

**Principles and Guidelines for Evaluating Federal Water Projects:
U.S. Army Corps of Engineers Planning and the Use of Benefit Cost Analysis**

A Report for the Congressional Research Service

Final Report, August 2009

**A course capstone project from the
Evans School of Public Affairs
University of Washington**

Prepared by the members of PbAf 599D:

Jonathan Armah
Hande Ayan
Christina Bernard
Aaron Blumenthal
Lea Fortmann
Lori Reimann Garretson
Christopher Godwin
William Dean Runolfson¹

Coordinated by:
Tyler Blake Davis
Julie Vano²

Supervised by:
Dr. Richard O. Zerbe, Jr.
Dr. Joseph Cook

¹ Bethanne Barnes, Ross Gilliland, and Peter Teigen also contributed to the report.

² Corresponding authors' E-mail: tbdavis@uwashington.edu and jvano@u.washington.edu

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GLOSSARY OF ABBREVIATIONS

<i>BCR</i>	Benefit-cost ratio
<i>Corps</i>	U.S. Army Corps of Engineers
<i>CRS</i>	Congressional Research Service
<i>CVM</i>	Contingent Valuation Method
<i>EC</i>	Engineering Circulars
<i>EPA</i>	Environmental Protection Agency
<i>EQ</i>	Environmental Quality
<i>FEMA</i>	Federal Emergency Management Agency
<i>GRP</i>	Gross Regional Product
<i>HAPs</i>	Hazardous Air Pollutants
<i>HSDRRS</i>	Hurricane and Storm Damage Risk Reduction System
<i>IWR</i>	Institute for Water Resources
<i>LCA</i>	Least Cost Alternative
<i>MACT</i>	Maximum Achievable Control Technology
<i>MCDA</i>	Multi-Criteria Decision Analysis
<i>MRC</i>	Mississippi River Commission
<i>NED</i>	National Economic Development
<i>NFIP</i>	National Flood Insurance Program
<i>NRC</i>	National Research Counsel
<i>NRCS</i>	Department of Agriculture's Natural Resources Conservation Service
<i>OIRA</i>	Office of Information and Regulatory Affairs
<i>OMB</i>	Office of Management and Budget
<i>OSE</i>	Other Social Effects
<i>P&G</i>	Principles and Guidelines (Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies)
<i>P&S</i>	Principles and Standards for Planning Water and Related Land Resources
<i>PDA</i>	Property Damage Alternative
<i>PGN</i>	Planning Guidance Notebook
<i>Reclamation</i>	Department of the Interior's Bureau of Reclamation
<i>RED</i>	Regional Economic Development
<i>REMI</i>	Regional Economic Models Inc.
<i>RIDF</i>	Risk-Informed Decision Framework
<i>RPI</i>	Real Personal Income
<i>TCM</i>	Travel Cost Method
<i>TVA</i>	Tennessee Valley Authority
<i>UDA</i>	Upstream and Downstream Analysis
<i>UMRCP</i>	Upper Mississippi River Comprehensive Plan
<i>VSL</i>	Value of a Statistical Life
<i>WRDA</i>	Water Resources Development Act
<i>WTA</i>	Willingness-To-Accept
<i>WTP</i>	Willingness-To-Pay

SUMMARY

Federal water resource agencies, such as the Army Corps of Engineers (Corps), follow planning guidance when evaluating plans for federally funded water resource projects. Currently, for the Corps, the 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) is the foundation for guidance, with additional direction provided in executive orders, and other executive branch and agency directives. Congress mandated in the Water Resources Development Act of 2007 (WRDA 2007, P.L. 110-114) that the P&G be revised for the Corps.

The P&G outlines how to use a benefit-cost analysis (BCA) for evaluating and comparing alternative plans. However, in the decades since the P&G were adopted, there have been evolutions in methodological, environmental, social, and regional approaches and concerns that are not reflected in the original document. Federal agencies, academics, and stakeholder groups have provided some criticisms of the P&G and suggestions for revision. Given current science, economic theory, and information technology, there are numerous options for updating the P&G.

This report discusses use of BCA in the P&G and provides a Corps case study to illustrate current implementation. The discussion is organized into three parts: (1) A review of current practices of BCA in Corps' projects; (2) A review of literature identifying criticisms and recommendations for changes to the P&G; and (3) An assessment of a case study on the Upper Mississippi River Comprehensive Plan to illustrate the importance of, and challenges to, using BCA in project planning and analysis.

Issues with the existing P&G that critics suggest should be revised or included in an update include:

- (1) **Regional vs. National Accounts:** Whether to consider regional benefits separately from national benefits.
- (2) **Planning Area:** How to select a planning area that captures the potential area affected.
- (3) **Ecosystem Services:** How to consider ecosystem services and other non-monetary environmental values.
- (4) **Public Safety:** How to more explicitly include public safety in the analysis.
- (5) **Uncertainty:** How to manage the uncertainty in estimates of costs and benefits.
- (6) **Output Pricing:** How to better capture project costs.
- (7) **Floodplain Risk:** How to evaluate and compare structural and nonstructural alternatives and options.

A more detailed summary of these issues and options for addressing them in the P&G update can be found throughout the report in text boxes at the beginning of each specified section. Whether and how to address these issues represents a significant challenge to the current P&G update.

PART I. BACKGROUND: A P&G PRIMER

Scope and Organization of Report

This report is intended to inform policy-makers when considering how federal agencies involved in water resource management evaluate project proposals and alternatives. The principle federal water resource agencies are the U.S. Army Corps of Engineers (Corps), the Department of the Interior’s Bureau of Reclamation (Reclamation), the Department of Agriculture’s Natural Resources Conservation Service (NRCS), and the Tennessee Valley Authority (TVA). This report focuses on activities within the Corps (**Figure 1**), with an emphasis on flood damage reduction projects, although many of these same concepts apply to project evaluation in the other three agencies and for projects with other purposes. The Corps civil works program includes water resource development activities in three primary mission areas: flood control, navigation, and aquatic ecosystem restoration.

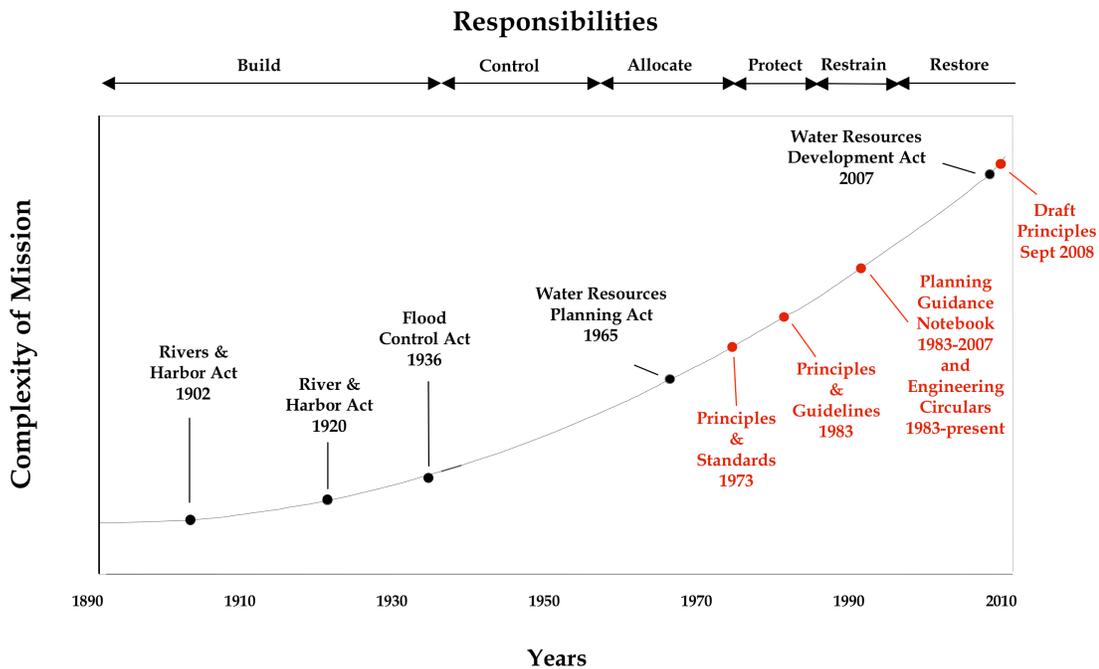


Figure 1. U.S. Army Corps of Engineers Planning Guidance. Conceptual representation of how the Corps’ mission has expanded and evolved, including significant legislation and federal water resources planning guidance. Items that relate specifically to benefit-cost analysis are indicated in red. Figure adapted from National Research Council’s report on *New Directions in Water Resources: Planning for the U.S. Army Corps of Engineers*.³

³ NRC. (1999). *New Directions in Water Resources: Planning for the U.S. Army Corps of Engineers*. National Academy Press. Washington, D.C.

Water resource projects affect both national and local economies through the construction and operations of facilities, the management of flood risk, the availability of hydropower and irrigation, the navigability of waterways for shipping, and the impact on the natural environment. Decisions regarding how public funds are allocated and which plans are implemented require tradeoffs that impact public safety and affect how costs and benefits of federal water resource spending are distributed. The *Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G)⁴ was published by the Water Resources Council in 1983 to provide the main basis for evaluating potential federal water resource projects and their alternatives. Since 1983, the P&G has been used by the Corps, Reclamation, NRCS, and TVA. This report provides a brief history of the P&G and earlier planning guidance, identifies existing criticisms, and provides an example of how the current P&G is being applied to a recent Corps project.

The report pays particular attention to issues in evaluating flood damage reduction (often called flood control) projects. Roughly 7% of all U.S. land area is located along rivers or streams in areas known as floodplains. Floodplains adjacent to rivers have historically provided flat, nutrient-rich land for agriculture. The combination of relatively low land prices in floodplain areas and existing flood protection structures, have led to urban and suburban encroachment, putting people, structures, infrastructure, and economic activities at risk of catastrophic flood.

Planning goals and analytical procedures for evaluation of new Corps projects are developed using guidance from Congress through statutes including Water Resource Development Acts, historic River and Harbor and Flood Control Acts, and the Water Resources Planning Act of 1965, the latter of which mandated development of principles, standards, and procedures for the evaluation of federal water and related land resources. Specifically, Congress mandated that the Water Resources Council:

Establish, after such consultation with other interested entities ... principles, standards, and procedures for Federal participants in the preparation of comprehensive regional or river basin plans and for the formulation and evaluation of Federal water and related land resources projects.⁵

The Act also specified that the principals and standards were to include economic evaluation:

The Council shall develop standards and criteria for economic evaluation of water resource projects. For the purpose of those standards and criteria, the primary direct navigation benefits of a water resource project are defined as the product of the savings to shippers using the waterway and the estimated traffic that would use the waterway.⁶

In response to this direction, the Water Resources Council produced the *Principles and Standard* (P&S) in 1973 which outlined how to evaluate benefits and costs of projects. In 1983 the *Principles and Guidelines* (P&G) replaced the P&S for federal water and related land resource

⁴ Water Resources Council. (1983). *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, D.C.: U.S. Government Printing Office.

⁵ WRPA 1962. U.S.C Title 42 Chapter 19B Subchapter 1 (a).

⁶ WRPA 1962. U.S.C Title 42 Chapter 19B Subchapter 1 (b).

projects undertaken by the four water resource agencies. Since then, the Corps has issued further implementation guidance, such as the *Corps' Planning Guidance Notebook* (PGN). U.S. Courts also have played a role in shaping federal water resource projects. Notwithstanding this other direction, the P&G have remained the primary basis for water resource project evaluations. Whether this guidance reflects current national concerns and methods has led to some controversy.

WRDA 2007 Revisions. In response to the scrutiny of ongoing criticisms and length of time since they were last updated, the U.S. Congress mandated in WRDA 2007 (Section 2031) that the Secretary of the Army issue revisions to the *Principles and Guidelines* within two years, which include the following:⁷

- (A) “Use of best available economic principles and analytical techniques, including techniques in risk and uncertainty analysis.
- (B) Assessment and incorporation of public safety in the formulation of alternatives and recommended plans.
- (C) Assessment methods that reflect the value of projects for low-income communities and projects that use nonstructural approaches to water resources development and management.
- (D) Assessment and evaluation of the interaction of a project with other water resources projects and programs within a region or watershed.
- (E) Use of contemporary water resources paradigms, including integrated water resources management and adaptive management.
- (F) Evaluation methods that ensure that water resources projects are justified by public benefits.”

Section 2033 of the act states that Corps feasibility studies of projects that would address flood damage reduction must include⁸:

- (1) “a calculation of the residual risk of flooding following completion of the proposed project (residual risk is the risk of flooding that remains after implementing a project to reduce the risk of flooding such as a levee);
- (2) a calculation of the residual risk of loss of human life and residual risk to human safety following completion of the proposed project;
- (3) a calculation of any upstream or downstream impacts of the proposed project; and
- (4) a calculation of benefits and costs associated with structural and nonstructural alternatives that ensures projects are evaluated in an equitable manner.”

In the context of on-going revisions to the Principles and Guidelines, this report considers existing practices and criticisms. Specifically, this report:

- (1) Analyzes current practices of benefit-cost analysis and steps required under the P&G

⁷ The following is from Section 2031 and Section 2033 of WRDA 2007.

⁸ Section 2032 of WRDA mandates that the President submit a report to Congress describing the vulnerability of the United States to damage from flooding.

- (2) Identifies, through a literature review, criticisms of the current P&G and recommendations for changes, made by experts and stakeholders
- (3) Presents a case study (the *Upper Mississippi River Comprehensive Plan* (UMRCP)) of how the current P&G are applied

The report is divided into three parts. Part I provides history and background on the P&G and the PGN, describes the mandate from Congress to revise the P&G, and briefly outlines the *Upper Mississippi Comprehensive Plan* (UMRCP). Part II highlights guidance elements and issues, summarizing the criticisms and recommendations for each and describing how the current guidance was applied to the UMRCP. Part III focuses on three issues specifically related to flood control projects: residual risk management, treatment of nonstructural approaches, and impacts of levees on economic development.

This document is intended to aid and inform policy-makers by considering:

- 1) the current benefit-cost analysis practice within the Corps;
- 2) criticisms of and options to modify current benefit-cost analysis practices; and
- 3) how current guidelines for benefit-cost analysis are implemented through a case study.

Benefit-Cost Analysis and the Principles and Guidelines

This section summarizes the guiding documents for using benefit-cost analysis (BCA) to evaluate the Corps' projects and reveals how and when changes have been made in BCA practice (**Figure 1**). First, the report reviews the policy rationale for conducting BCA and describes where it may be applied. Second, it reviews the history of BCA by tracing the legal foundations of BCA in national policy. Third, it summarizes BCA process as currently practiced. Finally, it provides an overview of the ways BCA processes have been modified since the publication of the P&G in 1983.

Benefit-Cost Analysis and Its Applications. In principle, BCA is intended to do two things: 1) “establish which public projects are likely to yield economic benefits” and 2) “furnish a basis for the apportionment of the cost” of such projects.⁹ Simply stated, BCA is “an accounting framework in which benefits and costs associated with a decision are set out for purposes of information and discussion.”¹⁰ Ideally, BCA provides objective information to a decision-maker about quantifiable costs and benefits in common (money-metric) terms. The decision-maker may then compare the costs and benefits of the decision and make a more informed decision. For example, when planning for flood protection, there will be costs from project construction and implementation and benefits from reduced flood risk (**Figure 2**). If decision-makers had information on benefits and costs of a range of different levels of flood protection, they could choose the level of protection that minimized total cost (labeled as “optimal minimum cost” in **Figure 2**).

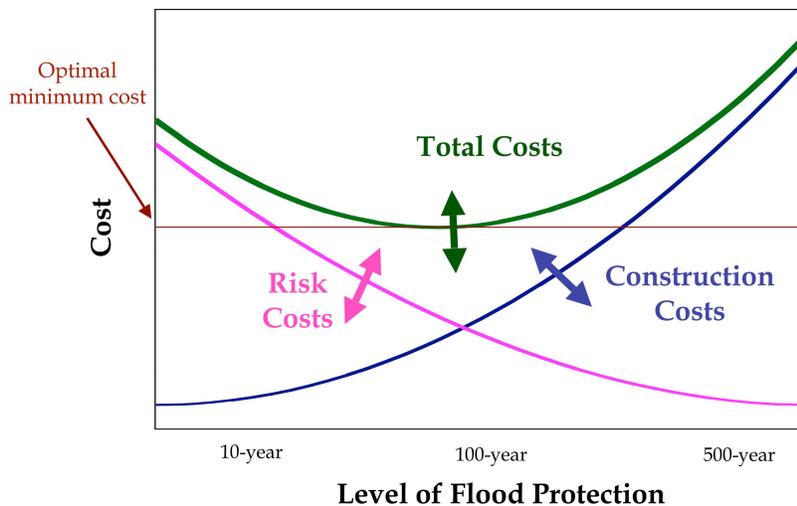


Figure 2. Benefit-Cost Analysis in Water Resources Planning. At its simplest, the level of flood protection increases for more severe floods, construction costs (plan implementation costs) increase. The higher the protection level, the less risk incurred. The decrease in risk costs, or damage curve, reflect how projects benefit from reductions in risk. Arrows indicate that all costs in BCA have some uncertainty. Regardless of the level of flood protection, risk costs never entirely disappear. Curves are conceptual simplifications; if included other components such as residual risk, curves would be altered. Figure concept derived from Figure 14-1 in G.W. Kite book on Frequency and Risk Analyses.¹¹

⁹ Hammond, R. J. (1966). Convention and Limitation in BCA, 6 *Natural Resources Journal*. 195-222.

¹⁰ Lesser & Zerbe (1998). In F. Thompson & M. Green (Eds.), *Handbook of Public Finance* CRC Press, 221..

¹¹ Kite, G.W. (1977). *Frequency and Risk Analyses in Hydrology*. Water Resources Publications, Fort Collins, CO, 203.

In practice, the application of BCA is more complicated. Benefits and costs are often difficult to identify, difficult to measure or monetize, and highly uncertain. Additionally, although the BCA process aims for objectivity, analysts must make many subjective decisions and assumptions. These might include the choice of discount rate, whether and how to value environmental amenities (which are not traded in a marketplace), and what categories of benefits and costs to use. For federal water resource projects, guidance like the P&G are used to ensure that types of subjective decisions are made as consistently as possible across projects and agencies.

In the United States, the idea of quantifying benefits for water resource projects was considered as early as the Rivers and Harbor Act of 1902.^{12,13} Language specifying the use of BCA in water related projects was provided in the River and Harbor Act of 1920.¹⁴ Later, the Federal Navigation Act of 1936 required the practical application of benefit-cost analysis when evaluating waterway infrastructure projects.¹⁵ The modern era of BCA within the Corps began with the 1965 Water Resource Planning Act (WRPA). The WRPA attempted to centralize water resource planning by creating the Water Resources Council (WRC) to draft water resource project evaluation standards, including BCA. The result of their efforts was the *Principles and Standards for Planning Water and Related Land Resources* (P&S)¹⁶ released in 1973, commonly called the *Principles and Standards*.

Principles and Standards (P&S). The P&S were approved by President Nixon in September of 1973 and became effective on October 25, 1973. They applied to all four federal water resource agencies within the Water Resource Council mandate (the Corps, Reclamation, NRCS, and TVA). The P&S had two main *and co-equal* objectives:¹⁷

- (1) To enhance the national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.
- (2) To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The relevant costs and benefits of alternative plans for these two objectives were to be enumerated in two "accounts." These two required accounts were for improving "national economic development" (the NED account), and the second was for enhancing "environmental quality" (the EQ account). Two other accounts were created for "regional development" and "social wellbeing," but were not required of analysts.

After a period of revisions, the P&S were established in 1980 as a set of formal rules with the aim of providing federal agencies with uniform requirements for evaluating project implementation studies.¹⁸ After a new Administration took office, the WRC repealed the

¹² Hammond, R. J. (1966). Convention and Limitation in BCA, 6 *Natural Resources Journal*. 195-222.

¹³ 32 Stat. 372-73 (1903)(The date you reference in the text is 1902 – is the discrepancy ok?)

¹⁴ River and Harbor Act, 41 Stat. 1009-10 (1920)

¹⁵ Watkins, Thayer. *An Introduction to Cost-Benefit Analysis*, San Jose State University. Retrieved April 22, 2009 from: http://www.usace.army.mil/cw/hot_topics/ht_2008/pandg_rev.htm

¹⁶ Federal Register number: 38 Fed. Reg. 24,778-24869, September 10, 1973.

¹⁷ P&S, p.6.

¹⁸ Federal Register 64366.

existing principles, standards, and procedures in September 1982 and replaced them with a new guidance document, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, commonly called the *Principles and Guidelines* or P&G.¹⁹ This document is still in effect today.

The (Current) Principles and Guidelines

The objective of the current P&G was to “contribute to national economic development consistent with protecting the Nation’s environment.”²⁰ In other words, the P&G treated economic development as the primary objective and environmental protection as a secondary constraint, rather than their co-equal status under the P&S objective (see **Table 1** for a summary of the similarities and differences between the P&S and P&G).

As suggested by its title, the P&G outlines several guiding *principles* for the purpose of ensuring consistent planning by federal agencies as well as detailed *guidelines* providing standards and procedures for federal agencies when conducting analyses of potential water resource projects and alternative plans.²¹ Principles include federal, state, and local concerns, as well as general guidelines for conducting analyses of project implementation studies.

Like the P&S, the P&G established four accounts for measuring the diverse potential impacts of water resource projects, although the P&G placed different relative weight between the accounts (see **Figure 1**). Only the National Economic Development (NED) account is required by the P&G, although the analysis that informs the Environmental Quality (EQ) account is typically required by other laws and regulations, such as the National Environmental Policy Act of 1969 (NEPA). Approximately 80 pages of the P&G outline the procedures for conducting NED benefit calculations, while the EQ account is treated in 22 pages. The Other Social Effects (OSE) and Regional Economic Development (RED) accounts are not treated in the guidelines portion of the P&G.

¹⁹ See 18 C.F.R. 725.6 concerning *Principals, Standards and Procedures for Conservation of Power and Water Resources*. All of Chapter IV of C.F.R. 18 concerns the Water Resources Council.

²⁰ P&G, Federal Objective, p. iv.

²¹ P&G, Section 1.1.1.

