether or not the alternative meets tolerable risk guidelines for Understanding the Risk (risk assessment) and Actions to Reduce Risk (risk management).

Other life risk considerations in alternative plan comparison are transfers and transformations of life risk. Teams should describe which factors are driving the remaining life risk in their study area and transfers or transformation of life risk, such as from one area to another.

IMPLEMENTATION

Identify the Tentatively Selected Plan

Study teams must clearly explain and document their rationale for identifying a tentatively selected plan (TSP). When life risk plays a role in the identification of that plan, the study team must describe if and how the plan selection was impacted by the consideration of life risk. Planning guidance requires teams to select the plan that reasonably maximizes net benefits. If life safety is an important consideration, a team could recommend a life safety plan that does not have the maximum “national economic development” (NED) outputs if that plan shows a greater reduction in life risk. However, this policy exception to the NED recommendation would have to be approved by the Assistant Secretary of the Army for Civil Works (ASA (CW)). Teams should be prepared to discuss the reasoning and importance of life risk benefits in relation to their TSP.

When a team is making a recommendation primarily on life risk, the consideration should be for an effective, efficient, and environmentally acceptable alternative. For residual life risk, an approach like CE/ICA, shown in Figures 4 and 5, could be used in helping to identify the tentatively selected plan, with consideration of other benefit categories such as NED or Other Social Effects.

Complete Risk Assessment of the Tentatively Selected Plan

Teams must assess residual life risk which remains with the tentatively selected flood or coastal storm risk management plan. When a TSP selection includes life risk, either residual or incremental, the TSP risk assessment should be a semi-quantitative or quantitative risk assessment.

The analysis that was used in the evaluation of plans can be used as the basis for the tentatively selected plan (TSP) life risk assessment, but the team should also identify any new, transformed, or transferred life risk that are generated by the TSP. These risks could be grounds for selecting a different plan, even if it is not the NED plan, or scaling up or down measures within the TSP.

One tip to developing the risk assessment is to use "Inverse Brainstorming." Inverse brainstorming allows people to ask themselves: What can go wrong? What could prevent us from achieving our benefits? Does our plan create new hazards or transfer existing ones to another area?

The risk assessment of a flood risk management project that relies on levees, for example, would include consideration of the risk of levee failure or overtopping, increases in the number of lives and property at risk attributable to the project and induced flooding, in addition to characterizing the residual risks.

Qualitative assessments of life risk may be appropriate earlier in the study or when life risk is not anticipated to affect the decision. However, any study that plans to make recommendations based on life risk must take a step beyond qualitative risk assessment and utilize semi-quantitative or quantitative risk assessment.

If the TSP includes either a new or an existing dam or levee, then the risk assessment needs to evaluate the TSP with respect to USACE Dam Safety or Levee Safety Programs' tolerable risk guidelines. The goal is to understand how the TSP may affect life risk and what could prevent the TSP from generating the expected reduction in life risk.

Figure 6 is an example where a project delivery team was considering sites for new dams in an FRM study. The project delivery team wanted to evaluate the potential incremental life risk of the new dams. In this study area, there were existing USACE dams with completed life risk assessments. The new dam sites had very similar site conditions to the existing dams, therefore the project delivery team was able to utilize the existing dams' life risk information to make evaluation and comparison decisions for the new dam sites, specifically that the incremental life risk of the new dams was expected to meet tolerable risk guidelines.

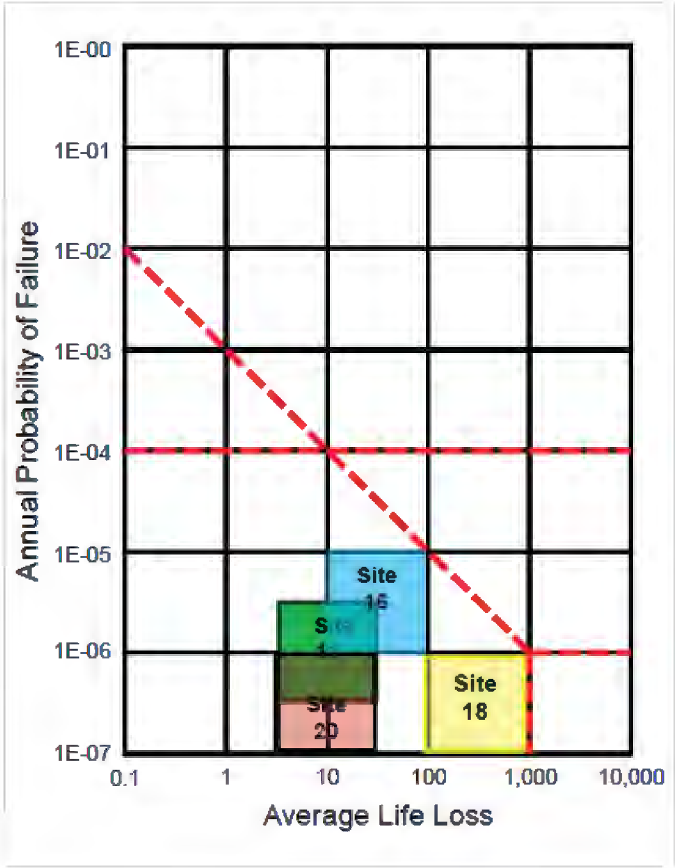

Figure 6. Evaluation of new dam sites using existing incremental life risk of near-by dams

Complete Feasibility-Level Analysis of the Recommended Plan

The selection of a recommended plan will be informed by comparison across all four accounts: national economic development; regional economic development, national ecosystem restoration; and other social effects. "No action" is the presumed future condition. For a plan to be recommended for implementation, it must be demonstrated that it provides positive contributions beyond the "no action" alternative.