Table 1. Summary of Objectives and Accounts in the P&G and P&S²²

		Principles, Standards, and Procedures (1973)	Principles & Guidelines (1983)
Federal Objectives		<p>1. To enhance national economic development by increasing the value of the Nation's outputs of goods and services and improving national economic efficiency.</p> <p>2. To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.²³</p>	To contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. ²⁴
National Economic Development	Description	Required account. Includes: increases or decreases in the value of the output of goods and services, changes in national economic efficiency resulting from the plan, value of resources required for or displaced by a plan, and value or losses of output resulting from external economies and diseconomies.	Only required account. Documents the economic value of the national output of goods and services produced by the proposed investment.
	Metric	Monetary values based on or derived from actual or simulated market prices.	Monetary values are to be expressed in average annual equivalents by appropriate discounting and annualizing techniques using the applicable discount rate.
Environmental Quality	Description	Required account. Includes: natural lands, archeological, historical, biological, and geological resources and selected ecological systems, quality of water, land, and air resources, and irreversible commitments or resources to future uses.	Documents ecological, cultural, and aesthetic effects on significant natural and cultural resources that cannot be measured in monetary terms.
	Metric	Environmental effects to be displayed in terms of relevant physical and ecological criteria or dimensions, including appropriate qualitative aspects. Can include monetary values.	Non-monetary. An overall description or summary of significant beneficial and adverse effects on EQ resources expressed in appropriate numeric units or non-numeric terms.
Regional Economic Development	Description	Account includes same effects as NED for regional planning area as well as the regional effects of the plan on the number of jobs resulting from plan, population distribution, economic stability, and the environment.	Account registers changes in the distribution of regional economic activity that result from each alternative plan, including the regional incidence of NED effects, income transfers, and employment effects.
	Metric	Measures expressed in monetary values based on or derived from actual or simulated market prices.	Measures expressed in monetary units, other numeric units, or non-numeric terms.
Other Social Effects/ Social Well-being	Description	Account displayed where appropriate including real income distribution, life, health, safety, education, culture, recreation, and emergency preparedness. Effects include, not only those in the planning area, but also elsewhere in the Nation resulting from implementation of the plan.	Account includes urban and community impacts and effects on life, health and safety, and relevant effects not reflected in other accounts.
	Metric	Measures used to describe effects on social well-being may be expressed in dollars, other quantitative units, and qualitative terms.	Measures expressed in monetary units, other numeric units, or non-numeric terms. Effects can be reported as positive or negative, beneficial, or adverse.

²² This table was created specifically for this report and compiles information from the P&S (1973) and P&G (1983). All information comes directly from these two sources and is summarized to fit the table.

²³ P&S, Section II. Objectives, p. 6.

²⁴ P&G, Federal Objective, p. iv.

P&G Process

Although all four federal water resource agencies must use the P&G for project evaluation, the implementation process varies among them. This report focuses on the process at the Corps.

The Planning Guidance Notebook (*PGN*) states that Corps' evaluation process for formulating plans and alternatives consists of two phases: a reconnaissance stage and a feasibility stage.²⁵ During the reconnaissance stage, the Corps is authorized to use \$100,000 and up to one year to conduct a primary analysis. At this stage the Corps is particularly interested in identifying if there is a substantial federal interest in the project — whether there is an appropriate role for the federal government or whether the proposed project is primarily local in nature and effect. If the proposed course of action passes the reconnaissance phase, the agency proceeds with a more detailed feasibility study.

The P&G outlines six major steps in the evaluation process:²⁶

- Specification of the water and related land resource problems and opportunities (relevant to the planning setting) associated with the federal objective and specific state and local concerns.
- Inventory, forecast, and analysis of water and related land resource conditions within the planning area relevant to the identified problems and opportunities.
- Formulation of alternative plans.
- Evaluation of the effects of the alternative plans.
- Comparison of alternative plans.
- Selection of a recommended plan based upon comparison of alternative plans.

While the P&G provides these specific steps to follow, it acknowledges that plan formulation is a dynamic process and iterations of steps will most likely take place. The final plan selected is to be “the alternative plan with the greatest net economic benefit consistent with protecting the Nation’s environment.”²⁷

Planning Guidance Notebook (PGN). Since the P&G was written, the Corps has proposed and adopted incremental modifications to its regulations on how to implement the P&G. Intermittent modifications of the regulations were circulated from 1982 until 1985, before they were compiled into a single publication. The *Engineering Regulations* (ER) were unified in ER-1105-2-100, also known as the *Planning Guidance Notebook* (PGN). The PGN was first published in 1990, and has been continually revised with the goal to present “the overall direction by which Corps of Engineers Civil Works projects are formulated, evaluated, and selected for implementation”.²⁸ To achieve the goal of “describing the planning process in straightforward, plain-language,” the PGN reviews specific policies applicable to each mission and program, and associated analytical requirements. The PGN updates the six steps to water resource project evaluation first described in the P&G to conform to new law and regulations, including how to

²⁵ *Planning Guidance Notebook* Section 4 paragraph 1-2.

²⁶ P&G, Section 1.3.2

²⁷ P&G, Plan Selection, p. v.

²⁸ *Planning Guidance Notebook* Section 1 paragraph 1-2.

accommodate mandates from the Water Resource Development Act of 1986 and 1996, and other statutory and regulatory requirements that postdate the original P&G. The latest version of the ER-1105-2-100 was published in 2000.

Engineering Circulars (EC). In between updates to the PGN, the Corps amends the guidance for project analysts through *Engineering Circulars (EC)*. The Corps' EC are binding for one or two years after their publication date. During this provisional time period the EC is open for public comment. At the conclusion of the provisional time period, the circular may be accepted as a new regulation. **Table 2** provides a summary of currently and recently binding EC documents.

Table 2. Summary of U.S. Army Corps Engineering Circulars

Circular Number	Title	Date	Purpose	Main Points
EC-1105-2-410	Review of Decision Documents	August 22 2008	To provide procedures for ensuring the quality and credibility of decision documents through an independent review process.	Provides a framework for establishing the appropriate level and independence of review and detailed requirements for review of project documentation and dissemination.
EC-1105-2-409	Planning in a Collaborative Environment	May 31 2005	To provide revised procedures for the conduct of Corps water resources planning and the preparation of feasibility level (decision) reports that require authorization by the U.S. Congress and those that are approved under delegated authority.	1) Timeframe should be 3 years; 2) Collaborative planning activities get highest authority; 3) Alternative plans may be selected after evaluating the four accounts; 4) Mitigation is integral; 5) Monitoring and adaptive management are essential; 6) Peer review should be conducted for validity; 7) Civil Works Review Board adds insights; 8) Report summaries are key to communicating findings; and 9) The Planning Models Improvement Program validates analytical tools and models.
EC-1105-2-408	Peer Review of Decision Documents	May 31 2005	To establish procedures to ensure the quality and credibility of the Corps' decision-making documents by adjusting and supplementing the current review process.	Complies with <i>Final Information Quality Bulletin for Peer Review</i> by the Office of Management and Budget (OMB). Presents independent technical review and external peer review.
EC-1105-2-404	Planning Civil Work Projects Under the Environmental Operating Principles	May 1 2003	Reaffirm the Corps' general policy and further describe the specific procedures for formulating and evaluating civil works projects consistent with the <i>Environmental Operating Principles and Implementation Guidance</i> .	In striving to balance environmental and economic considerations the Corps must consider both NED and NER. Under ER 1105-2-100, combined NED/NER plans are ones where no alternative plan or scale has a higher excess of NED plus NER benefit over total project costs. A Combined Plan is to be constructed using the six step planning process from IWR Report 96-R-21 and will comply with the following principles: broad formulation of alternatives to meet opportunities; identification of cost-effective plans with multiple benefits; identification of the highest ranked plan based on trade-off analysis; and the recommended Combined Plan must be justified.

P&G Criticisms and Revisions

Since 1983 there have been numerous studies and reviews that have suggested modifications to the P&G.²⁹ In 1994, a White House commissioned study of the Mississippi flooding of 1993 reported:

The principal federal water resources planning document, Principles and Guidelines, is outdated and does not reflect a balance among the economic, social, and environmental goals of the nation. This lack of balance is exacerbated by a present inability to quantify, in monetary terms, some environmental and social impacts. As a result, these impacts are frequently understated or omitted. Many critics of the Principles and Guidelines see it as biased against nonstructural alternatives.³⁰

In 1994 a group of eight professors led by Professor Zilberman at the University of California in Berkeley reviewed the P&G at the request of the Environmental Protection Agency (EPA). The EPA sought a review of the P&G in an effort to develop a framework for BCA within the EPA.³¹ Their work culminated in *The Zilberman Review*, which contains very careful and detailed analysis of several key economic questions.³² Professor Anthony Fisher provides an extensive discussion of the issues associated with using contingent valuation, and he suggests different ways to assess environmental quality costs within the Environment Quality (EQ) account and on the National Economic Development (NED) balance sheet. Professor William Hyde addresses five distinct sources of error in the P&G and suggests methods for limiting these errors.³³ Professor Douglas Larson argues that the P&G focuses too heavily on the monetary impacts of a project, which tend to over-emphasize the quantity of benefits and costs and neglects to measure how the project changes the quality or value of the environment. He argues that the three other accounts, Environmental Quality, Regional Economic Development, and Other Social Effects, should be considered more when assessing a project. (For more information about *The Zilberman Review* see the annotated bibliography in **Appendix A** in this report.)

In 2000, Congress requested that the National Academy of Sciences, through the National Research Council (NRC), review the planning procedures and methods of analysis used in Corps water resources planning.³⁴ The NRC responded with a series of reports published in 2004. Noting that the Corps is governed by over 219 public laws (as of December 2000), many of which may at times conflict, the NRC first recommended that the Administration, Congress, and states, reconcile inconsistencies within the existing, de facto, body of national water policy to

²⁹ Gerald Galloway, comments to the Corps regarding revisions to the P&G, June 8, 2008.

³⁰ Quoted in Gerald Galloway, comments to the Corps regarding revisions to the P&G, June 8, 2008.

³¹ Personal communication with Professor Zilberman, May 10, 2009.

³² Published by the EPA as "Review of Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies"

³³ The five sources of error are (1) Assessment of non-market values; (2) Output price affects; (3) Interactions between multiple project outputs; (4) Disregard of regional impacts; and (5) Tacit acceptance of non-standardized data from other natural resource organizations.

³⁴ NRC report, *Analytical Methods and Approaches for Water Resources Project Planning*, 2004, p. viii. The entire report is available from the NRC at http://www.nap.edu/catalog.php?record_id=10973

provide better direction to the Corps. The NRC offered ten other key recommendations for change, which are included in **Appendix B**. The recommendations most applicable to the P&G revision include.³⁵

- The Principles and Guidelines should be revised to better reflect contemporary management paradigms; analytical methods; legislative directives; and social, economic, and political realities. A revised version of the P&G document should be periodically and formally reviewed and updated.
- Benefit-cost analysis should not be used as the lone decision criterion in judging whether a proposed planning or management alternative in a Corps planning study should be approved.
- Periodic reviews of completed projects should be a routine part of Corps water resource project planning and management.
- Resources and time allocated for Corps reconnaissance studies should be commensurate with the scale and complexity of the water resources issue at hand.
- A summary document that identifies key environmental and social issues, primary assumptions, alternatives considered and evaluated, objectives sought, benefits and costs (monetized and non-monetized), trade-offs and stakeholder perspectives and differences, presented with a consistent format across studies, should be a standard in Corps planning studies.
- The Corps should strengthen its programs in the areas of systems engineering aspects of water resources, risk and uncertainty analysis, and the integration of engineering and ecosystem analyses. Part of this strengthening should include the development of updated design manuals that better reflect contemporary methods and theories. These manuals should be used as general guidance rather than as “cookbooks” that specify a series of steps that must be strictly adhered to.
- Independent experts from outside the Corps of Engineers should be routinely enlisted to provide advice in Corps programs and planning studies.”

In 2005, after the Corps came under increased scrutiny in the wake of Hurricane Katrina, Paul Scodari of the Army Corps of Engineers Institute for Water Resources (IWR) gathered a summary of existing criticisms of the P&G. After carefully comparing these criticisms with the actual language contained in the P&G, Scodari found that although some of the perceived flaws are closely linked to specific provisions, many cannot be directly traced to the P&G and must be attributed to other sources.³⁶ In his final report, Scodari detailed when and how the perceived

³⁵ NRC report, *Analytical Methods and Approaches for Water Resources Project Planning*, 2004.

³⁶ Paul Scodari, *Survey and Analysis of Criticisms of Corps Planning and Links to Planning Guidance*, 2005, p. 4.

flaws arise from the guidance within which Corps planning occurs, and when and how perceived flaws arise from other sources. (See **Appendix C** in this report for a table that summarizes key information from this report).

Ongoing Update of the P&G. On September 12, 2008, in response to the WRDA 2007 directives, the Corps released a draft of revised principles for public comment. An invitation was issued through Reuters, and the public was invited to mail in their comments or post them online.³⁷ Although the draft does not include the complete standards or guidelines, it includes new requirements for planners to assess a total of five accounts, review at least three alternatives (one focused on economic development, one on environmental considerations, and one based on nonstructural options), and use current risk and uncertainty techniques.³⁸ Several commentators, including the NRC, noted the inclusion of updated ideas into the principles as a step in the right direction and praised the Corps for some parts of the updated Principles. Many of these same commentators and others also pointed to gaps in several areas such as guidance on the evaluation of accounts and specificity and clear definitions of terms and ideas.³⁹

Asking for and receiving public comment is an important step in the revision process. However, it will be challenging for both policy-makers and the Corps to know how to evaluate and weigh the authority, expertise, and biases that may be represented within the comments that have been received. An extremely wide range of stakeholders commented, including: The Nature Conservancy, the Audubon Society, and numerous conservation groups; the American Society of Civil Engineers, the Associated General Contractors of America, and the Southwestern Power Resources Association; and a number of concerned citizens as well as numerous professors representing a variety of disciplines.

³⁷ <http://www.usace.army.mil/CECW/Pages/pgr.aspx>

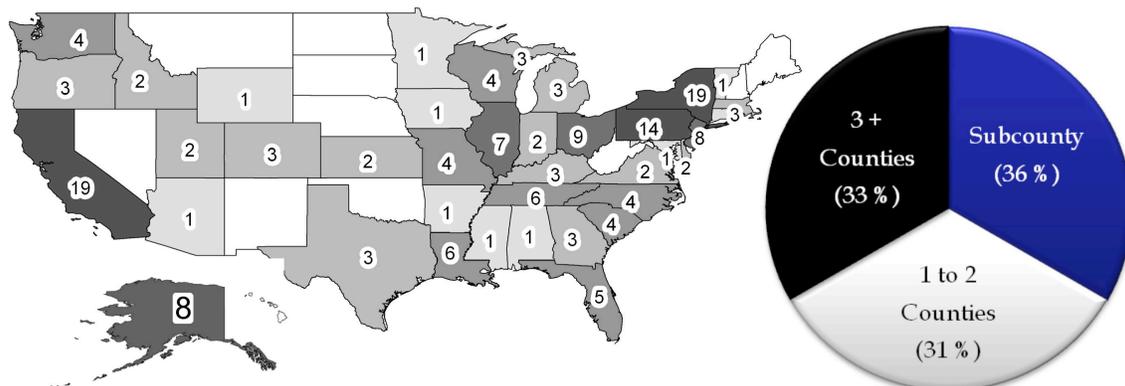
³⁸ Army Corps of Engineers. *Draft Principles*. September 2008.
http://www.usace.army.mil/CECW/Documents/pgr/pg_draft.pdf

³⁹ Public comments from Scott Farrow, Paul Kirshen, and others. <http://www.usace.army.mil/CECW/Pages/pgr.aspx>

Recently-Authorized Corps Planning Studies

One important question is whether the P&G is being updated with thought towards the type of projects the Corps is *currently* considering and evaluating, rather than the mix of projects it has done in the past. To set this context, this section provides an overview of 154 recently-authorized Corps planning studies proposed in the Water Resources Development Act of 2007 (100 projects) as well as Committee Resolutions in the House (51 projects) and Senate (3 projects) in 2007 and 2008.

Water resource projects are proposed throughout the country (**Figure 3**), with California (19 projects), New York (19 projects), and Pennsylvania (14 projects) having the most. Eleven states have no recently-authorized projects. Projects can cover multiple states; however, they are primarily local in scope, over 60% of projects have a planning area of two counties or less. For the purposes of this report, project location and extent was designated based on the area described within the legislation listed above. Municipal or sub-county levels were defined as "Subcounty," projects defined as countywide or two counties were categorized as "1-2 Counties," and any project area greater than two counties was designated in the "3+ Counties" level.



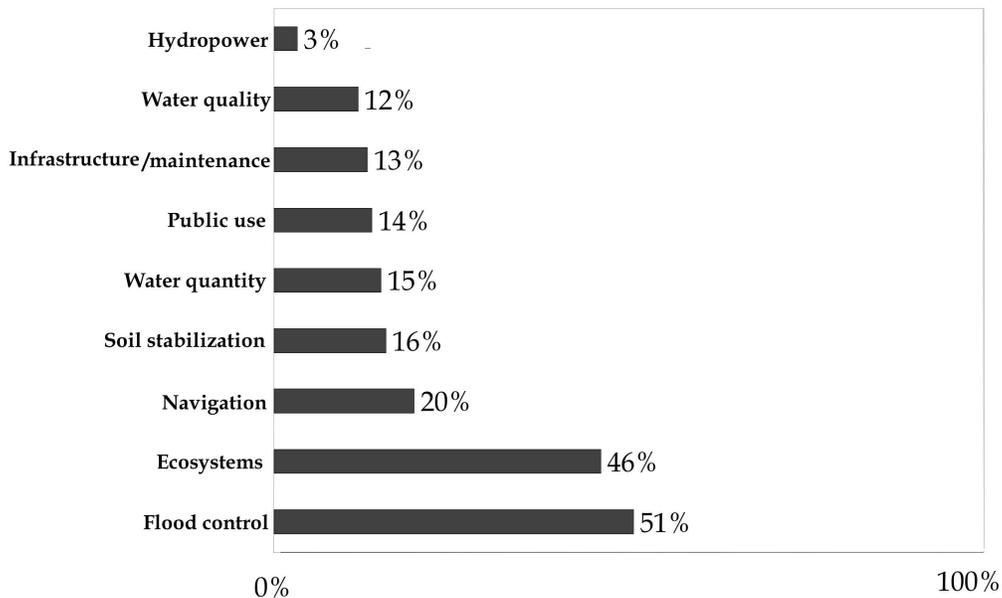


Figure 4. Proposed Project Goals. Of the total projects, 56% were categorized under a single goal. The remaining 44% had an average of 3 goals, but 10 projects had goals that fit into 5-6 categories. Five projects did not specify goals appropriate to be categorized, and therefore were excluded from these calculations.

The Upper Mississippi River Comprehensive Plan (UMRCP)

This section presents an overview of a case study, the *Upper Mississippi Comprehensive Plan* (UMRCP), which is used throughout the report to provide a context for potential revisions to the P&G. The UMRCP illustrates the significance of the planning framework because of the types of analytic tools it supports. It also provides a recent, post-Katrina example of implementing flood protection in a region that has a history of significant flooding. At the time of writing, the analysis of the UMRCP had been done at a limited reconnaissance stage; so much of the Corps' analysis is cursory or incomplete, with only minimal data collection efforts compared to the more comprehensive feasibility-level study. It cannot provide an accurate picture of how current or revised planning guidance would affect the *full* evaluation of any given project; nevertheless, there is considerable interest in increasing flood protection on the Upper Mississippi among citizens and political leaders. It is also a large-scale project that is significant for the agency and has the potential for large federal financial commitment that illustrates well the tensions between local desires (large local benefits) and federal spending limitations (large federal costs), so this illustrative example may be timely.

Rationale and Scope for the UMRCP

Widespread flooding in 1993 caused between \$15 and \$20 billion in damages in the Midwest, damaged or destroyed more than 70,000 homes, forced the evacuation of approximately 74,000

people, and caused forty-seven deaths. Furthermore, the Corps has written that “[w]hile the size and impact of the flood of 1993 was unprecedented in recent history, floods of equal or greater magnitude will likely occur in the future, and the region will likely again be exposed to the destructive potential of the Mississippi and Illinois Rivers.”⁴⁰

The threat of future devastation from flooding in the Upper Mississippi River System awakened renewed interest in developing a comprehensive, systemic approach to reducing flood damage within it. The Upper Mississippi floodplain comprises approximately 185,000 square miles of watershed area and about 1,100 river miles. Since the late 1800s, both federal and non-federal damage reduction facilities have been constructed throughout the Upper Mississippi without a systemic, coordinated plan. The majority of the system’s components were planned and built incrementally under various authorities, beginning around 1880. The age, structural integrity, and level of flood risk reduction provided for similar land uses vary greatly among the levees, floodwalls, and large tributary reservoirs within the Upper Mississippi.

In response to this, the Water Resources Development Act of 1999 authorized the Secretary of the Army to develop the UMRCP to “address water resource and related land resource problems and opportunities in the Upper Mississippi and Illinois River basins, from Cairo, Illinois, to the headwaters of the Mississippi River.”⁴¹ The objectives of the UMRCP are included in **Appendix F, Part 1** of this report.

In authorizing the development of the UMRCP, Congress recognized the need for a comprehensive planning effort that integrates the various existing structures and develops a floodplain management plan that might justify federal involvement and investment. However, due to the size of the study area and the inherent complexity of the system, as well as fiscal and time constraints, the Corps chose not to study the entire Upper Mississippi River System, but limited the scope of the UMRCP to a reconnaissance-level analysis of the Upper Mississippi and Illinois Rivers floodplain.⁴²

UMRCP Alternatives

The UMRCP final report presented fourteen alternative plans. In addition to a “no action” alternative, the thirteen alternatives (labeled A through M) provided varying levels of urban and agricultural flood protection. The alternatives varied primarily on the level of protection and type of flood damage reduction actions taken in agricultural areas; they ranged from a slight increase in existing protection to 500-year protection for agricultural areas.⁴³ Of the 13 alternatives, the Corps analyzed eight plans in greater detail, which included nonstructural plans, floodplain buyouts, and structural alternative plans, all with various improvements in the level of flood protection. The report evaluated the alternatives based on benefits and costs from each of the four accounts described above. A summary of the comparison between the alternative plans is found in **Appendix F, Part 2** of this report.

⁴⁰ Ibid., p. ES-1

⁴¹ UMRCP, p. ES-2

⁴² Ibid., p. 4

⁴³ For more information, see CRS Report, R240201, Carter 2009, p. 36.

Plan Recommendation

The Corps found that none of the proposed alternatives would come close to passing a benefit-cost test. Among the alternatives, the ratio of benefits to costs in the NED account ranged from a low of 0.03 to a high of 0.07, and the Corps did not recommend or request additional authority to implement any of the alternatives for the UMRCP. Despite this, the Corps compared the alternatives using a Risk Informed Decision Framework (RIDF), which incorporated considerations from the other three accounts. The final report identified Plan H as the preferred alternative. Plan H would provide a 500-year level of flood protection for urban areas and towns along the length of the main stem of the Mississippi and Illinois Rivers (but not other tributaries) and provide ecosystem restoration benefits. Additional details on UMRCP Plan H are contained in **Appendix F, Part 3** of this report.

The states could, of course, choose to develop further and possibly implement one of the alternatives studied without significant federal leadership or funding.⁴⁴

Stakeholder Response

In a letter dated January 15, 2009, John Paul Woodley, Jr., Assistant Secretary of the Army (Civil Works), wrote to the Honorable James M. Inhofe, a ranking member of the Senate Committee on Environmental and Public Works, that Plan H:

... was strongly supported by the Governors of Illinois, Iowa, and Missouri and overwhelming[ly] by a number of stakeholders. While the [Mississippi River Commission (MRC)] acknowledged that the reconnaissance level analysis of the UMRCP indicated that there is no Federal interest based on NED evaluation criteria, the MRC believed that the full benefits of implementing Plan H could not be adequately measured within current guidelines.⁴⁵

Despite the fact that the Corps did not recommend additional funding for the UMRCP, Illinois Representative Phil Hare called for full funding of the UMRCP on August 15, 2008, seeking congressional authorization to implement the plan with “federal funding so that work can begin as soon as possible”.⁴⁶ Representative Hare, recently appointed to the Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, stated, “I will use my seat on this subcommittee to help fund the Upper Mississippi River Comprehensive Plan.”⁴⁷ On April 2, 2009, Illinois Representative Aaron Schock requested \$550,000 to be allocated toward the UMRCP, noting that the funding would be used “to conduct a feasibility study of the entire Upper Mississippi River and Illinois Waterway flood protection systems”⁴⁸.

⁴⁴ For more information, see CRS Report, R240201, Carter 2009, p. 39.

⁴⁵ John Paul Woodley, Jr., Assistant Secretary of the Army (Civil Works), letter to the Honorable James M. Inhofe, ranking member of the Senate Committee on Environmental and Public Works. January 15, 2009, p. 2

⁴⁶ State News Service, August 15, 2008, Press release from the office of Illinois Representative Phil Hare.

⁴⁷ State News Service, January 16, 2009, Press release from the office of Illinois Representative Phil Hare.

⁴⁸ State News Service, April 2, 2009, Press release from the office of Illinois Representative Schock.

PART II. REVIEW OF CRITICISMS OF CURRENT CORPS BENEFIT-COST ANALYSIS GUIDANCE

The following sections address specific areas where the Corps' existing planning guidance has been criticized. We have grouped these criticisms into seven general categories: Regional vs. National Accounts; Planning Area; Ecosystem Services; Public Safety; Uncertainty; and Output Price Effects. Each section begins with an introduction to the issue, including how the topic is treated in current guidance. We then discuss existing criticisms and options for improvement.⁴⁹ We finish each section by describing how the issue was treated in the Upper Mississippi River Comprehensive Plan (UMRCP) case study. Each section also includes a "summary" box at the beginning for readers interested in section highlights.

⁴⁹ Drawing heavily on Scodari 2005 and NRC 2004.

REGIONAL VS. NATIONAL ACCOUNTS

Summary

The relationship and weighting between the RED and NED accounts in the current P&G is controversial. New methods in BCA may provide additional ways to measure benefits and costs, and aid decision-making in furthering national objectives for flood-control projects.

Criticisms of the P&G methods for RED vs. NED accounting:

- RED and NED accounts are not given equal weight in considering net benefits.
- Equity effects are not required in decision criteria accounts.
- RED is not required nor used to inform cost-sharing possibilities between national and local agencies.

Options for addressing these criticisms in P&G revisions include:

- Require RED and use RED analysis as part of decision criteria for proposed projects, possibly including RED net benefits in an NED-style account.
- Monetize equity effects to account for the rest of the nation's willingness to pay for benefits in region-specific projects.
- Rely less heavily on a strict cost-benefit criterion in order to accommodate equity concerns.
- Consider portfolio analysis of a collection of projects to better judge the benefits that accrue to the nation.
- Include information collected about the reduction of risk and remaining risk in a project alongside RED.
- Require and specifically tailor RED to inform potential cost-sharing options for projects that can benefit from them.

Regional vs. National Account in the Current P&G

Benefit-cost analysis for water resource projects considers a wide range of benefits and costs that can have effects on local, regional, and national scales. As discussed above, the NED account shows effects on the national economy, while the RED account shows how much of those national economic benefits and costs occur within the local region. This includes income transfers from one part of the country to another, as well as employment changes in the region.⁵⁰ The regional analysis is, by definition, a subset of the broader national analysis. The P&G loosely define "region" as areas "in which the plan will have particularly significant income and employment effects."⁵¹ The definition of "significance" is not developed further in the P&G (nor in this report); it is presumably left up to the agencies to define when conducting their analyses.

⁵⁰ P&G 1983, (1.7.1a)

⁵¹ P&G 1983, (1.7.4)

Relationship between NED and RED. The P&G define the NED account as the accumulated net benefits of all regions in the nation, including the project region. For this reason, the RED account is not required, and is to be included for agencies reference only. When computing the RED, the remaining benefits that accrue to the rest of the nation are shown for reference in the “rest of nation” account.⁵² It is important to note that because of the way the NED is currently constructed, requiring RED as a separate decision-criteria account alongside the NED would result in double-counting the benefits, since they are already factored into the NED total net benefits.

Conversely, the most recent revisions of the *Draft Principles* released in September 2008 suggest the Corps will be required to conduct a RED analysis, but RED benefits are not to be included in NED analysis. This suggests that no RED effects will be considered under Federal purview, and that only NED-type effects are important in project decision-making.

Existing Criticisms & Options for Addressing NED vs. RED Account in the Updated P&G

There are three broad criticisms surrounding the role of RED and NED. The first is NED is heavily weighted, and RED should be given more weight when projects are being decided. The second is the current P&G do not include equity effects that can affect the importance of regional and national benefits. The third criticism is that the lack of RED analysis prevents the development of cost-sharing formulas between local and federal agencies based on the magnitude of regional and national benefits.

1. Criticism that NED is heavily weighted

The P&G have been criticized for not considering local interests and the effects of alternative plans on regions, because decisions are determined primarily on the NED account. When the Corps invited comments on the revision of P&G in a public meeting in 2008, a frequent comment by participants was that final planning decisions did not adequately take regional effects into account because of the weight the current P&G place on the NED. As one participant said, “[t]he other three accounts are just as important. Even though identifying the NED plan [the plan selected only on the basis of the NED account] is important, there needs to be equal emphasis on the other three accounts when evaluating alternatives and selecting a plan to implement.”⁵³ Another participant added, “... other accounts that include non-monetary project benefits should receive the same weight as the NED and project planning and prioritization.”⁵⁴ Also, “[i]n spite of the fact that there have been exceptions, when you go to the field and talk to the planners, there’s this hesitation to do anything that moves away from NED.”⁵⁵ Both the UMRCP main report and participants in the first public meeting for P&G updates emphasize that for the last 24 years, the Corps’ focus in project implementation and

⁵² P&G 1983, (1.7.1, 1.7.4)

⁵³ *Principles & Standards for Water Resources Study, Meeting Transcripts* (2008). Public Meeting. Lockheed Martin Corporation. p. 54.

⁵⁴ *Ibid.* P.130

⁵⁵ *Ibid.* P.26-27

evaluation has been the NED account, which may not be the best solution for water resources planning. The alternative perspective is discussed further in the following criticism.

In general, national economic development (NED) analysis assumes that all resources are fully employed. As a consequence, regional economic development (RED) effects can occur only when resources are transferred from one or more regions of the country to the project region.”⁵⁶ This assumption suggests only one of many possible scenarios that could exist within the nation, some of which are outlined in **Table 3** below. The table pertains to employment and income-based benefits only, showing the possible net benefits of implementing a project under four different combinations of economic conditions. In reality, “employed resources” could also refer to all monetized benefits, and may include the existence of equity preferences discussed above, as well as environmental benefits, and others.

⁵⁶ UMRCP 2008, p. 82

Table 3: Economic Capacity in the Region and Nation

		Regional economy operating	
		Below capacity	Near capacity
National economy operating	Below capacity	<p>In the region: 1) Jobs created from unemployed (net gain). 2) Jobs taken from employed resources in competing industry (ambiguous depending on income changes).</p> <p>In the rest of the nation: 1) Jobs created from unemployed (net gain). 2) Jobs taken from employed resources in competing industry (ambiguous depending on income changes).</p> <p>Effect on national and regional net benefits is likely both positive.</p>	<p>Region: Jobs taken from employed resources in competing industry (ambiguous depending on income changes).</p> <p>In the rest of the nation: 1) Jobs created from unemployed (net gain). 2) Jobs taken from employed resources (ambiguous depending on income changes).</p> <p>Effect on national net benefit is more likely positive, and likely zero for the region, but possibly ambiguous.</p>
	Near capacity	<p>In the region: 1) Jobs created from unemployed (net gain). 2) Jobs taken from employed resources (ambiguous depending on income changes).</p> <p>In the rest of the nation: Jobs taken from employed resources (ambiguous depending on income changes).</p> <p>Effect on national net benefit is likely zero, and likely positive for the region, but possibly ambiguous.</p>	<p>Region: Jobs taken from employed resources in competing industry (ambiguous depending on income changes).</p> <p>In the rest of the nation: Jobs taken from employed resources in competing industry (net gain zero or loss depending on income changes).</p> <p>Effect on national and regional net benefits is likely zero, but possibly ambiguous.</p>

An option to address this criticism is weighting RED more heavily as a decision criterion.

2. Equity is not a major decision criterion in NED analysis

In contrast to the public comments referenced above, others suggest that weighting local benefits raises equity concerns when federal dollars primarily benefit local projects. Two relevant questions are 1) is it fair to use federal resources on local projects that benefit few; and 2) might residents nationwide place some weight on using federal dollars for projects in particularly poor, undeveloped or stricken areas, even though such projects may not produce sufficient *national-level* benefits to exceed costs? Conversely, citizens may wish to not displace or negatively affect an already-marginalized group or area with a new project that would pass a national-level benefit-cost test. The current P&G provide no guidance for answering these questions.

There are analytical techniques (stated preference methods) that allow practitioners to measure the value of equity considerations by surveying the public's willingness to pay for certain indirect effects. For example, survey respondents may report that they are willing to pay a specific amount to see another region avoid catastrophic loss, even if this loss is not directly felt by the survey respondents. In this way, the benefits of equity perceptions by the general public might be monetized and included in the NED account, although these techniques are not yet well-accepted among economists.

In addition, it may be valuable to place equity effects in a context that extends beyond individual projects. One of the challenges faced by the Corps and other federal water agencies is that flood-control projects generally have benefits that accrue to very local (flood-prone) regions. Taken one by one, no single project may be justified by its effect on national net benefits in an NED analysis, even in major economic centers, as implied by the public comments noted above. However, taken together, a portfolio of projects in many regions across the nation may show a wide distribution of benefits, justifying the use of federal dollars.

Ultimately, the importance of including equity effects in NED analysis is that these effects could significantly change the number and type of projects implemented compared to those selected under the current P&G methods. In some cases, projects that initially do not provide enough national-level benefits to pass a benefit-cost test may pass if the general public holds some large (and currently unmeasured) value on reducing inequity. Conversely, projects that pass a benefit-cost test may not pass if they harm marginalized groups citizens place value on protecting. Further discussion of where reversal of a BCR is possible is shown in **Appendix E** of this report.

The options presented by this critique are as follows:

- Include monetized equity effects to account for the rest of the nation's willingness to pay for benefits in region-specific projects.
- Rely less heavily on a strict benefit-cost criterion in order to account for equity effects in the decision-making process.
- Consider portfolio analysis of a collection of projects to better judge the benefits that accrue to the nation, taking into account the advantages and disadvantages of this type of analysis.

3. Combining regional and national interest with risk informed decisions could inform cost-sharing alternatives.

The risk information gathered from local data and stakeholders may provide a basis for a deviation from the NED plan to meet a reliability goal or constraint. The elimination of risk factors for important economic sectors in the region can increase benefits accrued to RED while NED benefits may not change substantially. For example, the NED plan may find a 90-year levee appropriate for unprotected agricultural areas, but the local sponsors, whose livelihood depends on agricultural outputs, may find the risk remaining after a 90-year levee is constructed is still unacceptable. Local interest can be willing to pay the difference between the NED plan and maximum protection from flood hazard desired by local interests.

Negotiating the protection level against flooding raises important trade-offs for both the Corps and the local sponsors of the project. However, it may require additional protection beyond the FEMA base flood (100-year flood). By permitting urban development in floodplains, communities may become more vulnerable to remaining risk, and suffer increased flood damages when floods above stated protection levels occur.

Finally, every reduction in risk typically brings additional cost to the table. Often, a move from high to very high levels of protection incur extreme increases in costs, where moving from low to moderate reductions in risk are much more affordable. Local sponsors should understand trade-offs fully, so they can make decisions that benefit their communities the most. Risk analysis can be used to show trade-offs between different alternative plans, and educate stakeholders on how each plan features differences in the likelihood of reduced flood damage, as well as local and federal project costs.

The options presented by this criticism are as follows:

- Include information collected about the reduction of risk and remaining risk in a project alongside RED.
- Require and specifically tailor RED to inform potential cost-sharing options for projects that can benefit from them.

RED vs. NED Application to the UMRCP

RED in the UMRCP. Despite the fact that the RED is not required, local stakeholders in the region asked the Corps to use the Tennessee Valley Authority (TVA) to conduct a RED-like analysis with existing regional data.

The TVA report analyzed the effects of construction employment, land value enhancement, farm income gains, and flood damages averted. These were included in a multisectoral computable general equilibrium (CGE) model formulated by Regional Economic Models Inc. (REMI) of Amherst, Massachusetts. The REMI model assumes multiplier relationships between direct economic impacts in the region (i.e., jobs created) and the additional economic activity stimulated by the direct effect (i.e., spending by the workers in local markets). The TVA estimated that every dollar spent on comprehensive flood risk management reduction would generate as much as \$5 in increased gross regional product.⁵⁷ Gross regional product is defined as “an estimate of each state or region’s share of the nation’s gross domestic product, which is the total value of the goods and services produced by labor and property in the United States.”⁵⁸

NED in the UMRCP. The NED analysis in the UMRCP study is outlined in Appendix C of the UMRCP. The primary focus of this analysis is to project potential flood damage (by river reach) under current climate conditions and with current levees. Because analysts can assign a probability to any given level of flood damages and plot these damages as a function of

⁵⁷ Ibid., p. ES-5

⁵⁸ Ibid, p. 79

probability (see **Figure 5**), this approach is referred to as the “damage curve” approach, which relates to the “risk costs” in **Figure 2**. Total expected flood damages for the status quo can be calculated by summing the area under the probability curve (the area in purple in **Figure 5**). A given plan alternative increases the level of flood protection (i.e., raises levees) and therefore reduces the expected flood damages, shifting the curve in **Figure 5** downward. NED benefits are then defined as the difference in expected damages between the status quo condition and the new alternative plan. This process is repeated for several alternative plans. Data for the damage curves in the UMRCP varied in completeness, with some sections of the river providing more recent data, and others with less information available.⁵⁹ In addition, the precise process for constructing these damage curves is not discussed within Appendix C of the UMRCP, suggesting the analysis may be largely incomplete. One reason for this may be that since the estimated benefit-cost ratios of all alternative plans were significantly below one (most are less than 0.1), a more detailed and time-consuming accounting of costs and benefits was not justified at the reconnaissance level.

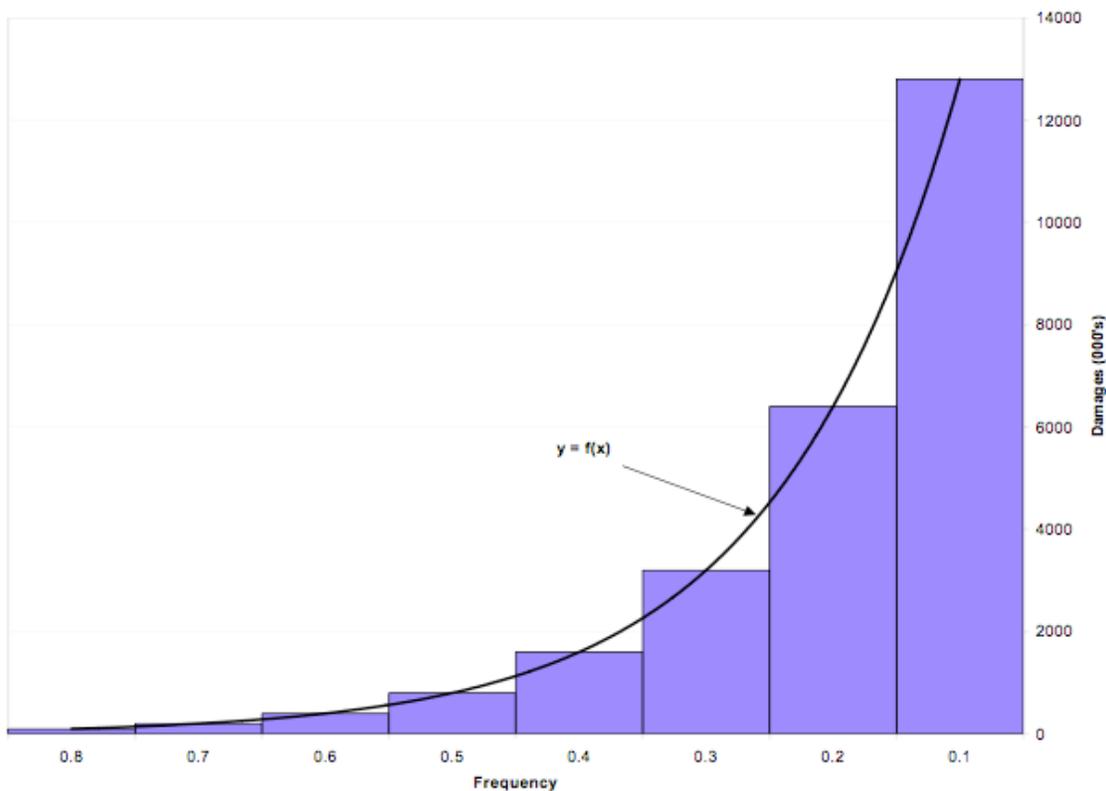


Figure C-3. Sample Damage Curve

Figure 5. Sample damage curve from UMRCP Final Report, Appendix C, p. C-17

There are three reasons why the Corps’ analysis in the UMRCP may not be representative for the purposes of illustrating existing criticisms and suggestions. First, the UMRCP was analyzed at the reconnaissance level, not the feasibility level. Second, the TVA’s analysis of regional

⁵⁹ UMRCP 2008. *Appendix C*, p. C-16.

economic impacts was adapted and included as a form of RED. A typical RED analysis, however, is a *subset* of the NED analysis. In the UMRCP, the NED analysis used a fairly simple damage curve approach while the RED analysis used a very sophisticated simulated economic model. The RED analysis in the UMRCP is certainly not a subset of the NED. Furthermore, it is worth noting that the TVA's RED analysis used proprietary commercial software (REMI) to model these effects. Although REMI makes a large amount of model documentation available through its website, the lack of a completely transparent and freely-available model that interested groups can test may be at odds with the Corps' goal of open public deliberation. Third, although the UMRCP included a fairly extensive environmental impact analysis in the EQ section (discussed more below), the Corps made no attempt to monetize any of these effects. Without monetizing the effects, they could not be included in the NED account.

PLANNING AREA

Summary

The completeness of a project's benefit-cost analysis is influenced by how its planning area, including areas both upstream and downstream of the project, is defined and managed.

Criticisms of the P&G methods for defining planning area include:

- Minimal guidance in defining geographical boundaries of project areas.
- Lack of focused guidance on how to integrate river basins when determining affected areas.
- Financial limitations and differences between local and national interests limit geographical boundaries of the planning area.

Options for addressing these criticisms in P&G revisions include:

- Coordinated upstream and downstream analysis can cover an entire river basin and help to minimize unintended impacts of upstream water resources projects on downstream communities.

Planning Area in the Current P&G

The P&G define planning area as “the geographic space with an identified boundary.”⁶⁰ The authorizing document of the study generally determines boundaries of the area. Additionally, two other components identify boundaries of the planning area:

1. Project areas, where alternative plans are located.
2. Affected area, where the resources affected by alternative plans directly, indirectly, or aggregately are located.

According to the P&G, the planning area should include planning problems and opportunities and geographic areas that alternative plans may impact. However, existing criticisms raise concerns about how that planning area is determined under the P&G, which will be discussed in the following section. The P&G provides minimum guidance to planners, and according to some critics, planners tend to limit the geographical scope of the planning area. Beyond planning guidance problems, limited budgets and local sponsors' cost-sharing concerns can constrict the scope of the planning area. As a result of a limited scope, planners often ignore watershed-wide effects by not looking at the impacts of alternative plans in affected areas outside the planning area. Some critics suggest including upstream and downstream analysis in the P&G in order to integrate a more comprehensive, watershed-wide perspective.

⁶⁰ (P&G, 1.4.7)

Existing Criticisms of Planning Area in the P&G

Criticisms relate to limited geographic scope for the planning area and a lack of guidance in watershed-wide planning. The following section will discuss these criticisms and associated factors more in-depth.

The overall criticisms on the planning area focus on the requirement for planners to account for indirect and regional effects of optional plans. P&G mandates planners to consider all possible effects wherever they emerge.⁶¹ Limited geographic scope prevents planners from taking into account all potential locations that may be included in alternative plans for planning problems and opportunities. Also, project planning can exclude indirect and comprehensive watershed effects of plans. For example, downstream economic and environmental effects are among the ignored indirect and watershed effects. There are a variety of factors that limit the geographic scope of the planning area:

1. Minimum P&G guidance for geographical boundaries of project areas

The P&G do not specifically define geographical boundaries of project areas; nor do they limit the geographical scope. However, in some instances the study area is defined in the project study authorization. Where this is the case, the planning area should comprise the study area as defined in the authorizing document. The P&G also guides planners to define the planning area according to problems and opportunities and the geographic areas that alternative plans can affect.⁶² Planners may or may not conclude that alternatives outside the geographical boundaries of the planning area can bring opportunities to solve planning problems. There is nothing in the P&G to prevent planners from excluding project areas outside the geographic boundaries of the planning area.

2. Lack of focused guidance on how to integrate river basins when determining affected areas

The P&G requires planners to consider all benefits and costs. Even costs and benefits accrued outside the geographical planning area are supposed to be included in the benefit-cost analysis. Because the affected area comprises resources affected by alternative plans directly, indirectly, or cumulatively, the P&G allow planners to include affected areas beyond the geographic boundaries of project areas. However, the P&G do not focus on any watershed-based planning, which can incorporate effects of alternative plans in other resources outside project areas. The Corps' general tendency to prefer local, single-purpose projects does not support a watershed-wide perspective in the planning process.⁶³ As a result of the lack of focused and integrated basin-wide planning, water resources planning projects guided by P&G ignore the indirect and comprehensive watershed-wide effects of alternative plans. A watershed-wide perspective in P&G could help ensure that these effects are considered in the planning process. In contrast to the P&G, the *Planning Guidance Notebook* (PGN) emphasizes the inclusion of a watershed-wide perspective in project planning.

⁶¹ Scodari, 2005, p.10-12.

⁶² P&G, 1.4.8, p. 8

⁶³ Scodari, 2005.

3. Financial limitations and differences between local and national interests can limit geographical boundaries of the planning area.