Under current policy, USACE recommends the plan that reasonably maximizes net national economic development benefits, known as the NED plan, unless an exception is granted by the ASA(CW). Plans that can be shown to reduce life-safety risk, consistent with the objectives of cost-effectiveness, meeting tolerable risk guidelines, and addressing societal concerns, may be proposed for such an exception.

PLAN	NET NED BENEFITS	CHANGE IN LIFE RISK
No Action	–	–
New Levees (NED Plan)	$100 M	None
New Levees and Warning Improvement (Recommended Plan)	$95 M	1 order of magnitude reduction in life risk

Table 6: Presenting the Recommended Plan and NED Plan

If the study is addressing incremental risk, the ways in which the plan does or does not achieve all tolerable risk guidelines are described. An example of how to display in tabular format compliance with tolerable risk guidelines is shown in Table 5. Incremental life risk can also be presented on an F-N plot as shown in Figure 6. Lastly, narrative descriptions of how a plan does or does not achieve all tolerable risk guidelines should be included in the report.

When describing the recommended plan in the report, the study team should make it clear to what level the life risk is reduced and whether there are tradeoffs to achieve that risk reduction. For example, the study team may choose to recommend the alternative that is not the NED plan, but the one that best meets a study objective to reduce life risk and has other positive social effects. The decision document should explain how the study team made this choice and explain why the recommended plan was selected.

For example, the rationale could include any of the following:

- The NED plan increases life risk within the study area, and the study team determined the life risk is not an acceptable condition to achieve more economic benefit.
- The NED plan transfers life risk to another location within and/or outside of the study area.
- There is a plan that generates slightly less economic benefit, but significantly more reduction in life risk than the NED plan.
- There is a locally preferred plan that has been requested by the non-federal partner that would provide a more significant reduction in life risk than the NED plan.

PRESENTING LIFE RISK INFORMATION

The effective communication of life risk first requires an understanding of the life risk that exists in the existing and future without project conditions so that the reader understands what the baseline risk is without federal action. The decision document should then outline how each of the different alternatives affect life risk vs. that baseline condition.

Engineer Regulation 1105-2-101, Risk Assessment for Flood Risk Management Studies, provides guidelines for evaluating and documenting risk, including life risk, in decision documents. Study teams should work to balance the reporting of required technical information and the readability of the document by the public and other agencies. Study teams should consider how the report narrative is conveying the required information in a way that also tells the story to a more general audience.

When communicating the assessment and management of life risk, the study team should consider:

- Evaluate, compare, and describe life risk effects for each alternative in terms of the various factors that contribute to overall life risk (e.g., flood depth, timing, and velocity).
- Framing bias occurs when people make a decision based on how information is presented. Life risk is very susceptible to this bias. For example, "average annual life loss" is typically a very small number, and

people are predisposed to treat smaller numbers as less consequential. Project delivery teams should consider presenting change in life risk as percentages in addition to average annual life loss.

- Reports need to present average annual life loss, not just life loss for specific events. However life loss for specific hypothetical or past events can help people contextualize the consequences.
- Choose intuitive ways of displaying data. Note, F-N plots can describe incremental life risk or residual life risk and are the standard USACE method for conveying risk characterization, however F-N plots will generally need additional explanation because most lay audiences are not familiar with them.
- In addition to describing how the recommended plan impacts life risk, capture how actions by others, including the non-federal sponsor, other federal or state agencies, and non-governmental organizations, affect the overall life risk.

CONCLUSION

Assessing risk and communicating risk are the two major elements in order to drive action to reduce life risk. Life risk must be considered and integrated from the beginning of any study. It is as basic a consideration as economic damages. Analysis focuses on establishing life risk with and without project and reducing uncertainty related to the results of the analysis. After the initial assessment, the level of effort is scaled to the importance of life risk for a specific study. A holistic view is essential including agencies outside the federal government, non-governmental organizations and the public.

> ***"Assessing and communicating risks to establish effective courses of action and shared expectations for likely outcomes, both internal and external to USACE, is an essential element of good business practice."***
>
> *— Risk-Informed Decision Making for Program and Project Delivery (Director's Policy Memorandum 2020-04)*

Analysis is not the end point. Analysis without clear communication appropriate to the audience is virtually useless to drive action that will reduce life risk. Life risk can be challenging to present; however, there are experienced professionals within the agency who can assist.

To paraphrase the Director's Policy Memorandum 2020-04, risk is inherent in all of our work, and no risk is more important to consider than life risk.

USACE Expertise in analyzing and presenting life risk information can be found in many programs and centers of expertise, including:

- Dam Safety Program
- Levee Safety Program
- Risk Management Center
- Levee Safety Center
- Mapping, Modeling & Consequences Center
- Flood Risk Management Planning Center of Expertise
- Coastal Storm Risk Management Planning Center of Expertise
- Institute for Water Resources
- Collaboration and Public Participation Center of Expertise
- Operations & Regulatory Division
- Asset Management Community of Practice

APPENDIX A

References

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