Not all factors limiting the scope of the planning area may come from planning guidance. Study budgets and local sponsors can limit the planning area's geographical scope. Limited budgets can contribute to limited scope, which make watershed planning less likely.⁶⁴ Local sponsors, on the other hand, may be concerned about cost-sharing of the project. If the alternative that local sponsors prefer is not viable from the federal funding perspective, local sponsors may choose to ignore affected areas and project areas beyond the geographical boundaries defined by the authorizing document. For example, an alternative, which causes a possible economic and ecological problem in downstream communities, may be preferred by local sponsors. Since this alternative cannot be accepted from the federal funding perspective, local sponsors may want to limit geographical boundaries of the planning area by rejecting opportunities that use a watershed-wide perspective.⁶⁵

Options for Addressing Planning Area in the Updated P&G

Upstream/ Downstream Analysis: An Integrated River Basin. Integrated, watershed-wide planning ensures the coordination of water resources plans along a watershed.⁶⁶ Upstream and downstream analysis (UDA) can help engineers identify the performance of flood control in communities upstream and downstream by examining risk factors in both reaches of a river basin.⁶⁷ Flood control strategies, which target optimum flood damage reduction, are unique to each watershed, because different watersheds within a basin may have different flooding patterns and landscape characteristics. For example, upstream projects, which are often uncoordinated with downstream projects, may result in unintended impacts downstream. Consequently, upstream flood control projects need careful assessment of when and how much floodwater is accumulated in the downstream reaches of a basin.⁶⁸ Coordinated upstream and downstream analysis can cover an entire river basin and help minimize unintended impacts of upstream water resources projects on downstream communities.

Upstream and Downstream Analysis in Current P&G. While upstream and downstream analysis can fit a variety of water resources related projects such as sediment control, watershed management, water quality monitoring and evaluation, streambank fencing, and floodplain management, the P&G provide limited guidance on this type of analysis. Although downstream and upstream concerns are mentioned in the P&G, the P&G neither requires nor suggests analyzing upstream watershed management methods or downstream flood reduction. The P&G guide the Corps to “increase upstream watershed management and conjunctive use of ground and surface waters” as a part of nonstructural measures and conservation methods.⁶⁹ Upstream

⁶⁴ Ibid.

⁶⁵ Scodari, 2005.

⁶⁶ Ibid.

⁶⁷ Red River Basin Flood Damage Reduction Work Group, 1998

⁶⁸ Ibid.

⁶⁹ P&G, p.117

flooding issues are also mentioned in NED benefit evaluation procedures for urban flood damage. If an urban flood damage plan or project causes downstream flooding, P&G regards downstream flood damages as an increase in damage.⁷⁰ Since downstream damages are categorized as NED other direct costs, the Corps counts the downstream flood damages as a part of national economic development direct costs.

Other direct costs: Costs of resources directly required for a project or plan, but for which no financial costs are compensated by Federal or non-Federal agency or entity. These costs are uncompensated, unmitigated NED losses caused by the installation, operation, maintenance, or replacement of project or plan measures.⁷¹

Contrastingly, the PGN emphasizes the importance of watershed studies because of their multi-purpose and multi-objective scope.⁷² Since watershed management brings flexibility and collaboration in the formation and evaluation of alternative plans, it is recommended for successful planning initiatives. Therefore, there are two primary reasons for including UDA into the P&G.

First, all parts of the basin are inter-linked.⁷³ Any decision ignoring a complete analysis of the basin can result in problems in different locations of a basin. A flood control strategy that fits upstream may cause different results downstream, causing tension between different parts of the river basin. Downstream communities may fear that they are incurring costs associated with upstream structures while benefits are being accrued by upstream communities. Local sponsors in the upstream, on the other hand, may think that unexpected flooding problems in the downstream result from their flood mitigation strategies.⁷⁴ Upstream and downstream analysis could be used to better account for costs and benefits of a project at a system level as opposed to a project level.

Second, dam safety issues and associated risk analysis highlight the importance of upstream-downstream connections.⁷⁵ Decisions on upstream and downstream reaches of the dam can be examined in a risk context to balance demands of local interests. When dams break, the safety of downstream communities is in jeopardy. Flood damage will be more serious than it will be upstream, because flood magnitudes increase as contributing areas of water increase downstream. Such residual risks prevalent at different levels of river basins require a holistic understanding of watersheds along a river. UDA can integrate a watershed-wide perspective into decision-making.⁷⁶

⁷⁰ P&G, 2.4.17

⁷¹ P&G, 1.7.2, p. 10

⁷² PGN, 3-37

⁷³ SLMcLeod Consulting et al. (1999) *Review of Red River Basin Floodplain Management Policies and Programs*. Retrieved from <http://www.rrbdin.org/communication/filebank/files/Floodpln.pdf>

⁷⁴ SLMcLeod Consulting et al., 1999.

⁷⁵ Moser, D.A. (2001); CRS Report, RL33129, Carter & Cody, 2008.

⁷⁶ U.S. Bureau of Reclamation, 2000; Cooter, 2006; SLMcLeod Consulting, 1999.

Case Study: Jackson Mississippi

The Jackson Mississippi case exemplifies what can happen if consensus along a watershed is not reached regarding flood management strategies. Jackson has faced severe flooding for the past 25 years. Throughout that time, upstream localities such as Pearl River and downstream regions such as Columbia, MS have implemented different flood control plans. Although the plans have reduced the short-term flood risk for communities along the watershed by mitigating floods with different strategies, the absence of consensus in flood management strategies caused stronger floods in the region.⁷⁷ Uncoordinated strategies made downstream communities more vulnerable to the higher flood elevations each year, increasing their residual risks.⁷⁸ In the Jackson case, upstream and downstream analysis may have provided the necessary level of informed decisions among local sponsors by recognizing interests of both upstream and downstream communities collectively, leading to coordinated floodplain management along the entire watershed.⁷⁹

Planning Area Application to the UMRCPP

The UMRCPP demonstrates typical tensions that can arise between upstream and downstream communities during and after public meetings north and south of St. Louis, MO.⁸⁰ In the UMRCPP, Plans A, D, G, and M (see **Appendix F** of this report) mention upstream and downstream effects of proposed alternatives. The plans mainly have impacts on the Lower Mississippi area by creating flood-water storage areas or eliminating certain agricultural lands. Among the alternatives, Plan G was favored strongly by residents living north of St. Louis, MO at public meetings, because Plan G involved a high level of protection and a 10,000 acre storage area located downstream of north of St. Louis, MO, the floodplain of Monroe County, IL. Unlike north of St. Louis, Chester, IL, — located south of St. Louis, MO — strongly refused Plan G because of the storage area and potential buy out of 10,000 acres of agricultural land. The tension between upstream and downstream communities in the St. Louis district resulted in the formulation of Plan M, created nine months after the public meetings. Plan M is a variation of Plan B. Plan M ensures that impacts on the downstream water surface is minimized, and it provides additional strategies for the area south of St. Louis to raise their protection level. Compared to Plan G, Plan M eliminates the purchase of 10,000 acres of storage area in Monroe County, MO.

⁷⁷ Kilgore & Davis, 2000.

⁷⁸ Ibid.

⁷⁹ Ibid.

⁸⁰ UMRCPP, p. ES-5

ECOSYSTEM SERVICES

Summary

Environmental effects and ecosystem services are difficult to quantify or value in benefit-cost analysis. The P&G account for these effects mainly in a separate, non-required EQ account.

Criticisms of the P&G methods for environmental analysis include:

- The P&G do not provide strong guidance on how to quantify and monetize environmental effects.
- Since effects can be quantified in a number of ways, it is difficult to make comparisons between accounts and within the EQ account.

Options for addressing these criticisms in P&G revisions include:

- The new P&G could require EQ analysis and provide additional guidance on making comparisons between accounts.
- They can also provide further guidance on methods for quantifying and valuing environmental effects, possibly including newer methods developed since 1983.

Ecosystem Services in the Current P&G

The procedures in the *Principles and Guidelines* (P&G) handle environmental effects of projects primarily as a separate issue from economic and other effects. Chapter three of the P&G includes guidelines for assessing factors in the Environmental Quality (EQ) account. Items to be included in the EQ account include “ecological, cultural, and aesthetic properties of natural and cultural resources that sustain and enrich human life.”⁸¹ The specific environmental effects and the methods for quantifying or assessing them are not described and can vary widely between projects. The account is separate from the NED account, but according to the P&G, any EQ cost or benefit that can be monetized should be included in the NED costs and benefits.⁸²

While not explicitly discussed in the P&G, effects on ecosystem services are one of the ways environmental impacts can be studied in assessing projects. Ecosystem services broadly encompass any benefit to humans provided by natural ecosystems. They can include anything from providing naturally occurring foods to purifying water or regulating the climate. When analyzing projects that can affect or change the natural environment, increases in ecosystem services are included as a benefit, while decreases can be added to the cost of the project.

⁸¹ *Principles and Guidelines*, p. 103.

⁸² *Ibid.*

Existing Criticisms of Ecosystem Services in the P&G

In critiques of the P&G, authors remark that the valuation and inclusion of ecosystem services is not adequately covered and the guidelines for including ecosystem services in the accounts is not consistent. The main concerns can be combined into three general points.

1. The P&G are not clear in stating how monetized environmental effects should be included in the NED account, and those that cannot be monetized should be recorded in the EQ account.⁸³ When separate accounts are included in analysis, this can blur the line between accounts and the costs and benefits relevant to each. Also, according to some critiques, the P&G do not provide sufficient guidance on how environmental quality effects and ecosystem services should be evaluated and monetized to be included in the NED account.⁸⁴ While procedures and techniques from the early 1980s, such as travel cost method and contingent valuation, are described briefly in the P&G, there is little direction for including monetary valuation of nonmarket environmental benefits and costs. Additionally, there has been significant progress in this field in the last 25 years, with advances particularly in stated and revealed preference methods for valuing non-market costs and benefits, which are not described or required by the P&G. The Corps incorporated some updated methods and requirements on valuing ecosystem services into the *Planning Guidance Notebook* (see below).

2. The P&G do not include guidance on environmental services such as soil fertilization or degradation that can be relevant to benefit-cost analysis for alternative projects. Critics point out that BCA only takes into account present environmental quality or quantity, and it does not consider environmental changes resulting from the implementation of the different alternatives,⁸⁵ resulting in the failure to include increases or decreases in the level of ecosystem services from the different alternative projects. Other critiques claim that the P&G ignore the value of environmental protection and ecosystem services in general and suggest that revisions to the P&G should fully account for the costs of environmental damages and benefits of environmental services.⁸⁶

3. Benefit-cost analysis should not be the single deciding factor on whether or not to go forward with a project. The NRC Report (2004) emphasizes the importance of including a wide range of factors in decision-making stating that:

Implicit in the current planning process is that sound water management decisions are based primarily on monetized values derived by analytical methods, but this is clearly not

⁸³ From critical review (is critical review the title? If so, indicate with punctuation) of the P&G by Anthony Fisher, Department of Agricultural and Resource Economics, University of California at Berkeley, commissioned by the U.S. Environmental Protection Agency. (July 16, 1993).

⁸⁴ Scodari, 2005.

⁸⁵ Larson, Douglas. (1994). Procedures Used to Assess Environmental Benefits in Principles and Guidelines. *Review of Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*.

⁸⁶ From Scodari (2004). National Wildlife Foundation and Taxpayers for Common Sense. *Crossroads: Congress, the Corps of Engineer and the future of America's water resources* (March).

the case. Other important social, environmental, and even political considerations should be recognized explicitly in the decision-making process.⁸⁷

Options for Addressing Ecosystem Services in the Updated P&G

Several scholars have offered methods for how ecosystem services can be quantified and then valued to be incorporated in a more comprehensive benefit-cost analysis. Select major methods of valuing ecosystem services are discussed below, along with approaches for including non-quantifiable ecosystem services.

Methods for Valuing Ecosystem Services. Since conducting nonmarket valuation studies is often timely and expensive, benefit transfer is a potential way for providing monetized values for ecosystem services by using values from previous studies and applying them to similar studies being conducted by the Corps. This method is useful if it is not feasible to conduct a full analysis of the benefit in question. Douglas Larson, an academic who was part of *The Zilberman Review*, suggested creating a database of valuation studies that the Corps could use when analyzing alternative plans, which could also include meta-analyses of multiple environmental valuation studies.⁸⁸

Alternative Analyses. Complete data is not always available when making decisions. In these cases, policy-makers may be aided in making more informed decisions by using alternative analytical strategies:

- Qualitative discussions of the benefits could be included in cases where quantitative analysis is not possible addressing why such quantitative analysis is not feasible and the reasons why the qualitative data is relevant. The P&G description of methods for the EQ account allows for some use of qualitative analysis, but provides little detail on how to complete the analysis and combine or compare it with other analyses.
- Breakeven analysis could be used in cases where risk or valuation data is lacking to estimate the number of units affected or willingness-to-pay value required to "breakeven" on a given project. Decision-makers can then determine whether the breakeven estimate is reasonable or not.
- Bounded analysis could be used when values are available for high-end and low-end scenarios for ecosystem services and environmental quality to create upper and lower bounds for the value. The estimated benefits can then be evaluated based on the range of values, which may provide insight or guidance when analyzing benefits and costs of environmental quality and ecosystem services.

The Planning Guidance Notebook and Army Corps Circulars. Circulars issued by the Corps guide the evaluation of future projects when considering ecosystem restoration and services, and one option for updating the P&G could be to incorporate the methods used in the environmental circulars into the revised version.

⁸⁷ NRC Report, p 51. (2004).

⁸⁸ Ibid. Larson, Douglas. (1994).

The Corps' *Planning Guidance Notebook* (PGN) includes ecosystem restoration as one of the project purposes, along with other purposes such as flood damage reduction and navigation. The objective of ecosystem restoration according to the PGN is "to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition."⁸⁹ Ecosystem restoration can be the sole purpose of the project or part of a multi-purpose project. The PGN states that "similar to other project purposes, the value of ecosystem restoration outputs shall equal or exceed their cost."⁹⁰ Outputs of ecosystem restoration must be clearly identified and quantified in appropriate units⁹¹ such as habitat units restored or increases in number of breeding birds. The PGN recognizes that "the significance of the outputs is a critical factor in determining if the monetary and/or non-monetary benefits of the proposed project justify the costs,"⁹² including considerations of scarcity of the outputs. Contingent valuation surveys for estimating non-market values of ecosystems are not approved PGN standards for quantifying benefits or outputs due to the speculative nature of estimating values and difficulty in controlling for bias.⁹³ Cost effectiveness analysis is to be used for identifying "the least cost solution for each level of environmental output being considered,"⁹⁴ where the additional cost of achieving each additional unit/level of output can be assessed to assist decision-makers when forming and evaluating plans.

Under the PGN, project outputs can fall under the NED Plan or the National Environmental Restoration (NER) Plan, which for ecosystem restoration projects is the plan that "reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective."⁹⁵ When projects have both NED and NER benefits, a Combined NED/NER Plan is created with the goals of maximizing the "sum of the net NED and NER benefits, and offering the best balance between two Federal objectives,"⁹⁶ considering both monetary and non-monetary benefits and costs.

The Corps further issued *Circular 1150-1-404*, "Planning Civil Work Projects Under the Environmental Operating Principles." The objective of this circular is to promote environmental sustainability, which is defined as a "synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations."⁹⁷ The circular calls for formulating a Combined NED/NER Plan that incorporates both NED and NER plans into one plan and addresses the discord these two plans often encounter when weighing economic benefits against environmental quality. The document states, "the formulation and evaluation process for the Combined NED/NER Plan shall explicitly account for those conflicts and identify a balanced plan that addresses both types of benefits," and outlines steps to follow for formulating the Combined NED/NER Plan. This plan places more emphasis on considering environmental quality when comparing alternative plans

⁸⁹ *Planning Guidance Notebook*, 3-5b.

⁹⁰ *Ibid*, 3-5.

⁹¹ *Ibid*, 3-5c.

⁹² *Ibid*, 3-5c.

⁹³ *Ibid*, 3-5c.

⁹⁴ *Ibid*, 3-5c.

⁹⁵ *Ibid*, 2-3f.

⁹⁶ *Ibid*, 2-3f.

⁹⁷ Army Corps Circular 1150-1-404, "Planning Civil Work Projects Under the Environmental Operating Principles."

and provides a framework for incorporating environmental considerations into the final plan, addressing the issue of comparing monetized benefits with more qualitative benefits through trade-off analysis. Trade-off analysis is a tool used by the Corps to “identify the potential gains and losses associated with producing a larger or lesser amount of a given output or outputs.”⁹⁸

Ecosystem Services and the EQ Account in the UMRCP

The UMRCP contains a preliminary assessment of ecosystem services effects and the EQ account, based mainly on existing reports and data.⁹⁹ Environmental effects were quantified for six of the 12 plans. The potential magnitude of the effects of the six other plans is discussed briefly in comparison to the six assessed plans.¹⁰⁰

In addition to a description of current environmental conditions focused on habitat loss, endangered species and water quality, five areas of environmental assessment were quantified and compared for Plans B, D, E, H, I, and J:

- *Mitigation*, reported as the number of acres of habitat mitigation required. The Corps estimated the area and habitat types likely to be impacted by each plan. This estimate was then multiplied by a generic cost per acre estimate for required mitigation to arrive at a total mitigation cost.
- *Secondary development*, reported as the potential acres of new development. The Corps estimated the number of acres that would be above the 100-year protection level for each plan. These acres would then be available for development and the related potential negative environmental and economic impacts, such as increased water pollution from runoff and increased damages when floods overtop levees.
- *Ecosystem restoration opportunities*, reported as the number of ecosystem restoration acres, percent of sustainability achieved and related costs. The Corps quantified the number of potential restoration projects and the area they would cover.
- *Nutrients reduction*, reported as the potential acres of wetland restored. The Corps used an estimate that showed that 38% of the 100-year flood area was either wetland or damaged wetland. This percentage was applied to the number of acres of potential ecosystem restoration to estimate the potential acres of wetland restoration.
- *Sediment reduction*, reported as the number of tributary feeders restored. The Corps used the number of tributaries identified in the ecosystem restoration category above.¹⁰¹

While some of these categories included monetized values for costs of environmental restoration and mitigation of negative effects, the monetized values were not added to the NED account, as required by the P&G.¹⁰² Instead, they are presented and assessed as part of the separate EQ account.¹⁰³ Since only a few of the EQ categories were monetized and there is no standard method to compare NED with non-monetized EQ effects, it is difficult to determine whether the

⁹⁸ Ibid, 2-3f.

⁹⁹ UMRCP, Appendix A, p. A-2.

¹⁰⁰ UMRCP, p. 96.

¹⁰¹ UMRCP, p. 92-93.

¹⁰² *Principles and Guidelines*, p. 103.

¹⁰³ UMRCP, p. 99-100.

EQ costs could be large enough to have an impact on the Corps' NED-based decision. However, based on the assessment, Plan J was determined to be the best plan from an environmental perspective, ranking highest in all five environmental categories covered.¹⁰⁴

The Corps also looked at a number of other environmental effects and impacts, but did not include any quantification or analysis within the EQ account. It is unknown whether full assessment of these particular environmental effects and opportunities might be included in further study. For example, the study includes a list of federal and state endangered species found within the study area.¹⁰⁵ However, there is no specific analysis of which species may be positively or negatively impacted by the different plans and the potential magnitude of these effects.

Additionally, expert opinion was used to grade each plan on its potential impact in 12 other categories of general environmental effects. Likely impacts were rated between +3 (major beneficial effects) and -3 (major adverse effects).¹⁰⁶ However, this assessment is considered very preliminary and is not part of the EQ account. The Corps suggests a much broader and more intensive environmental assessment in the case that one or more of the alternative plans are recommended for further consideration.¹⁰⁷

¹⁰⁴ UMRCP, p. 95.

¹⁰⁵ UMRCP, Appendix A, p. A11-A14.

¹⁰⁶ Ibid. p. A-31.

¹⁰⁷ Ibid.

PUBLIC SAFETY

Summary

How and whether public safety is accounted for in benefit-cost analysis can have a big impact. The Corps does not currently take public safety into account in its project analyses. This may become especially important given the commitment to include “human safety” as an important consideration in the P&G update.

Criticisms of the P&G methods for accounting for public safety include:

- The P&G do not provide strong guidance on how to quantify and monetize public safety effects.

Options for addressing these criticisms in P&G revisions include:

- The new P&G could require a public safety account that includes recent tools to monetize public safety effects, like Value of Statistical Life.

Public Safety in the Current P&G

In assessing damages and benefits of programs, one method of quantifying impacts on public safety is to measure the expected number of lives saved as a result of increased protection, or the expected number of lives lost if an existing or new structure would fail. These types of effects are included in the optional Other Social Effect (OSE) account under the current P&G. Since the Corps has not attempted to monetize these effects, they have not been included in the required, binding NED account.

Existing Criticisms & Options for Addressing Public Safety in the Updated P&G

One approach for monetizing expected reductions in mortality risk is the Value of a Statistical Life (VSL) method. VSL attempts to monetize reductions in mortality risk by observing or directly asking how people trade-off money for changes in mortality risk. Estimates come from labor market studies examining wage premiums that workers demand for risky jobs, studies of demand for risk-reducing products (helmets, car safety improvements, etc.), or stated preference studies.

VSL has been incorporated into many benefit-cost analyses undertaken by federal agencies such as the EPA,¹⁰⁸ though their use remains controversial. Guidance provided by the Office of Management and Budget (OMB) includes a detailed discussion of accepted usage as well as important considerations when including VSL calculations in agency analyses.¹⁰⁹ OMB documentation indicates, “a substantial majority of the resulting estimates of VSL vary from

¹⁰⁸ Kenkel, Donald (2003). “Using Estimates of the Value of a Statistical Life in Evaluating Consumer Policy Regulations” *Journal of Consumer Policy* 26 (1): 1-21.

¹⁰⁹ Office of Management and Budget Circular [0]A-4, September 17, 2003.

roughly \$1 million to \$10 million per statistical life”¹¹⁰ Because of the high value per statistical life, including or excluding VSL calculations in BCA can be the determining factor in whether a project passes a benefit-cost test.

Although the updated *Draft Principles* as of September 2008 recognize the importance of analyzing public safety issues, they do not suggest that including or monetizing these effects as a requirement.¹¹¹

The option presented by this criticism is to use recent VSL methodologies in calculations of reduced mortality risk, as well as the residual risk remaining after the project.

Public Safety in the UMRCP

Because the Corps is not required to use public safety calculations, the UMRCP reconnaissance study did not attempt to place an economic value on the reduction in lives lost as a result of flood protection from each of the alternatives. Similarly, neither the UMRCP’s Appendix I (on Risk-Informed Decision Framework) nor discussions of residual or other types of risk and uncertainty in the planning process specifically mention any type of monetization of potential loss of human life in the analysis.

¹¹⁰ Office of Management and Budget Circular [0]A-4, September 17, 2003. p.30

¹¹¹ P&G *Draft Principles*, September 2008. <http://www.usace.army.mil/CECW/Pages/pgr.aspx>

UNCERTAINTY

Summary

Most components within benefit-cost analysis do not have one value, but are best captured as being within a range of values. Analytical tools can be used to provide benefit-cost information as probabilities and better account for uncertainty. Impacts such as the amount of precipitation a region receives in a given year, the effect of climate change on a river system, and the development of communities in a river basin are perhaps best presented as ranges rather than fixed values.

Criticisms of the P&G methods for accounting for uncertainty include:

- The current P&G focus on point estimates of risk and uncertainty

Options for addressing these criticisms in P&G revisions include:

- Incorporate uncertainty in input prices.
- Use Monte Carlo analysis to simulate probability distributions.
- Use confidence intervals as opposed to point estimates to describe uncertainty whenever possible.

Uncertainty in the Current P&G

The P&G state that “uncertainty and variability are inherent in water resources planning. . . . In situations of uncertainty, potential outcomes cannot be described in objectively known probability distributions Because there are no known probability distributions to describe uncertain outcomes, uncertainty is substantially more difficult to analyze than risk.”¹¹²

The P&G offer the following steps for addressing risk and uncertainty in water resource projects:

1. Planners should collect more detailed data during the feasibility and reconnaissance stages of a project to reduce measurement error.
2. More refined analytical techniques, such as sensitivity analysis, should be used.
3. Safety factors within the design models should be increased.
4. Planners should select measurements or indicators with better-known performance indicators.
5. Irreversible or irretrievable commitments of resources should be reduced.
6. Planners should perform sensitivity analysis to make better estimates of the benefits and costs of the alternatives.¹¹³

Some uncertain phenomenon, such as demographic, economic, hydrological, and metrological events, can be described using historical data to fit a probabilistic distribution, while others can be described subjectively by expert opinion. The measures above may increase the costs and

¹¹² P&G, 1983 Supplement I.

¹¹³ P&G, 1983 Supplement I.S2.2.b

benefits of a proposed project; however, integrating uncertainty into decision-making is an important component of water resource planning.

The National Economic Development (NED) account treats uncertainty in two ways. First, general guidelines are outlined in the supplemental to Chapter 1, where NED project benefits are required to be “calculated on the basis of ‘the most probable’ with-project and without-project conditions”.¹¹⁴ The chapter prescribes sensitivity analyses, including comparing current benefit units (e.g., shipping tonnage) to projected units (e.g., projected tonnage) of a new waterway, incorporating growth rates for the time period, and incorporating changes in user charges.

The second treatment of uncertainty in the current P&G fall within specific guidance for each of the various components of the NED account: Municipal and Industrial Water Supply, Agriculture, Urban Flood Damage, Power, Transportation, Recreation, Commercial Fishing, Other Direct Benefits, Labor Resources, and Cost Evaluation Procedures. Of these sections, three give specific guidance on evaluating uncertainty. Measuring savings to shippers is confounded by uncertainty in impact on the long-run marginal costs to shippers.¹¹⁵ The solutions are to 1) establish consistent sources of data, 2) expand data gathering, and 3) estimate the range of benefits. It is also suggested that planners produce high and low projections as well as with and without estimates of impacts for project costs and benefits.¹¹⁶ Finally, it is stated that “risk and uncertainty attached to the hypothesized outcomes can be reduced by clearly revealing areas of uncertainty.”¹¹⁷

Notably, the P&G do not include an analysis of uncertainty in the evaluation of EQ effects. The P&G decision-making process states that “the agency decision-maker is responsible for judging which of these types of net EQ effects best reflects the desirability of an alternative plan's overall effect on environmental quality.” This decision is to be made based on, at minimum, “the tables used to document the previous activity” where the “the net EQ effect of each alternative plan should be expressed in a clear and complete narrative statement that identifies the type of net EQ effect expected.”¹¹⁸

There is no information specifically dealing with uncertainty in the P&G in either the OSE or RED accounts.

Existing Criticisms and Options for Addressing Uncertainty for Updated P&G

Experts highlight fundamental ways in which the Corps can improve its use of risk and uncertainty analysis for water resource projects.¹¹⁹ In general, critiques suggest that uncertainty analysis should:

¹¹⁴ *P&G, 1983, Ch. 2.6.15.d*

¹¹⁵ *P&G, 1983, Ch. 2.6.15.d*

¹¹⁶ *P&G, 1983, Ch. 2.7.4.2*

¹¹⁷ *P&G, 1983, Ch. 2.10.7*

¹¹⁸ *P&G, 1983, Ch. 3.4.15.b-d*

¹¹⁹ Scodari, P. (2005). *Survey and Analysis of Criticism of Corps Planning and Links to Planning Guidance*.

1. Consider uncertainties in input prices.

Physical costs of levee construction are particularly sensitive to the height of the levy, as even incremental increases in levee height can result in costs drastically higher than projected.¹²⁰ The same could apply to other aspects of physical construction, such as varying costs of materials over the lifetime of a long-term project. While PNG does advise sensitivity analysis regarding input price levels in relation to population and income, it does not address uncertainty related to policy change. Even policies in unrelated fields could drastically alter the demand elasticity and other factors relevant to input prices. Projections made far into the future should therefore address the sensitivity of BCA conclusions to such policy changes.¹²¹

2. Incorporate uncertainties concurrently using Monte Carlo analysis.

The relative weighting of individual parameters is one of the major problems in conventional risk analyses. Elicitation of weights from decision-makers can be difficult, especially when the concepts of uncertainty are not well-understood, and are often inconsistent from one individual to the next. Monte Carlo methods¹²² can account for the sensitivity of a project to the relative weighting of these parameters. The explicit incorporation of uncertainties, both in the individual parameters and within the analysis itself, will strengthen the analysis and make decisions much easier for the decision-makers (because the elicitation of weights is not as crucial).^{123,124}

3. Use confidence intervals rather than point estimates.

Point estimates are often misinterpreted by decision-makers and the general public, and do not give a complete picture of the range of outcomes resulting from uncertain systems. Monte Carlo analysis explicitly incorporates uncertainty throughout the planning process, ultimately resulting in a probabilistic distribution of costs and benefits. This type of analysis will allow decision-makers to consider the likelihood that a project will pass a cost-benefit test, rather than having to rely simply on a point estimate.¹²⁵

¹²⁰ Davis, D.W., Faber, B.A., & Stedinger, J.R. (2008). USACE Experience in Implementing Risk Analysis for Flood Damage Reduction Projects. *Journal of Contemporary Water Research & Education*, 140, 3-14.

¹²¹ Hyde, W. F. (1994) Principles and Guidelines: A Ten-Year Critique. *The Zilberman Review*, 3.

¹²² Monte Carlo techniques allow the analyst to allow several uncertain parameters to vary simultaneously and construct a range of possible outputs (in this case, net benefit measures). Specifically, the analyst defines a distribution of plausible values for each uncertain parameter. The Monte Carlo model then randomly draws from this distribution for each uncertain parameter and calculates the net benefits that would result from the "draw." It repeats this process many times (e.g., 10,000), each time generating a net benefit estimate. The result is a distribution of 10,000 net benefits estimates, which can then be described probabilistically.

¹²³ Suedel, B. C., Kim, J., Clarke, D. G., & Linkov, I. (2008). A risk-informed decision framework for setting environmental windows for dredging projects. *Science of The Total Environment*, (403)1-3, 1-11.

¹²⁴ Ibid, Davis 2008

¹²⁵ Clemen, R. T. (1997). *Making Hard Decisions: An Introduction to Decision Analysis*. South-Western College Pub.

Application of Uncertainty in the UMRCP

Because the UMRCP analysis was done only at the reconnaissance level, the Corps did not conduct an uncertainty analysis.

OUTPUT PRICE EFFECTS

Summary

Under the current P&G, prices of goods or services that are affected by a project are to be valued at current market prices. However, it is possible that goods and services prices can be affected by the project itself (called Output Price Effects), changing the actual benefits and costs.

Criticisms of the P&G methods for incorporating Output Price Effects:

- P&G do not require analysis that accounts for potential changes in output pricing due to the implementation of a project.

Options for addressing these criticisms in P&G revisions include:

- Include output pricing effects in NED calculations of net benefits.
- Include demand analysis of affected goods to predict price changes for a projected change in quantity of the good in question.

Output Price Effects in the Current P&G

An integral part of conducting a complete BCA for any project is to consider the broad effects that will change accrued benefits and costs when a project is implemented. With large projects that result in large variation in the output of products (i.e., agricultural outputs affected by flood control measures, or hydroelectric power outputs from a dam project), it is possible that prices for these outputs can rise or fall depending on the project, and potentially have significant effects in calculating both regional and national net benefits. This change in price is referred to as an output price effect.

Methods of accounting for prices, and specifically for crop prices, are discussed explicitly in the P&G. Net benefits are calculated by anticipating the change in output volume of a good under proposed project alternatives, and then multiplying this quantity by a set price of the good. In the case of agricultural goods, the price is determined by the Department of Agriculture.¹²⁶ However, there is no method in the P&G to account for changes in price due to project effects.

Existing Criticisms and Options for Addressing Output Price Effects in the Updated P&G

Critics argue that analysis according to the P&G ignores output price effects on calculated benefits of a project. The omission ignores the potential that increases or decreases in outputs

¹²⁶ P&G, 1983, 2.3.3b

from the project can have significant effects on the market value of these outputs (i.e., downward pressure or upward on prices, respectively)¹²⁷.

Proponents of this view argue that in the case where a project creates a large increase of a good into a market (i.e., a flood control program that allows a formerly scarce agricultural good to be produced in great quantity), original benefit calculations that rely on current prices may overvalue the benefits of the project. Similarly, rising prices are suggested as a possibility when a previously productive good is reduced by a project (i.e., if a quantity of goods from a cropland that depends on floodwaters for irrigation and fertilization is severely reduced).

In both cases, a localized change in goods may have broader national effects, like in the case of subsidized goods, or goods and services that are transported out of the project region. For this reason, it can be challenging to determine exactly where benefits accrue.

The suggestions presented by proponents of taking into account output price effects are as follows:¹²⁸

- Include output pricing effects in NED calculations of net benefits.
- Include demand analysis of affected goods to predict price changes for a projected change in quantity of the good in question.

Beyond maintaining the current guidance, no alternative perspectives to account for output price effects have been suggested from the review of existing criticisms.

Application of Output Price Effects in the UMRCP

Within the UMRCP, the Corps did not consider output price effects in calculating benefits and costs. At the least, output price effect could have impacted the final results of a BCA: agricultural output changes as a result of reduced incidence of flood. Since the proposed project area within the Mississippi system largely supports agricultural output in the nation, project alternatives may have a significant effect on output prices.

¹²⁷ Hyde, 1994, p. 50

¹²⁸ Hyde, 1994, p. 50

PART III: FLOODPLAIN RISK: RESIDUAL RISK, NONSTRUCTURAL MEASURES, AND LEVEE DEVELOPMENT EFFECTS

“Let no one believe that because you are behind a levee, you are safe”
-- Brig. Gen. Gerald Galloway, February 2005

Introduction

This section focuses on three related issues central to the analysis of floodplain management projects: 1) risk and residual risk, 2) nonstructural alternatives, and 3) levee development effects.

The first section begins by defining and describing risk and residual risk in the P&G. Then nonstructural alternatives are explained. And finally, the third section discusses levee development effects along with existing literature on levee development and nonstructural approaches. Within each section, as in Part II, existing criticisms are highlighted and options are identified. The final sub section in each section reviews how the issue is addressed in the UMRCP case study.

RISK AND RESIDUAL RISK

Summary

Risk is assessed as a potential outcome that is described by reasonably well-known probability. Residual risk is the risk that remains after preventative measures have been taken.

Criticisms of the P&G methods for incorporating risk include:

- Residual risk management is not discussed extensively. This may be especially important in light of the expected hydrological impacts of climate change, where historical meteorological data may no longer be an accurate predictor of future conditions.

Options for addressing these criticisms in P&G revisions include:

- Improve methods of identifying, estimating, and combining risk and uncertainty information.
- Conduct *ex post* studies of projects to evaluate accuracy and reliability of risk models.
- Consider uncertainties in flood damage and overall project performance as residual risk.
- Accessibly communicate risk analysis findings to make them part of the deliberative process.
- Adopt Residual Risk Practices from other agencies or programs.

Defining Risk and Residual Risk in Floodplain Management

The P&G define risk as “the potential outcomes [that] can be described in reasonably well-known probability distribution.”¹²⁹ Once measures have been adopted to reduce risk of flood damage, the risk that flood damage will still occur is termed “residual risk.”¹³⁰

In the context of BCA, benefits and costs may be considered functions of the probability of flooding and the value of the area damaged by a flood. No Corps project removes all possibility of floods and associated flood damage. Given historical meteorological data and existing flood protection structures on a river, hydrologists have made estimates of probabilities of floods of a given magnitude. However, predictions of future events are subject to assumptions made when estimating flooding event probability distributions.

Additionally, even after hydrologists forecast floods with underlying probability distributions, presenting probabilities to the public and policy-makers in a clear and understandable format is a continuing challenge. To translate the concept of flood likelihoods to the general public, flood risks are typically portrayed as an “X-year flood”. For example, if flood levees were 15 feet and floods were expected to exceed 15 feet with a probability of 0.01 for each year, it would be

¹²⁹ P&G, 1983 Supplement I.S1

¹³⁰ <http://www.asce.org/files/pdf/erp.pdf> (accessed 8-02-09)

termed a “100-year flood.” The number of years is simply one divided by the probability of that level of flood.

X-Year Flood Models: The term is simply one divided by the probability.

If a given level of flooding is modeled to have a probability of 0.01:
 $1/0.01 = 100$ or a “100-year flood”

If the probability were .002 then the flood would be:
 $1/0.002 = 500$ or a “500-year flood”

Although this approach seems intuitive, it is often misinterpreted. For example, more than one 100-year flood may occur in 100 years. This is because the probability of seeing a “100-year” flood in one year is independent of whether one occurred in another. Additionally, the 100-year flood refers to one location; it is possible that a 100-year flood could occur each year in different locations.

In anticipation of flooding events, the Corps has employed structural measures to manage floods that include dams, reservoirs, levees, walls, diversion channels, pumping, and land treatment. By either storing or diverting the flow of flood waters, the Corps regulates the magnitude and direction of floodwaters.¹³¹ Corps structures are built with a specific design level in mind; for example, a “100-year” levee is designed to withstand a 100-year flood without failing. A levee built to withstand a flood anticipated to occur with a probability of 0.01 is termed a “100-year” levee. Many landowners incorrectly interpret this to mean that a flood will occur once every 100 years. In fact a 100-year levee means that there is a 1% chance *each year* that a flood of the magnitude identified will occur.

Despite building levees to 100- or even 500-year standards there are numerous ways in which levees may fail, including overtopping, becoming saturated and collapsing, eroding, and undergoing structural failures.¹³² After a levee or structure is built, the risk of the structure failing for any of the above reasons is termed residual risk. Given an inability to fully predict the future, residual risk can never be completely eliminated; it can only be managed (**Figure 6**).¹³³

¹³¹ National Research Council, Committee on Risk-Based Analysis for Flood Damage Reduction, Water Science and Technology Board, Commission on Geosciences, Environment and Resources. (2000). *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*. Washington D.C.: National Academy Press.

¹³² Steinman, F. & Banovec, P. (2008). *Flood Hazard, Flood Damage Potential, Residual Risk*. A presentation for Drava River Vision, Maribor. University of Ljubljana, Faculty of Civil and Geodetic Engineering, and Chair of Fluid Mechanics.

¹³³ More details of levee limitations are discussed in the CRS Report R40201, *Federal Flood Policy Challenges: Lessons from the 2008 Midwest Flood*, by Nicole Carter.

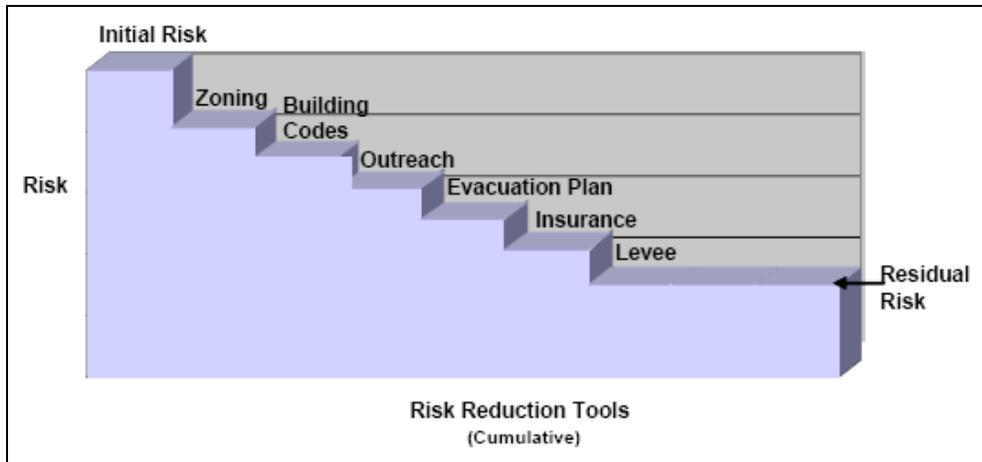


Figure 6. The existence of flooding risk even after protection by flood mitigation structures¹³⁴

Global climate change can also compromise the ability to predict future events based on historical data.¹³⁵ Therefore, an additional challenge in incorporating risk is accounting for the impact of global climate change into forecasts of future hydrological events. Patterns of increased flooding, as well as continued land-use changes, are now changing the probable maximum flood levels. For example, severe Mississippi floods have become more frequent since the 20th century. As of 1884, there have been 17, 100-year floods in St. Louis, and 16 of them have taken place in the 20th Century. St. Louis has experienced 14, 100-year floods in the past 66 years, 10 of which have occurred in the past 50 years.¹³⁶ Therefore, residual risk combined with nonstructural alternatives and development behind levees are key considerations when evaluating water management plans in the midst of changing conditions and future uncertainty.

Risk and Residual Risk in the Current P&G

Calculating risk presents both a theoretical and empirical challenge. Planners need to ask: 1) what risks to include in planning, and 2) how to include those risks. The P&G addresses these two questions in both theoretical (*Principles*) and empirical (*Guidelines*) settings.

Section 10 of the current *Principles* states:

Planners shall identify areas of risk and uncertainty in their analysis and describe them clearly, so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans.¹³⁷

¹³⁴ Figure from Corps at <http://www.asce.org/files/pdf/erp.pdf>

¹³⁵ Milly, P. C. D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., & Stouffer, R.J. (2008). Climate Change. Stationarity Is Dead: Whither Water Management? *Science* 319, 573. [DOI: 10.1126/science.1151915]

¹³⁶ McMaster, S. W. (April 1996). *The Influence of Flood Protection Structures on the Level of Development in Midwestern Floodplains*. Masters Thesis. Southern Illinois University.

¹³⁷ P&G, 1983, p. v.

The *Principles* direct analysts to identify changes in the risks of damages both before and after a project. The change in risk is weighted against either the cost of the project or the benefits of the project, so policy-makers may have the most realistic estimate of the change in damages should an adverse event occur.

Risk is treated both generally and in specific cases in the *Guidelines*. Chapter 1 Section IV gives an outline of how to include risk considerations in planning, Supplemental I treats risk more specifically. Finally, specific guidelines are given for how to evaluate risk when calculating NED benefits.

Within Chapter 1, Section IV the *Guidelines* state that the planner's primary role is to identify areas of risk and describe them. Situations of risk are defined as occurring within a reasonable, well-defined probability distribution. The role of the planner is to identify ways to reduce risk and describe the costs and benefits of reducing risk.¹³⁸

Supplement I of the *Guidelines* acknowledges that risk will always play some role in water resource-related projects, and states that the planner should identify sources and ranges of risks. Types of risk identified include natural, social, and economic unpredictability. The *Guidelines* state that the assessment of risk in project evaluation should be reported and displayed in a manner that makes clear to the decision-maker the types and degrees of risk and uncertainty believed to characterize the benefits and costs of the alternative plans considered.¹³⁹

Finally, the P&G offer specific guidance when calculating the NED account in Chapter 2, Section III. The P&G recognize that there are inherent problems in evaluating damage reduction benefits.¹⁴⁰ The challenge is to measure the change in the probability of damage happening before and after a project has been completed. For this reason, the impact of residual risk is housed within an evaluation of two levels of risk: with and without the proposed project.

Not every section of NED treats risk explicitly, but it does give some examples of how risk may be incorporated into estimating costs and benefits. The P&G state that when calculating the NED benefits of agriculture, the NED benefit evaluation procedures should take into account "residual damages" for agricultural benefits from the water resources plan. For these purposes residual damages are defined as "... damages that would still occur with implementation of the plan."¹⁴¹ For evaluating risk in the "without" plan, calculating risk will depend on what projects have been completed by the local authority that has jurisdiction over urban flood damage projects. If residual hazard exists after implementing local risk reducing regulations, those local regulations may still be certified by the Flood Insurance Agency, under the Federal Emergency Management Agency (FEMA).¹⁴²

¹³⁸ P&G, 1983, Ch. 1.4.13

¹³⁹ P&G 1. Supplement I.S2

¹⁴⁰ P&G Section 2.3.8

¹⁴¹ P&G Section 2.3.8 (d)

¹⁴² P&G Section 2.4.3 (2) (ii)

The P&G identify several methods for including residual risk in the “with” and “without” options.¹⁴³

- 1) Damage Reduction Benefits
- 2) Change in Land Constraint
- 3) Benefit Attribution of Drainage and Flood Damage Reduction
- 4) Changes in Land Value

To evaluate the changes in the preceding four categories of benefits, the P&G suggest four sources of data: a) interviews with farmers and area residents, b) physical specialists such as agronomists and soil scientists, c) universities and federal agencies, and d) land appraisers.

Existing Criticisms and Options for Addressing Residual Risk in the Updated P&G

In critiques of the P&G, five categories emerged that relate to how risks are addressed and how they could be more fully addressed in the future.

1. Improve methods of identifying, estimating, and combining risk and uncertainty information

The NRC recommended that the Corps should adopt probabilistic performance measures of engineering risk, which more accurately estimates uncertainties associated with each component of the project.¹⁴⁴ While improving risk-based analysis will increase project costs, in terms of retraining and reeducating existing personnel, these up-front training costs may be mitigated by better performing projects in the long-term. In addition, more accurate projections of project performance may help secure financial support from potential beneficiaries or other cost-sharing partners.¹⁴⁵

2. Conduct *ex post* studies of projects to evaluate accuracy and reliability of risk models

The NRC recommended that the Corps perform empirical, *ex post* studies of a number of projects to evaluate accuracy and reliability of risk models. Probabilities of failure for flood mitigation projects could be compared against actual frequencies of structural and nonstructural failures. These studies will be appropriate for determining shortfalls in the risk analysis and reliability in the engineering models.¹⁴⁶

3. Consider uncertainties in flood damage and overall project performance as residual risk.

Darryl Davis from the USACE Institute for Water Resources notes that the Corps should analyze the “consequence of the exceedence of project capacity to public safety, lifeline security, and

¹⁴³ P&G Section 2.4.3 (a)

¹⁴⁴ National Research Council (NRC). (2000). *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*. National Academy Press. p.162

¹⁴⁵ Moser, D.A. (2001). *The Use of Risk Analysis by the U.S. Army Corps of Engineers*. U.S. Army Corps of Engineers Institute for Water Resources

¹⁴⁶ National Research Council (NRC). (2000) *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*. National Academy Press. p.163

local and regional economic impacts.”¹⁴⁷ If possible, these consequences need to be quantified and included in the NED account during the planning stage of the project.¹⁴⁸ This would address naturally-occurring uncertainty, as well as knowledge uncertainty, which arise from a limited understanding of those systems. In the language of levee certification, the focus should be placed on "annual exceedence probability," the likelihood that an area will be affected by any flood, rather than whether or not it passes the 100-year flood certification.

4. Accessibly communicate risk analysis findings to make them part of the deliberative process.

The goal of the Corps’ risk analysis is to inform the public and decision-makers. While probabilistic distributions are inherently more complicated and are more difficult to convey to a non-technical audience, the Corps should try to present this information to its constituents and policy-makers in an accessible way, through the use of intelligible terminology and visual aids.¹⁴⁹ The Corps should present analysis in a transparent manner and use standardized prose to avoid confusion. In general, more practical guidance as to how risk analysis should be used to inform policy would help decision-makers use this information more effectively.¹⁵⁰ Furthermore, uncertainties in flood frequency estimations need to be conveyed, including more consistent terminology when discussing natural variability, uncertainty, risk, and system reliability.¹⁵¹

5. Adopt Residual Risk Practices from other agencies or programs.

Although the current P&G do not incorporate residual risk, the examples below may be feasible options to enhance the risk assessment in P&G.

Residual Risk at the Environmental Protection Agency (EPA)

The Clean Air Act mandated the EPA to prepare reports on their residual risk assessment methods. In their “Residual Risk: Report to Congress,” the EPA explains how it evaluates the remaining risk after the implementation of Maximum Achievable Control Technology (MACT) on emission sources of hazardous air pollutants. The EPA defines the standards beyond MACT as “an ample margin of safety to protect public health” and to “prevent, considering costs, energy, safety, and other relevant factors, an adverse environmental effect” as required by the act.¹⁵² Given directives by the act, the EPA’s residual risk assessment provides information to formulate standards for the identified emission sources. In this way, their decision-making

¹⁴⁷ Davis, D.W., Faber, B.A. and Stedinger, J.R. USACE Experience in Implementing Risk Analysis for Flood Damage Reduction Projects. (2008). *Journal of Contemporary Water Research & Education*, 140, 6.

¹⁴⁸ National Research Council (NRC). (2000). *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*. National Academy Press.

¹⁴⁹ David A. Moser (2001). *The Use of Risk Analysis by the U.S. Army Corps of Engineers*. U.S. Army Corps of Engineers Institute for Water Resources.

¹⁵⁰ Davis, D.W., Faber, B.A. & Stedinger, J.R. (2008). USACE Experience in Implementing Risk Analysis for Flood Damage Reduction Projects. *Journal of Contemporary Water Research & Education*, 140, 3-14.; National Research Council (NRC). (2000). *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*. National Academy Press.

¹⁵¹ Ibid, Davis et al. 2008

¹⁵² EPA, 1999, p.ES-8

process ensures that appropriate standards for the public and environmental health are considered in the decision-making.

The EPA residual risk assessment is a detailed, multi-step process, which consists of six steps (See **Appendix D** of this report for the description of each step). The EPA's analysis measures the human health risk for each case of exposure and emission of hazardous air pollutants, which differs from the P&G's approach. If the level of risk involved is acceptable, the EPA stops assessing the residual risk in the fourth step; otherwise, the process continues with the evaluation of management options to reduce the associated residual risk. Factors such as residual risks, costs, economic impacts, feasibility, energy, and safety are all considered in weighting of management alternatives, and the residual risk assessment is completed after analyzing the options' impacts. With the analysis provided by the residual risk assessment, the EPA proceeds with decision-making. The residual risk assessments inform the final decision that identifies the best management option to reduce hazardous air pollutants (HAPs) emissions.¹⁵³

Residual Risk in Hurricane/Storm Protection

The Hurricane and Storm Damage Risk Reduction System (HSDRRS), which will be upgraded with a 100-year system by the Corps,¹⁵⁴ decreases but does not eliminate risk entirely. Once HSDRRS structures are built, their impact on storm damage reduction stays static. Factors such as sea level rise, erosion, changing weather patterns, land use changes, and/or performance of storm or flood protection contribute to the (changing) residual risk. To reduce the remaining risk after taking all protection measures, the New Orleans team suggests the following strategies:¹⁵⁵

- Heeding evacuation orders
- Restoring wetlands and barrier islands
- Raising buildings and making them flood-proof
- Relocating buildings to higher ground
- Purchasing insurance

As a response to Hurricane Katrina, Congress mandated the Corps to prepare a comprehensive plan for South Louisiana. The Corps were required to consider hurricane protection, flood control, and coastal restoration. The end product, Louisiana Coastal Protection and Restoration (LACPR), creates a decision framework to produce risk-informed decisions. The Corps recognize that storm and flood risk fluctuates over time because of changes in project planning conditions such as weather, land-use patterns or performance of the flood or storm protection projects. In order to inform decision-makers of possible future conditions, the Corps uses Risk Informed Decision Frameworks to guide the decision-making process.

¹⁵³ United States Environmental Protection Agency, Office of Air Quality. (March 1999). *Residual Risk: Report to Congress*. Retrieved from http://www.epa.gov/ttn/oarpg/t3/reports/risk_rep.pdf

¹⁵⁴ US Army Corps of Engineers Headquarters (September 23, 2008). *U.S. Army, State of Louisiana Sign Project Partnership Agreement*. Retrieved from <http://www.usace.army.mil/CEPA/News/Pages/LaAgree.aspx>

¹⁵⁵ US Army Corps of Engineers, Team New Orleans. (Last updated 02/26/2009). *Understanding Risk*. Retrieved from http://www.mvn.usace.army.mil/hps2/hps_riskgen.asp

Application of Residual Risk in the UMRCP

In the UMRCP, risk analysis was discussed in the context of the Risk Informed Decision Framework (RIDF), a system developed by the Corps in which traditional risk analysis is combined with tools from the field of multi-criteria decision analysis (MCDA), and used to evaluate structural and nonstructural alternative plans for the Upper Mississippi River basin. The foundation of RIDF is outlined in Appendix I of the UMRCP, and is composed of the following steps:

- 1) Define the boundaries of the analysis
- 2) Develop performance metrics and associated uncertainty
- 3) Formulate alternative plans
- 4) Evaluate alternative plans
- 5) Eliminate objective-dominated plans
- 6) Select recommended plan

Step 2 is primarily where risk analysis is conducted as it applies to flood protection. In constructing metrics to begin to evaluate the benefits and costs associated with any alternative plan, the Corps suggests, “along with indicating the basic source of metric estimates, it is necessary to explicitly state the important underlying assumptions and indicate which are highly uncertain, moderately uncertain, or highly certain.”¹⁵⁶ Within the UMRCP RIDF analysis, the following metrics were defined according to their associated P&G accounts. The NED uses empirical data and models to assign dollar values to metrics for the NED, which are construction costs, annual net benefits, and the benefit-cost ratio. RED uses the Regional Economic Model Inc. (REMI) to assign dollar values to measure the construction costs. The environmental quality account uses empirical data and expert opinion to estimate the acreage for mitigation, secondary development, and ecological restoration opportunities.¹⁵⁷

However, beyond reporting point-estimate values for these metrics within the RIDF Appendix I, no assumptions or models used to estimate these metrics were reported in the RIDF analysis. Likewise, no analysis of uncertainty about metric accuracy, including estimate ranges, variance, sensitivity analysis, or other methods of quantifying uncertainty and associated risk for flood protection were reported in the plan.

Once metrics have been determined by model estimation and risk analysis, the UMRCP uses tools from MCDA in steps 4) through 6) to determine weights for the importance of each metric, convert weights to a comparable scoring system, rank alternatives using these scores, and finally choose the highest scoring plan¹⁵⁸. Historically the Corps has focused on selecting the plan that maximizes the national economic development (NED) benefits. Counter to this tradition, MCDA seeks to use “a comprehensive decision analytic framework that considers a broad array of objectives and criteria/metrics, including those associated with ecosystem restoration.”¹⁵⁹

¹⁵⁶ Appendix I: Risk-Informed Decision Framework for the Upper Mississippi River Comprehensive Plan, p. 4

¹⁵⁷ Appendix I: Risk-Informed Decision Framework for the Upper Mississippi River Comprehensive Plan, p. 4

¹⁵⁸ In addition, RIDF performs a sensitivity analysis on these weights to determine how changes in weighting preference between metrics and their associated accounts by the public and decision-makers might affect each plan’s overall score.

¹⁵⁹ Ibid. p. 7

NONSTRUCTURAL ALTERNATIVES

Summary

Nonstructural alternatives are changes that do not require physical alteration of floodwater flow or direction. These could include modifications in public policy, alterations in management practices, regulatory changes, or modifications in pricing policy.

Criticisms of the P&G methods for incorporating risk include:

- Nonstructural alternatives are encouraged, but they are not weighted equally with structural alternatives in the assessment process. This may be because nonstructural alternatives do not meet all four criteria required by the P&G for assessment: completeness, effectiveness, efficiency, and acceptability.
- Nonstructural alternatives are also frequently outside the jurisdiction of the Corps, as they primarily involve local and municipal regulations.

Options for addressing these criticisms in P&G revisions include:

- A plan that employs nonstructural alternatives should be included in future planning. This is included in the September 2008 Draft Principles.

Nonstructural Alternatives in the Current P&G

In addition to structural measures, the P&G discuss the possibility of using nonstructural measures to manage residual risk. Nonstructural measures are defined in the P&G as a modification in public policy, an alteration in management practice, a regulatory change, or a modification in pricing policy that provides a complete or partial alternative for addressing water resources problems and opportunities. Nonstructural measures can include the following:^{160,161,162}

1. *Watershed Management.* The idea of “catching the water where it falls” calls for modifying the formation of floodwater by managing land-use and soil conservation policies to minimize surface runoff, erosion, and sediment transport.

¹⁶⁰ Andjelkovic, I. (2001). Guidelines on Non-Structural Measures in Urban Flood Management. *UNESCO, Technical Documents in Hydrology*. Paris: International Hydrological Programme.

¹⁶¹ Army Corps Circular 1150-1-404, Planning Civil Work Projects Under the Environmental Operating Principles. May 2003.

¹⁶² Green, C., Parker, D., & Tunstall, S. (2000). *Assessment of Flood Control and Management Options*. Vlaeberg, Cape Town, South Africa: Secretariat of the World Commission on Dams.

2. *Zoning and Relocation.* Local land use policy and zoning guidelines can be used to ensure safer development and settlement on the floodplain. Residents that are currently in danger can be relocated to safe areas.
3. *Flood Forecasting and Warning.* By monitoring factors likely to cause a flood and warning residents of a likely flood, local governments can prepare residents for evacuation measures or reinforcement techniques.
4. *Awareness Raising.* Communicating with the public about flood risk and what likely damages will be increases the motivation for individuals to prepare themselves for floods and reduces the economic impact of a flood.
5. *Insurance.* Insurance against flood damages can reimburse affected individuals for the economic losses they have suffered in the case of a flood. The National Flood Insurance Program (NFIP), created by Congress in 1968, requires homeowners with federally backed mortgages to purchase flood insurance. While this does nothing to reduce the risk of a flood, insurance protection reduces the financial risk of people in floodplains.
6. *Natural Flood Reduction Strategies.* Preserving wetland areas or restoring wetland areas to their natural state helps to divert water into a catchment area and reduces the volume and velocity of floodwater going into the original floodplain. This diversion reduces the frequency, intensity, and severity of floods.
7. *Flood Preparedness and Recovery Plans.* Developing preparedness and recovery plans with public participation increases the ability of the community to react to a flood proactively. Increased preparedness and knowledge of who needs to do what when, and where they need to go, reduces the loss of life and economic damages that result from a flood, and decreases the time required for the community to recover.

These alternatives are termed “nonstructural” because they do not rely upon physical alteration of floodwater flow or direction. In many instances these alternatives are policy driven and may be less costly. However, an additional challenge to consider when implementing nonstructural alternatives is policy jurisdiction.

Important jurisdictional differences play a key role in how the federal water agencies approach nonstructural approaches to flood control. Comprehensive flood management plans are locally driven, usually at the city or county level of government. The Corps generally does not have the power to impose nonstructural and comprehensive flood management plans on local jurisdictions. Because the authority for different aspects of comprehensive flood management can lie in many different jurisdictions, coordination may be a difficult challenge. Where local governments have implemented comprehensive flood management plans that include nonstructural alternatives, there is some evidence that they have been effective.

One challenge is that state and local governments may lack incentives to invest in more comprehensive flood management plans, because federal insurance programs partially cover costs of a flood. Since the Federal Emergency Management Agency (FEMA) mitigates consequences of floods that exceed the 100-year level of protection, this decreases the motivation of local governments to incur costs in expensive flood prevention projects.¹⁶³

¹⁶³ (33 USC 701n) Galloway Jr., 2005.

However, Corps planning guidance — the P&S, the P&G, and the PGN — have encouraged use of nonstructural alternatives. The important difference between the P&S and the P&G is that current guidance does not specifically *require* planners to consider a nonstructural alternative.¹⁶⁴

Currently the P&G recommends that “non-structural alternatives should be considered as means for addressing problems and opportunities” and “shall receive equal consideration in the planning process to structural measures” regardless of whether the Corps itself could legally implement this plan. Nonstructural measures are included in Section VI — Alternative Plans, and nonstructural alternatives can make up the complete alternative plan or can be combined with more traditional structural methods.¹⁶⁵

The PGN also encourages nonstructural alternatives. According to the PGN, “[t]he first phase in the plan formulation process is the identification of management measures that could be implemented, giving equal consideration to structural and non-structural measures.”¹⁶⁶ And the feasibility report should document that “all reasonable alternatives for addressing the identified problems, including non-structural measures and measures beyond the authority of the Corps to implement, have been systematically formulated and evaluated in accordance with the P&G.”¹⁶⁷

The September 2008 *Draft Principles* state, “[i]n order to facilitate the development of the widest range of practical alternative plans, the following required alternatives constitute the minimum series of plans necessary.”¹⁶⁸ The minimum series will include a NED plan, an EQ plan, and a Primarily Nonstructural Plan. The Primarily Nonstructural Plan would be a plan that primarily employs nonstructural elements, and as a secondary consideration adds structural features to address the planning issues. This would return Corps guidance to the requirements of the P&S.

Existing Criticisms and Options for Addressing Nonstructural Alternatives in the Updated P&G

Federal water projects are not a good panacea for bad public policy.
-Griffin¹⁶⁹

While the P&G recommend that planners consider nonstructural alternatives, they are not weighted equally with structural alternatives in the assessment process. This is due to a number of factors. One of the most important is that nonstructural alternatives frequently do not meet all four criteria required by the P&G for assessment: completeness, effectiveness, efficiency, and acceptability.¹⁷⁰ Depending on how planning objectives are defined in a study, potential

¹⁶⁴ Scodari, P. (2005). *Survey and Analysis of Criticism of Corps Planning and Links to Planning Guidance*, 9.

¹⁶⁵ P&G Section 1.6.1

¹⁶⁶ PGN page 2-4

¹⁶⁷ PGN Appendix G-6

¹⁶⁸ Draft Principles and Guidelines http://www.usace.army.mil/CECW/Documents/pgr/pg_draft.pdf (accessed 8-02-09)

¹⁶⁹ as quoted in Scodari, P. (2005). *Survey and Analysis of Criticism of Corps Planning and Links to Planning Guidance*.

¹⁷⁰ Scodari, page 10.

nonstructural measures might be rejected early in the planning process because they fail to meet one or more of the formulation criteria. And while the P&G encourages the consideration of nonstructural alternatives, unlike the P&S guidance, it does not specifically require a primarily nonstructural plan.

However, others argue that the Corps should make their assessments as if policies advocating nonstructural alternatives were already in place at local and regional levels. This would maintain the responsibility for local and regional policy at local and regional levels.¹⁷¹

Nonstructural Alternatives in the UMRCP

In the UMRCP main report, one of the 13 plans presented has a nonstructural component and two of the plans could be described as primarily nonstructural. Plan H combined structural and nonstructural components with “cost-effective buyouts” to purchase certain floodplain properties where the benefits of structural protection (100-year levees) are less than the value of the property. Plan I and Plan J were both primarily nonstructural — Plan I would combine buyouts in the agricultural districts with urban floodplain development restrictions (with the 500-year floodplain), and Plan J would purchase land in the 100-year floodplain and (presumably) relocate any existing residents or structures. These nonstructural approaches would also have the benefit of increasing floodplain connectivity.¹⁷²

In the public comments the Corps gathered while preparing the UMRCP, it is interesting to note there was strong, repeated support for the idea of nonstructural alternatives. However, when the Corps proposed Plan G, which would have involved raising levees north of St. Louis to the 500-year level together with buy-outs and the use of 10,000 acres south of St. Louis as an overflow area, there was strong opposition among residents in the county designated for buy-outs, and the Corps abandoned this controversial plan. While Plan G was not a nonstructural plan, as it involved a significant structural component, the strong opposition to the creation of a storage area demonstrates how challenging buy-outs can be. Nonstructural alternatives are a popular concept, but possibly most attractive when they involve another family’s backyard.

¹⁷¹ Griffin, (1993). *The Zilberman Review*.

¹⁷² UMRCP, p. 72 -74.

LEVEE DEVELOPMENT EFFECTS

Summary

Construction of levees alters development patterns and therefore influences benefits and costs of a levee-constructing alternative in multiple ways. Construction may result in more development behind levees, but still on the floodplain. With lowered risk of flooding but higher property value on the floodplain the net effect may result in higher property damage than expected.

Criticisms of accounting for levee development effects include:

- The National Floodplain Insurance Program (NFIP) may discourage efficiently pricing land in flood prone areas to minimize risk and maximize flood damage reduction efforts
- Extensive construction of levees may result in all levees offering a lower level of protection, as floodwaters are not diffused into the floodplain but instead channeled downstream.
- Limited academic studies have been done to determine whether levees serve as catalysts for economic development.

Options for addressing these criticisms in P&G revisions include:

- Include anticipated development behind levees in BCA.
- Include impact of proposed new levees on existing levees in BCA.
- Include the impact of NFIP incentives to develop on the floodplain when evaluating proposed Corps levee projects.
- Invested more resources in tracking regional effects post-levee construction.

Existing Criticisms and Options in Accounting for Levee Development Effects

When weighing structural and nonstructural approaches to floodplain management, in addition to residual risk and nonstructural alternatives, a third consideration is accounting for the type of development that occurs in the floodplain once levees are built and the subsequent expectations by the people moving into the floodplain.¹⁷³ This “levee development effect” is the increased incentive to build on a floodplain after a levee is constructed. Perversely, by both increasing development in the floodplain and reducing the risk of flooding the net result may be the same value of property will be damaged as before the levee was built.

The land that is developed can be used for residential, commercial, industrial, and agricultural purposes. Development may be limited by nonstructural efforts such as constraints on land-use

¹⁷³ White, G.F. (1945). *Human Adjustment to Floods: A Geographical Approach to the Flood Problems in the United States*. University of Chicago Press.

planning, zoning, and including regional growth boundaries. Once a levee has been built, the floodplain is often perceived as being less flood-prone than it actually is, and residents may rely on the National Flood Insurance Program (NFIP) protection to reimburse them for any flood losses. Furthermore, if cheaper floodplain land values attract disproportionately poor residents, they may be unable to move themselves and their property away from the flood risk without incurring considerable costs.¹⁷⁴

Finally, as more development occurs on the floodplain, people moving to the floodplain start to demand greater flood protection to reduce the risk of flood damage. This can lead to the so-called “escalator effect”. In the escalator effect urban development sites behind a floodwall depend on the water storage in the floodplain. With increasing urban development in floodplains, the demand for protection by flood mitigation structures such as levees increases. This heavy protection narrows the floodway to the point where every flood can result in overtopping. Even the best possible protection may experience flooding beyond its base flood.¹⁷⁵

Academic Studies of Levee Development and Nonstructural Approaches

Limited research has been done to determine whether levees serve as catalysts for economic development, which is a key factor when calculating benefits for the RED account. In the last 50 years, some have assumed that building a levee spurs development in the form of job creation: jobs created by building the levee, construction in the floodplain after the levee has been built, and jobs associated with any industry moving into the floodplain.

While it is possible that levee development may spur economic development, it is also possible that levees simply displace jobs that would have been created outside the floodplain. Furthermore, changes of land values in floodplains may not accurately reflect the change in residual flood risk from structural protection.

With limited studies on this topic, federal agencies have had to rely on single documents such as the master’s thesis described below, which was used to determine estimates of economic development behind levees in the UMRCP. The results of one study have had a significant impact on how the RED account is weighted. In the thesis, McMaster tried to empirically estimate the “levee effect” by comparing the amount of money invested in either commercial or residential construction or renovation before and after a levee was built. To create a control group, McMaster compared the pre- and post-levee values of activity in three cities that built a levee to values in two cities that did not build a levee. The findings were inconclusive.

The McMaster thesis considered the level of activity (in terms of money invested in new construction in the floodplains that had little to no pre-existing structures and money invested in renovation in floodplains that already had pre-existing structures) of five cities. Two cities saw statistically significant levels of increased activity within the floodplain post-levee construction, while three cities did not.

¹⁷⁴ McMaster, S. W. (April 1996). *The Influence of Flood Protection Structures on the Level of Development in Midwestern Floodplains*. Masters Thesis. Southern Illinois University

¹⁷⁵ Parker, D J. (1995). Floodplain development policy in England and Wales. *Applied Geography* . 15(4), 341-363.

Two concerns may hamper the application of McMaster results to the UMRCP:

(1) Displacement of Development

The thesis considered the possibility that constructing a levee might simply displace activity that would have happened outside of the floodplain, pulling this activity into the floodplain. In terms of tracking the development, the thesis considered the displaced activity a benefit in the floodplain, but did not consider it a cost outside of the floodplain. The net benefit (activity in the floodplain less activity outside the floodplain) would ultimately be a better indicator of the levee effect. Consider the case of Davenport, Iowa, which saw higher levels of activity outside the floodplain. According to McMaster, had a levee been built in Davenport, the level of activity in the floodplain might have increased at the cost of the activity outside the floodplain, in addition, or some variant of the two.

(2) Causation Correlation Confusion

The McMaster thesis compared two groups: The experimental group that built a levee and the control group that did not. The report found the two cities that built levees had significant increases in the level of activity within the floodplain. It is possible, but not certain, the values observed in the McMaster thesis can be attributable to regional development, a variable independent of levees. Cities with levees were clustered together, so that rising general economic development (not attributable to the levees) in the cluster may have been a bigger factor.

Chivers and Flores documented the effect a levee can have on property values in their critique of the National Flood Insurance Program (NFIP).¹⁷⁶ Their article claims that the NFIP failed to efficiently price land in flood prone areas to minimize risk and maximize flood damage reduction efforts.¹⁷⁷ They attribute this mainly to the failure of federal regulators and mortgage lenders to uniformly enforce flood insurance requirements. They found the complex calculation of premiums, the variability of rates, and the consistent lack of premium disclosure to homebuyers until purchase prevented the reflection in property prices of the inherent flood risk. Furthermore, they found that cheap land, combined with poor consumer information, created an incentive for developers to develop high-risk floodplain areas and sell property to less informed homebuyers. Chivers and Flores proposed the removal of mandatory NFIP and, instead, suggested home sellers should be required to obtain a flood-rating certificate as a necessary condition for listing a property in a flood-prone area.

Holway and Burby found the effect a levee has on the NFIP, and by extension land values, can be either enhanced or negated by nonstructural alternatives.¹⁷⁸ They found the value of the land increased by \$689 per acre after construction of a levee, although the direct experience of

¹⁷⁶ Chivers, J and Nicholas Flores. (2002) Market Failure in Information: The National Flood Insurance Program. *Land Economics*. 78(4), 515-512.

¹⁷⁷ Under NFIP, flood insurance premiums were priced based on location and flood risk, where high-risk areas had higher premiums to discourage development, and lower risk areas had lower premiums to maximize use of the land.

¹⁷⁸ Holway and Burby use hedonic modeling to determine the difference. Hedonic models use existing variation in prices and amenities to predict values for a property with a given set of similar amenities, or the value of one specific amenity (in this case the presence of a levee).

individuals affects the valuation: An individual who experienced a recent flood decreased the value of the land more than older floods (a decrease of \$288 for recent, \$182 for older). However, nonstructural measures the local jurisdiction put in place were found to have a much greater effect on the value of the land. Holway and Burby further found that when local government ensured that floodplains were zoned for low-density development, the value of the parcel was \$268 lower per acre than when they zoned for medium-density development. The limited development combined with the lower land value reduces the potential damages that can be caused by a flood.

Holway and Burby also found that if local governments required buildings to be elevated above minimum NFIP elevation, it reduced the value of the land by \$74 per acre for each additional foot. Finally, they found the enforcement and coordination of floodplain management by local governments made a significant difference. In areas where the local government designated a single individual or department to oversee floodplain development, parcels that resided in the floodplain were valued at \$188 per acre lower than those areas where the responsibility was either nonexistent or distributed among many agencies.¹⁷⁹

Academic studies have not conclusively proven that levees spur economic development. Scholars have documented some post-levee construction effects, but evaluations have not yet tied all of the subsequent actions to the levee as a catalyst. Furthermore, the literature has shown that it is difficult to differentiate which effects are attributable to the levee and which are attributable to the policies of the local governments. Future efforts could benefit considerably if the Corps invested more resources in tracking regional effects post-levee construction. This collection of data for analysis is consistent with project management theory that holds evaluation and assessment as the concluding step to any project.

Levee Development in the UMRCP

As discussed above, the Corps contracted with the Tennessee Valley Authority (TVA) to calculate regional-level benefits, which used a computable general equilibrium model from the REMI firm. Because the model results depended heavily on assumptions about levee development effects (and multipliers), it is discussed in more detail here.

For the UMRCP, the REMI model used information gathered about different factors to predict how levee construction would affect five indicators of economic development. The purpose of the model is to project the marginal benefits in economic activity that a levee would bring to the region.

The five indicators used in the REMI model were:¹⁸⁰

¹⁷⁹NRC. (1999). *New Directions in Water Resources: Planning for the U.S. Army Corps of Engineers*. National Academy Press. Washington, D.C.

¹⁸⁰TVA (2004). *An Economic Evaluation of Proposed Flood Protection Plans on the Upper Mississippi River and Illinois Waterway*. Prepared for The Rock Island District U.S. Army Corps of Engineers. Available online at <http://www2.mvr.usace.army.mil/UMRCP/Documents/CompPlanRegionalEconomicDevelopmentRpt.pdf>.

- ***Construction,***
The model projected that levee construction would bring both direct and indirect monetary benefits to the region. Direct benefits would include the jobs created and the money invested to purchase the materials and supplies for construction. Indirectly, construction would bring benefits to the region because of the goods and services that the workers and their families could buy with the money earned through construction jobs. The model does acknowledge that some of the indirect benefits would be enjoyed by families of construction workers living outside the regional boundary of the study.
- ***Economic development,***
The model projected that building a levee reduced the risk of flooding in the flood plain behind levees. The subsequent impact of levee construction would be 1) reduced operating costs for businesses with lower flood damage insurance premiums, 2) a greater amount of usable land, and 3) more feasibly upgraded infrastructure.
- ***Land value enhancement,***
The model projected that building a levee and providing greater protection from flooding, increased the value of the land. The model also assumes reduced flood insurance premiums are positive income flows for landowners.
- ***Farm income gains, and***
The model projected that building a levee and providing greater protection from flooding would lead to a decrease in crops destroyed by flooding. This was considered a gain to the farmers who would reap more of the crops they sowed.
- ***Damages averted.***
The model also considered the damages that could be averted as a result of constructing a levee.

Each of five indicators is measured in terms of increased gross regional product (GRP), increased real personal income (RPI), jobs created, and increased efficiency measured in terms of output.¹⁸¹

- The REMI model uses information garnered from large data sets maintained and managed by agencies such as the Bureau of Labor Statistics, Bureau of Economic Analysis, the Department of Energy, the Census Bureau, and others. REMI uses values generated from data collected by the different agencies to develop a multi-sector equilibrium analysis and calculate how the presence of a levee would increase each of the five indicators.
- The REMI model concluded that the 500-year protection plan would generate the greatest amount of regional benefits based primarily on two of the five input variables: construction and economic development. The model calculated that regional gross product would increase by \$30.381 billion, total personal income would increase by

¹⁸¹ Ibid. TVA (2004).

\$25.295 billion, and output would rise by \$51.518 billion. The model also concluded that 25,690 jobs would be created, but it is unclear whether those jobs were included in the model as net benefits or net costs. The REMI model concluded that the region would benefit significantly from constructing a levee. The model calculated that the region would see 19,023 in average employment each year, \$20.427 billion increase in gross regional product, \$16.927 billion increase in regional personal income, and \$33.952 increase in output. The economic development portion of the TVA report depended primarily on the work done in the McMaster thesis. The REMI model included McMaster conclusions in a linear regression model that considered employment as the dependent variable. The conclusion is that economic development is measured in terms of employment. The equation considered population growth, the presence of a levee, and time.

As stated above, the REMI model is proprietary. This reality limited the amount of information available about the model and prevents further analysis.

APPENDIX

Appendix A: Annotated Bibliography

This annotated bibliography covers existing literature on the use of Benefit-Cost Analysis (BCA) by federal agencies that manage water and water related natural resources. Specifically, these agencies include the Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation), Tennessee Valley Authority (TVA), and the Natural Resources Conservation Service (NRCS). The bibliography is organized by topic with four sections.

Section I. Planning Documents

Section II. Evaluation of Existing Principles and Guidelines for Benefit-Cost Analysis

Section III. Methodology (discussion of BCA or other measurement techniques)

Section IV. Scientific and Policy Background

SECTION I. Planning Documents

Water Resources Council. (1983). *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, D.C.: U.S. Government Printing Office.

The *Principles and Guidelines* (P&G) document outlines a set of rules and steps to be followed in assessing costs and benefits of implementation alternatives for water resource projects. The document aims to provide consistent planning and decision-making for water resource projects implemented by the Corps of Engineers, the Bureau of Reclamation, the Tennessee Valley Authority, and the Natural Resources Conservation Service (formerly the Soil Conservation Service). The objective of the assessed projects is to contribute to national economic development (NED) by increasing the value of national output, while being consistent with relevant environmental regulations. Four agencies are required to use the P&G: the Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and the Natural Resources Conservation Service. The largest part of the document details how to calculate the NED benefits for each plan. Benefits are based on: 1) municipal and industry water supply services, 2) agricultural production, 3) urban flood damage reduction, 4) hydropower production, 5) ease of transportation, 6) recreation, 7) commercial fishing, and 8) use of unemployed or underemployed labor. Most benefits are measured using either market values or public willingness to pay. Costs include installation, operation, management, and replacement. Costs and benefits are discounted to present value, and the project with the greatest net economic benefits is chosen unless there is an overriding reason to select a different plan. The document also briefly outlines methods for analyzing uncertainty and risk, as well as evaluation of projects in three other areas: environmental quality, regional economic development, and other social effects. However, these analyses are not required.

U.S. Army Corps of Engineers. (2000). *Planning Guidance Notebook*. ER 1105-2-100, April 22, 2000. Available online at <http://140.194.76.129/publications/eng-regs/er1105-2-100/entire.pdf>

The PGN shows Corps practitioners how to apply the BCA in the Corps setting. This Corps document provides the overall direction by which Corps projects are formulated, evaluated, and selected for implementation. It contains a description of the Corps planning process, missions and programs, specific policies applicable to each mission and program, and analytical requirements. Its fundamental purpose is to describe the planning process in “straightforward, plain language”¹⁸². The added benefit of the PGN is condensing the P&G into key ideas and outlining how BCA in the Corps should be conducted.

The PGN is divided into four chapters that correspond with four components of the P&G:

Chapter 1 gives an overview of the background of the P&G from beginning to current revisions; the entire 1983 Executive Order from President Regan is included as a founding document. Next the PGN outlines the purpose, scope and application of the P&G.

Chapter 2 begins by describing the federal objective of the P&G as “contributing to national economic development consistent with protecting the Nation’s environment”¹⁸³. Next each of the six steps of BCA mandated by the P&G are reviewed and summarized:

- Step 1 — Identifying problems and opportunities
- Step 2 — Inventorying and forecasting conditions
- Step 3 — Formulating alternative plans
- Step 4 — Evaluating alternative plans
- Step 5 — Comparing alternative plans
- Step 6 — Selecting a plan

Thirdly, Chapter 2 discusses individual elements of BCA including: System Analysis, With and Without Project Analysis, BCA and Cost Effectiveness Analysis, Ecosystem Restoration, Risk and Uncertainty, Time Horizons, and Discount Rates, among other topics.

Chapter 3 identifies and details each of the seven mission areas of the Corps: Navigation, Flood Damage Reduction, Ecosystem Restoration, Hurricane and Storm Damage Reduction, Water Supply, Hydroelectric Power Generation and Recreation. Each mission is reviewed, and types of measures (both structural and nonstructural) are itemized and summarized.

Finally, Chapter 4 details the bureaucratic process by which projects are described in decision documents, technical and policy reviews, and how these documents are promulgated through the Corps. This final chapter identifies types of studies and reports, approval authorities, procedures, review, and authorization.

¹⁸² PGN section 1-1

¹⁸³ PGN section 2-2

SECTION II: Evaluation of Existing Principles and Guidelines for Cost Benefit Analysis

Cicchetti C.J., Davis, R.K., Hanke, S.H., and R.H. Haveman, et al. (1973). Evaluating federal water projects: a critique of proposed standards. *Science*, 181, 723-728

Authors provide a concise set of criticisms of *Principles and Standards* proposed by the Water Resources Council in 1973. They argue that the standards use faulty estimation procedures that misuse economic methods that “encourage inefficient projects and neglect harmful environmental impacts” and are bias toward development. They outline concerns of having benefits and costs distributed between four accounts while not providing clear direction on how measurements should be made and how accounts should be integrated. Within the discussion, they describe problems in how regional economic development effects are included, and how the environmental quality account encourages double counting for benefits but single counting for costs and thus downplays adverse environmental effects. They also provide cautions on how the three measures of economic benefits (willingness to pay, change in net income, and least-cost alternative) are attributed. The article also briefly addresses issues surrounding discount rate policy, pricing and cost-sharing policies, and the role of the public. Throughout, the authors urge readers of the need to carefully assess these issues, otherwise evaluations using the *Principles and Standards* will result in unnecessary large land and water resource development programs.

Fisher, A. C. (1994). Principles and Guidelines: Some Methodological Issues. In The Zilberman Review, D. Zilberman (Ed.), *Review of Principles and Guidelines*, 82-93 (Chapter 7).

Anthony Fisher presents a point-by-point critique of the first two chapters of *Principles and Guidelines*, suggesting improvements such as better ways to assess environmental quality costs within the Environment Quality (EQ) account and on the National Economic Development (NED) balance sheet; ideas regarding accounting for benefits and opportunity costs with unemployed labor statistics, and accounting for costs that are changing over time due to technological advances; and appropriate ways to avoid expensive benefit estimation by measuring benefits as the savings in cost over an existing alternative. Fisher suggests that a more straightforward approach to compare the costs of structural measures would be to look at changes in consumer surplus; however, to evaluate the cost of energy-saving measures, he encourages looking at the real resource costs of the measures and comparing them to the cost of producing the energy instead of evaluating change in consumer surplus, which provides the upper bound. Fisher also provides an extensive discussion of issues using contingent valuation, including the hypothetical nature of the process as well as concerns about embedding and the warm glow effect. Fisher advocates further discussion of these points and pooling insights of members of the panel who have had varying degrees of involvement in contingent valuation research.

Hyde, W. F. (1994). Principles and Guidelines: A Ten-Year Critique. In The Zilberman Review, D. Zilberman (Ed.), *Review of Principles and Guidelines*, 46-65 (Chapter 5).

In this article Hyde addresses five distinct sources of error in *Principles and Guidelines* (P&G) and suggests methods for limiting these errors. These errors arise from 1) assessment of non-market values, 2) output price affects, 3) interactions between multiple project outputs, 4) disregard of regional impacts, and 5) tacit acceptance of non-standardized data from other natural resource organizations. His proposed remedies range in nature from specific to entirely general, in some cases relying simply on warning the P&G reader of the existence of the tendencies for such error. Hyde's analysis is broad but could nevertheless prove a valuable first step in addressing identified weaknesses of the P&G.

Jacobs, J. W. (2002). Broadening U.S. Water Resources Project Planning and Evaluation. *Natural Resources Journal* 42(1), 21-31.

This paper discusses the importance of conducting "ex-post" project evaluations in water resource projects and programs. Jacobs argues that project planning is a dynamic iterative process that should be evaluated to achieve the best results. While *Principles and Guidelines* outlines steps the Corps, the Bureau of Reclamation, NRCS and the TVA must follow when designing and planning projects, it does not require evaluations upon completion or anytime thereafter. The author argues that ex post evaluations are important to make improvements to new or current projects. The article also discusses the difficulties surrounding evaluating environmental and ecological projects and makes three recommendations for such evaluations: 1) evaluations should be "comprehensive, integrated, long-term, cumulative, and adaptive" when reported, 2) adaptive management should be used in doing these evaluations (adaptive management emphasizes iteration and evaluation is key to this process) and 3) outside evaluators should conduct these evaluations when appropriate (to overcome any bias that employees may have in evaluating their own projects and to alleviate the fear that poor evaluations will be attributed to and used against management). Additionally, conducting ex-post evaluations allows for project benefits, goals, preferences, or costs to be measured into the future.

Larson, D. M. (1994). Procedures Used to Assess Environmental Benefits in Principles and Guidelines. In The Zilberman Review, D. Zilberman (Ed.), *Review of Principles and Guidelines*, 66-81 (Chapter 6).

This article critiques procedures used for environmental assessment in the *Principles and Guidelines* (P&G) used by the Corps. The main critique is that the P&G focuses too heavily on the monetary impacts of a project, which tends to over-emphasize the quantity of benefits and costs and neglects to measure how the project changes the quality or value of the environment. Of the four accounts used to assess the proposed project, only the Nation Economic Development (NED) account is required. The article argues the three other accounts, Environmental Quality, Regional Economic Development, and Other Social Effects, should be considered more when assessing a project. The other accounts often show effects that cannot be monetized but are still important, including environmental impacts on the local ecology, culture,

and community. Larson recognizes that it is not easy to compare different “units” of measurement from the various accounts, but nevertheless argues that more effort should be made for comparisons to get a truer sense of environmental impacts of a project. A second issue addressed in the article regards defining the role of the P&G when considering new strategies that may correct current inefficiencies. If the P&G is to place more emphasis on these “nonstructural measures,” such as changes in policies, management, or pricing, then they should be covered more extensively in the P&G.

Mazzotta, M. J. & Opaluch, J. J. (1994). Methodological Problems with Principles and Guidelines. In The Zilberman Review, D. Zilberman (Ed.), *Review of Principles and Guidelines*, 23-45 (Chapter 4).

This article addresses general and specific shortcomings of P&G. General comments focus on the absence of economic concepts such as nonuse values and random utility models, the importance of using these guidelines for contexts other than water quality improving projects, and the need to make P&G more reader-friendly. More specifically, the authors directly address the use of particular concepts and shortcomings on a page-by-page basis. They explain methods in contingent valuation surveys for asking respondents their willingness to pay for access to an environmental site, and methods for monetizing specific environmental services. Furthermore, they discuss that expected benefits and costs should be included in the benefit-cost analysis of environmental quality assessments rather than in uncertain total benefits, because even a small likelihood of occurrence may result in loss of lives or property.

National Research Council (NRC). (2004). *Analytical Methods and Approaches for Water Resources Project Planning*. Washington, D.C.: National Academy Press.

The Flood Control Act of 1936 mandated the use of formal benefit-cost analysis in its planning studies, followed by two Presidential Executive Orders (12,191 [1981] & 12,866 [1993]), which require benefit-cost analysis (BCA) be used for proposals that affect human health and the environment. The aim of BCA is to “(1) separate acceptable from unacceptable projects and (2) prioritize project alternatives”¹⁸⁴. The NRC report evaluates BCA within the Corps as specified by the planning guidance document *Principles and Guidelines* (1983), discusses willingness to pay as a measure of human preference, and outlines other difficulties the Corps is faced with when trying to value non-economic measures. Two other techniques that economists often use are stated preferences and revealed preferences when trying to value non-market goods. Stated preferences are those that people explicitly express, usually through a survey, while revealed preferences are those that economists derive from market behavior (such as paying more for a house near a school versus a similar house not near a school). Other economic issues that the report raises are efficiency, valuation techniques, and discounting, which are all relevant when conducting a comprehensive benefit-cost analysis. Finally, the report recommends that BCA, like any analytic tool, not be the lone factor for determining whether or not to execute a project.

¹⁸⁴ NRC 2004 p. 39

Scodari, P. (CEIWR-GI). (2005). *Survey and Analysis of Criticisms of Corps Planning and Links to Planning Guidance*. Available online at http://www.usace.army.mil/CECW/Documents/pgr/feb2005_iwr_sac.pdf

Paul Scodari surveyed criticisms that relate directly to issues addressed in the Principles and Guidelines (P&G) and the Planning Guidance Notebook (PGN). The survey addressed eight different issue areas and developed the following criticisms: (1) despite P&G stating that the goal of any project should be to further national economic development (NED) in a way that is consistent with protecting the nation's environment, NED is still prioritized over environmental quality; (2) agencies do not adequately consider nonstructural solutions to planning problems; (3) the area affected by any given project is defined too narrowly and does not allow planners to consider indirect or region-wide effects of alternative plans; (4) the P&G allow for planners to ignore effects that are not considered primary to national economic development; (5) national ecosystem restoration (NER) has recently been elevated to be as important as NED, however, P&G do not define the mission of NER as clearly as they do NED, which makes comparing the two values and considering trade-offs between them difficult; (6) the process for evaluating NED is inconsistent and does not adequately consider the effects of one project on others; (7) planning guidance does not specifically instruct planners to use probabilistic methods in assessing risk and uncertainty; and (8) planners are instructed to use a discount rate that may be incommensurate with the project they are planning.

Stakhiv, E., Cole, R., Scodari, P. & Martin, L. (2003). *Improving environmental benefits analysis in ecosystem restoration planning*. IWR Report 03-PS-3. IWR: Alexandria VA: Institute for Water Resources.

The Corps now considers national ecosystem restoration (NER) a priority when planning civil works projects. Traditionally, the Corps pursued national economic development (NED) as the primary goal for any project. However, while the development outputs are required to be expressed in monetary units, the restoration outputs are required to be expressed in non-monetary units. Furthermore, the methods for measuring the restoration outputs are not well developed, and there is no universal unit for measuring ecosystem restoration. This scenario makes comparing and contrasting the outputs particularly difficult. The authors argue that the metrics that should be used to best determine the success of an NER project need to relate to genetic diversity in the ecosystem and the survival of genetically unique species. Furthermore, the authors argue that benefit-cost analysis for NER projects should be forecasted using multiple time horizons to best account for the incremental effects of a project, and new technology needs to be used to better approximate the values of benefits of such projects.

SECTION III. Methodology (discussion of BCA or other measurement techniques)

Apogee Research, Inc. (1996). *Monetary Measurement of Environmental Goods and Services: Framework and Summary of Techniques for Corps Planners*. IWR Report 96-R-24. Alexandria, VA: Institute for Water Resources.

This article provides planners with tools for establishing the monetary benefits of environmental programs and indicates when such analysis is appropriate. The article presents three approaches to evaluating the economic benefit of goods and services that directly impact individuals. There are three broad approaches to assess society's willingness to pay of society: 1) The Market Approach (Factor Income/Productivity Technique Measures), which uses data for ecosystem goods that are traded in markets or data for marketed goods that rely on non-market ecosystems for inputs; 2) The Revealed Preference Approach (Hedonic Pricing and Travel Cost Method), which uses data on market goods that are used in conjunction with or somehow related to non-market goods; 3) The Expressed Preference Approach (Contingent Valuation and Benefits Transfer Measures), derives value by getting people to state their preferences for select goods. This article also explains how Least Cost Alternative (LCA) and Property Damage Alternative (PDA) methods can be used to determine the value of projects that indirectly benefit individuals, such as flood control or sediment retention projects. Information on the required level of data, technical expertise, expected costs, timelines, and major assumptions required are included for each method.

Arrow, K.J., Cropper, M.L., Eads, G.C., Hahn, R.W., Lave, L.B., Noll, R.G., Portney, P.R., Russel, M. Schmalensee, R. Smith, V.K., and R.N. Stavins. (1996). Is there a role for benefit cost analysis in environmental, health, and safety regulation?, *Science*, 272, 221-222.

In this short policy forum article, the authors advocate for using benefit-cost analysis (BCA) for agency and legislative policy decisions based on protecting and improving the natural environment, health, and safety. The authors recognize that BCA is not a panacea for all public policy problems; however, they write that it provides a very useful framework for considering complex problems that can lead to making more informed decisions. While admitting that BCA should not be considered as either necessary or sufficient for crafting good public policy, the authors provide eight principles for BCA's appropriate use.

Loomis, J. B. (1997). Use of non-market valuation methods in water resources management assessments. *Water Resources Update*, 109, 5-9.

This article is primarily intended for water resource researchers and educators. Loomis explains non-market valuation attempts to estimate the economic value in dollar terms of benefits society receives from use of water resources that are not allocated through markets. He discusses two commonly-used methods for estimating recreation and existence values, briefly addressing the travel cost method (TCM), and focusing on the contingent valuation method (CVM). Economists typically assess the value of recreation based on TCM, which relies on actual visitor

travel behavior to determine a demand curve and estimate participants' willingness to pay (WTP) for water-based recreation at a particular site. To assess the value of the existence of a water resource (i.e., for individuals who may never fish or boat on a river, but still receive some benefits from just knowing that free flowing rivers exist), economists often use CVM by conducting a survey wherein respondents are asked about their WTP for the resource under different circumstances. For estimating non-market benefits of recreation, CVM results in estimates of WTP that are slightly less than estimates based on TCM. The validity of CVM-derived estimates of WTP for existence values tend to be higher (sometimes many times higher) than actual contributions or payments, according to economic experiments to date. After illustrating these principles by discussing several cases (e.g., the process of estimating the valuation of improved salmon habitat on the Elwha River), Loomis concludes qualitatively that, while CVM-derived WTP estimates from surveys of the general public may indicate the intensity of their preferences, the exact dollar values may not be as heavily relied upon as they are in recreation analyses. However, in many instances, the public good nature of the existence values often dwarf the recreation use values and the opportunity costs of protecting water resources. For example, individuals who may never fish or boat on the Elwha River may still derive substantial benefit from knowing of the existence of a free flowing river, on which natural salmon migrations may continue.

National Research Council (NRC). (2005). *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*. Washington, D.C.: National Academy Press.

This report provides an overview and comparison of different valuation methods for assessing both use and existence values from aquatic ecosystems. Additionally the report identifies the factors, controllable and otherwise, which are likely to influence the outcome of a benefit-cost analysis. These factors include the valuation of relevant ecosystem goods, geographical scope and the spectrum of involved stakeholders, chosen temporal scale, whether willingness to accept or willingness to pay is used, discretion in methods of discounting future costs and benefits, and the degree to which uncertainty is prevalent in individual parameters and overall analysis. The most significant factor, and perhaps most subtle, is the framing and context of the analysis itself, as there is no obvious and universal framework with which to analyze every situation. The report suggests that high levels of uncertainty present in living ecosystems requires a certain level of flexibility in policies such as avoiding the intensive investment of fixed capital.

Freeman, A. M. (1994). *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, D.C.: Resources for the Future.

This text primarily addresses theoretical economics of resource valuation, focusing on willingness to pay (WTP) and willingness to accept (WTA) methods of valuation. It covers topics from the classic perspective of Compensating Variation (CV) and Equivalent Variation (EV). It provides (with justification) theoretical methods that can quantify difficult-to-value resources such as health of populations, mortality, recreational use of environmental resources, and property values, as well as methods for quantifying wages, values changes over time, and value estimates limited by conditions of uncertainty. Specific valuation methods include, but are

not limited to, revealed and stated preference methods, intertemporal value methods, market methods, property value models, hedonic wage models, and recreational use models, all of which provide either new methods for hard-to-value resources, or alternatives that take into account moral and philosophical issues surrounding valuation.

Venkatachalam, L., (2004). The Contingent Valuation Method: a Review. *Environmental Impact Assessment Review* 24, 89 – 124

The Contingent Valuation method (CVM) is commonly used in benefit-cost analysis to assess the value people derive from a good regardless of any use that they might make of the good, commonly called a non-use value. This article reviews major criticisms of the CV method and recent work that addresses those criticisms. The author discusses factors that can affect the reliability and validity of the assessment of an individual's willingness to pay (WTP) or willingness to accept (WTA), and examines reasons for the disparity between the WTP and WTA figures. The author also addresses other sources of possible error or bias in CV method studies: the embedding effect, sequencing effect, information effect, elicitation effects, hypothetical bias, strategic bias, and the benefit transfer issue. The article concludes by summarizing two methods used to check for bias in CV method results: the test-retest method and testing for convergent validity.

SECTION IV: Scientific and Policy Background

Chivers, J., & Flores, N.E. (2002). Market Failure in Information: The National Flood Insurance Program. *Land Economics*, 78(4), 515–521.

This paper reviews the failure of National Flood Insurance Program (NFIP) pricing efficiency. In 1968, Congress created the NFIP. The Task Force on Federal Flood Control Policy, chaired by Gilbert F. White, defined the efficiency potential of insurance premiums proportional to risk and equal to the private and social costs of flood plain occupancy. Such pricing efficiency depended on the deterrence of unsupportable use of floodplains and, conversely, the development of floodplain land that was economically supportable. The NFIP program has failed efficiency standards in two ways: Federal regulators and mortgage lenders failed to uniformly enforce insurance participation requirements, and as a result of asymmetrical information about flood risk and premium costs, property pricing has been inflated. This study finds that the complex calculation of premiums, the variability of rates, and the consistent lack of premium disclosure to homebuyers until purchase all inhibit economic efficiency. Also, developers who build homes in high-risk areas often absorb the benefits of discounted, undeveloped land and sell the property, minus the risk-related discount, to less-informed homebuyers.

This study proposes that mandatory NFIP be replaced by allowing communities the choice to participate in the National Flood Insurance Program. Home sellers in participating NFIP communities would be required to obtain a flood-elevation certificate, indicating the flood risk and cost of insurance premiums up front, as a necessary condition for listing a property. The authors do not present a proposal for non-participation communities. Their conclusion that

“communities wanting the benefit of the NFIP would need to comply suggests that non-participation communities would not qualify for NFIP federally backed mortgages.”¹⁸⁵ Therefore, communities that choose not to participate, a policy that could potentially create another type of information asymmetry, would not benefit from valid elevation, flood insurance rate, and flood risk details at the time that sellers list available properties.

Holway, J. M., & Burby, R. (1990). The Effects of Floodplain Development Controls on Residential Land Values. *Land Economics*, 66 (3), 259-270.

This study examines the effects of 1) the risk of flooding and 2) local policies regarding floodplain development on the value of that development, as shown by the value of land parcels that lie within the floodplain. The value of floodplain development is assumed to be a valid indicator of the possible damages that could occur due to flooding. Using a hedonic pricing model to control for comparable parcel features, the authors examine nine communities at risk of flooding from a river. Communities at risk from oceanic flooding are excluded. The authors find that the following factors significantly reduced the value of land parcels within the floodplain: low density zoning of the floodplain; requirements to elevate structures built on the floodplain to above the 100 year flood level; and local government having a specific department or individual overseeing the development.

Porter, T. M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life. U.S. Army Engineers and the Rise of Cost-Benefit Analysis* (pp. 148–189). Princeton, NJ: Princeton University Press.

The author presents a historical context for understanding the current use of divergent benefit-cost techniques. Although benefit-cost analysis began as “a strategy for limiting the play of politics in public investment decisions,”¹⁸⁶ the author contends that its’ current methodologies, used by the Corps and other government organizations, were transformed by several years of bureaucratic conflict. The demands of industrialization and the need to cap congressional expenditures helped to routinize the Corps’ use of payback and benefits-to-exceed-cost methods that, while applied since the 1920s, were not written into law until the Flood Control Act of 1936. This act required Corps approval for Congress to authorize flood control projects. Railroad and utility stakeholders and local constituents that were turned down by Corps benefit-cost analyses stirred opposition between private, local, and national policy interests. This opposition created a demand for standardized benefit-cost analytical methods. Inter-government agency differences also created a push for standardized methods. However, the negotiation for uniform benefit-cost standards between these government agencies failed. This chapter reviews several examples of divergent economic analysis and benefit-cost rationale used by these government agencies to win projects, achieve department missions, and to define the most desirable private, social, and political outcomes. Currently, benefit-cost analysis influences all government expenditures, yet diverse methodologies remain.

¹⁸⁵ Chivers, J., & Flores, N.E. (2002) p. 521

¹⁸⁶ P. 189

Appendix B. Recommendations offered by the National Research Council (NRC)

From the NRC report *Analytical Methods and Approaches for Water Resources Project Planning*, 2004¹⁸⁷.

Recommendation One:

To provide clearer direction to the Corps, the administration, and the Congress, in cooperation with the states, should reconcile inconsistencies within the existing, de facto, body of national water policy.

Recommendation Two:

A body should be specifically charged to coordinate water resources policies and activities among the administration, the Congress, the states, and federal water resources management agencies with water resources management responsibilities.

Recommendation Three:

The Principles and Guidelines document should be revised to better reflect contemporary management paradigms; analytical methods; legislative directives; and social, economic, and political realities. The new planning guidance should apply to water resources implementation studies and similar evaluations carried out by all federal agencies. A revised version of the P&G document should be periodically and formally reviewed and updated.

Recommendation Four:

Therefore, even if the Administration should choose not to revise the P&G, the Corps should draft a revision to its Planning Guidance Notebook that is consistent with this report's recommendations and propose this revision to the Administration.

Recommendation Five:

Benefit-cost analysis should not be used as the lone decision criterion in judging whether a proposed planning or management alternative in a Corps planning study should be approved.

Recommendation Six:

Periodic reviews of completed projects should be a routine part of Corps water project planning and management. Congress should provide resources to conduct these "ex post" evaluations.

¹⁸⁷ The entire report is available from the NRC at http://www.nap.edu/catalog.php?record_id=10973

Recommendation Seven:

Resources and time allocated for Corps reconnaissance studies should be commensurate with the scale and complexity of the water resources issue at hand.

Recommendation Eight:

The Corps should conduct a comprehensive review of district-level experiences with stakeholder participation procedures and activities. The Corps should also develop training and reference materials on stakeholder participation standards.

Recommendation Nine:

A summary document that identifies key environmental and social issues, primary assumptions, alternatives considered and evaluated, objectives sought, benefits and costs (monetized and non-monetized), trade-offs and stakeholder perspectives and differences, presented with a consistent format across studies, should be a standard in Corps planning studies.

Recommendation Ten:

The Corps should strengthen its programs in the areas of systems engineering aspects of water resources, risk and uncertainty analysis, and the integration of engineering and ecosystem analyses. Part of this strengthening should include the development of updated design manuals that better reflect contemporary methods and theories. These manuals should be used as general guidance rather than as “cookbooks” that specify a series of steps that must be strictly adhered to.

Recommendation Eleven:

Independent experts from outside the Corps of Engineers should be routinely enlisted to provide advice in Corps programs and planning studies.

Appendix C: Summary of Criticisms from Scodari (2005)

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
NED Objective and Plan Selection	<p>The NED federal objective and plan selection rule elevate economic development over environmental and social considerations, and do not recognize the potential for civil works activities to advance environmental and social goals</p> <ul style="list-style-type: none"> • The WRC was zero funded in 1981, and the federal objective has been redefined to be to maximize NED benefits (net benefits) subject to compliance with all relevant environmental laws, but the ideas that it adopted form the bases of contemporary Corps planning. The economic evaluation principles articulated by the Harvard Water Program and other economists remain the foundation for the NED analysis. Environmental considerations are defined as legal constraints, however, not as objectives to be achieved. Furthermore, the operational meaning of EQ in the context of the Corps program and planning model remains ill-defined (NRC, 2004: New Opportunity). • Benefit-cost analysis should not be the sole decision criterion because such analyses may contain uncertainties and may not adequately reflect difficult to measure and qualitative considerations such as stakeholder opinions, nonmarket values and equity. Benefit-cost analysis should not be used as the lone decision criterion for justification (NRC, 2004: Analytical Methods). • The P&G severely limits the Corps' ability to select an alternative with fewer environmental consequences, or one that could contribute to the national interest in ways other than economic development. The P&G exclusive emphasis on NED should be balanced with increased focus on protecting and restoring the environment. The P&G must be updated to require the Corps to consider sustainable environmental management and NED as co-equal goals in formulating projects (NWF and TCS, 2004: Crossroads). • Flood damage reduction projects are complex and you cannot disqualify non-economic factors. Today, public preferences and true environmental concerns are not incorporated into identifying the NED plan. The Corps should consider accepting a plan to be in the federal interest if the net benefits and B/C ratio falls within a range around the NED plan (Fitzgerald, 2002: Local Sponsor Comments). • In the context of the UMR-IWW inland navigation feasibility study, the Corps approach to considering environmental resources only after the locks have been extended is inadequate because the environment is treated as a planning constraint rather than as a resource on par with waterway infrastructure investment. Environmental improvements, not just the mitigation of environmental damages, should be examined as part of the feasibility study (NRC, 2001: Inland Navigation). • Make economic development and environmental protection and restoration co-equal goals of water resources planning (S. 1987 reported in 2002 and S. 646 reported in 2001: Corps Reform Bills). • The Corps should revise the P&G to make sure project benefits accrue to the general public (S. 1987 reported in 2002: Corps Reform Bill). • Some projects, such as inland navigation and beach replenishment, benefit just a few private interests. Congress should deny public funding for projects that provide only private benefits (TCS and NWF, 2000: Troubled Waters). • Ecological and social considerations are often of great importance in project planning and should not necessarily be considered

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Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<p>secondary to the maximization of economic benefits. P&G revisions should consider movement away from consideration of the NED account as the most important concern (NRC, 1999: New Directions).</p> <ul style="list-style-type: none"> • The P&G is outdated and does not reflect a balance among economic, social, and environmental goals of the nation. The president should immediately establish EQ and NED as co-equal objectives of planning, and the P&G revised to accommodate the new objectives and to ensure full consideration of nonstructural approaches to floodplain management (IFMRC, 1994: Sharing the Challenge). • The P&G lift the NED account above the EQ account. The rules go too far in elevating monetized benefits and costs, and they do not envision any incommensurable or intangible increases in EQ as worthwhile (Griffin, 1993: EPA Review). • The P&G may give undue emphasis to monetary dimensions of projects at the expense of EQ deterioration, since there is little or no emphasis on including the change in monetary values of EQ effects (Larson, 1993: EPA Review). • The directive to choose the plan that maximizes NED consistent with environmental protection is puzzling. What does consistent with protecting the environment mean when comparing alternative plans? Plan A may have greater NED benefits than Plan B, but also greater EQ impacts. How does one choose? (Fisher, 1993: EPA Review) • The selection rules appear to place too much emphasis on the NED account. Why wouldn't the decision maker balance the NED account with the remaining accounts? (Mazzotta and Opaluch, 1993: EPA Review). • It is unclear what is meant by "consistent with protection of the Nation's environment." Does this mean that no environmental degradation is allowed, or that no significant degradation is allowed? The former is unrealistic while the latter would appear to be purely a matter of judgment of the administrator (Mazzotta and Opaluch, 1993: EPA Review). <p>Mitigation requirements do not ensure environmental protection</p> <ul style="list-style-type: none"> • Mitigation for fish and wildlife losses must at a minimum acquire and restore the same number of habitat acres that fully replace hydrological and ecological functions and characteristics of each acre of habitat adversely affected by the project (S. 2773 reported in 2004: WRDA Bill, Boxer amendment). • Prohibits the Secretary of the Army from submitting to congress any project proposal unless it contains a certification that the project minimizes to the extent practicable adverse impacts on natural hydrological patterns and the aquatic value or native diversity or aquatic ecosystems, and a determination has been made that the alternative has the greatest probability of cost-effectively and successfully mitigating adverse impacts on aquatic resources, fish and wildlife (H.R. 2566 reported in 2003; Corps Reform Bill). • The federal objective can be viewed as a constrained optimization problem -- determine plan that maximizes NED while keeping EQ at same level. The fact that NED is in dollars and EQ is not would be no problem if the full costs of mitigation to achieve the EQ constraint were included in the plans considered. However, the P&G guidance on mitigation is less than this. It indicates that environmental protection is to be achieved by mitigation of adverse effects, but the level of mitigation is that "determined to be appropriate by the agency head" (Larson, 1993: EPA Review).

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<p>The project justification threshold (NED benefits greater than costs) does not ensure an adequate rate of economic return on public investments.</p> <ul style="list-style-type: none"> • Project recommendations should be required to achieve a minimum 1.5 BCR (S.B. 1987 proposed in 2002: Corps Reform Bill). • Benefits from Corps projects should always significantly exceed costs before committing taxpayer dollars. Congress should require the Corps to ensure taxpayers get a solid return on investment by raising the BCR threshold to at least 1.5 to 1 (NWF and TCS, 2004: Crossroads). • The President’s Budget for FY2004 says that for prioritizing across the portfolio of recommended NED projects, the Corps should rank projects by the ratio of estimated net benefits to costs. By extension, this implies that the existing project justification criteria might be usefully changed (e.g. to the one with the highest B-C ratio). It also says the Corps has agreed to exclude project features and increments that do not significantly increase total net benefits relative to costs; this also points away from the current justification test based on maximization of net benefit (OMB, 2003: President’s Budget).
Formulation of Alternative Plans	<p>Project planning places insufficient emphasis on formulating and considering nonstructural management measures that could address planning problems and opportunities while minimizing adverse effects on the environment.</p> <ul style="list-style-type: none"> • The Corps should revise the P&G to eliminate bias and disincentives working against nonstructural flood protection, and encourage the restoration of aquatic ecosystems (S. 1987 reported in 2002: Corps Reform Bill). • Under a new portfolio planning authority, planning studies should identify at least one nonstructural alternative to current operations that seeks more efficient operation of existing investments to help achieve goals w/o altering hydrologic regimes, such as purchase of flood easements (NRC, 2004: New Opportunity). • Demand management is an essential management tool to obtain improved use of existing project capacity. Efficient management of existing projects requires use of appropriate pricing or other demand management strategies whenever public use begins to exceed their capacity (Dickey, 2002: Congressional Testimony). • Congress should instruct the Corps to fully explore nonstructural options for improving traffic management as the baseline condition for the NED and environmental evaluation of proposed lock extensions on the UMR-IWW (NRC, 2001: Inland Navigation). • The President should revise the P&G flood to accommodate a new EQ objective and to ensure full consideration of nonstructural alternatives for reducing vulnerability of flood damages (IFMRC, 1994: Sharing the Challenge). • Encourage nonstructural flood damage reduction projects (TCS and NWF, 2000: Troubled waters). • To what extent should plans evaluated under P&G attempt to introduce better mechanisms or institutions for managing resources? Should such activities be permitted or encouraged under the P&G? Section 1.6.1(f) indicates that

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<p>nonstructural measures, including changes in policy, management and pricing, should be considered. This is one of the few, if not the only, places such measures are mentioned. If they are to become part of standard practices for project definition and evaluation, they must be written much more extensively into the P&G (Larson, 1993: EPA Review).</p> <ul style="list-style-type: none"> • Federal water projects are not a good panacea for bad public policy. It makes excellent sense to perform economic assessments of federal projects as if good policies were in place. This perspective places the policy onus where it should be. It would be unfortunate if an infusion of federal dollars could be justified everywhere that bad public policy created a problem. In my way of thinking, the guiding concept of nonstructural measures encourages efficient resource use. I argue that the P&G requirement about considering nonstructural alternatives obligates the analyst to presume that efficient practices, such as agricultural cropping practices, are in place. If efficient cropping practices are not being used, then the analyst must consider an alternative plan that removes barriers to use of efficient cropping practices. Project benefits must then be gauged in relation to the alternative, efficient-cropping plan (Griffin, 1993: EPA Review).
Planning Area	<p>Project planning considers only a narrow geographic scope that fails to adequately consider all possible alternatives for addressing planning problems and opportunities, and fails to account for the watershed-wide implications (such as downstream economic and environmental effects) of those plans that are formulated.</p> <ul style="list-style-type: none"> • Over the past 30 years the objectives sought for water projects have shifted to include an increased emphasis on environmental and recreational objectives, which has increases the complexity of water project planning while expanding the spatial and temporal scales that must be considered. To meet these demands, the Corps is being asked to undertake integrated water project planning, adopting a watershed or regional approach and including an ecosystem perspective. Integrated water resource planning at the river basin or coastal system scale provides an organized framework within which tradeoffs among competing objectives can be evaluated; multiple stressors, unintended consequences, and cumulative effects can be identified; and the true costs and benefits of a project can be examined in a context that incorporates the interests of all those with any substantial stake (NRC, 2004: New Opportunity). • One PGN principle regarding planning area says it is the regional focus defined by the study authorization document, while another says benefits are to be counted wherever they accrue, even outside the study area. Similarly, for ecosystem restoration, PGN says changes are to be measured in the planning area and the rest of the nation. This presents mixed signals about the importance of the planning area relative to an accounting of benefits and costs to whomsoever they might accrue. To be consistent with benefit-cost principles, all significant effects should be evaluated while legislative and budgetary considerations are considered separately. The PGN should be revised to incorporate these spatial considerations (NRC, 2004: Analytical Methods). • Since projects often merge together geographically and involve interrelated engineering, economic and environment effects, and advent of regional scale projects such as CERP, this necessitates a systems engineering (and effects measurement) approach to planning (NRC, 2004: Analytical Methods).

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<ul style="list-style-type: none"> • Despite clear authority and strong evidence for internal support for integrated river basin, coastal system and ecosystem planning, the amount of focused guidance for such planning is relatively limited compared to that for economic evaluation. Corps guidance should be revisited to bring it into closer conformity with generally stated principles and methods that support integrated water resources planning (NRC, 2004: River Basins). • The Corps tendency is to favor single purpose projects that focus primarily on local issues, rather than treating water resources as interdependent parts of ecological systems. Congress and the Corps should direct planners to utilize comprehensive watershed-based planning as the basis for development and management planning (NWF and TCS, 2004: Crossroads). • The Corps tends to ignore indirect and cumulative environmental impacts of a new project and maintains a narrow view of the projects scope (TCS and NWF, 2000: Troubled Waters). • The watershed or river basin, estuarial region, and coastal units should be used as the basic spatial units in water planning, when and where it is appropriate and circumstances allow (NRC, 1999: New Directions). • For too long agencies have viewed their policies and programs in isolation. The Corps and other agencies should examine the watershed-wide implications of their programs to take into account the regional and downstream ecological, social and economic consequences, rather than using a limited project-by-project approach (NRC, 1999: New Strategies).
Evaluation of Effects	<p>Project evaluations fail to account for the full range of project effects that people care about, including environmental and social effects (of which some may be measurable in NED terms) as well as non-NED economic effects.</p> <ul style="list-style-type: none"> • Along with NED and non-monetary NER analysis, Corps economic analyses for portfolio planning should evaluate and report on a) effects of new projects on national and regional economies, and international competitiveness, b) magnitude and incidence of foregone benefits from modifying current projects and their operation, c) traditional categories of NED benefits that accrue from restoration measures (NRC, 2004: New Opportunity). • Feasibility studies shall include an analysis of the benefits and costs, both quantified and unquantified, which shall identify environmental costs and benefits, including the costs and benefits of protecting or degrading natural systems, social costs and benefits, including risk analysis regarding potential loss of life, and cultural and historical costs and benefits (S. 2773 Manager's Amendment reported in 2004: WRDA Bill). • The lowered cost of transport is assumed to be the dominant source of national benefits for improved navigation services. Although this may capture many of the benefits, it omits others. For example, the PGN does not allow the inclusion of reduced highway fatalities in calculating navigation benefits (NRC, 2004: Analytical Methods). • Current benefit calculation procedures for Corps flood damage reduction projects include only a subset of potential benefits. BCA should count all benefits and costs, not just a subset of preferential categories of benefits that may be consistent with conventional methods for their calculation. If a flood damage reduction project affects human lives and the environment, these costs and benefits should be included in the analysis (NRC, 2004: Analytical Methods). • The Corps should ensure that all project plans include an assessment of how the project fulfills the Corps' commitment to

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<p>environmental stewardship. The cumulative environmental effects of each project, together with other past and future human activities in the same system, should be consistently evaluated for each project (NRC, 2004: River Basins).</p> <ul style="list-style-type: none"> • The American Association of Port Authorities and others supporting improvement at ports, need to provide better documentation of project benefits that fall outside of traditional NED analysis, including the extent to which water project investment and operations may affect jobs, income, competitiveness of industries among regional economies, and trade, since these non-NED benefits are the primary reason for the political support that the ports receive at the state and local level and may more realistically portray the real benefits that the ports provide. Justification of projects based on the basis of transportation costs savings is an unrealistically narrow measure of a project's overall worth (Steinberg, 2004: AAPA). • Feasibility studies should exclude any project benefits derived from any intensification of land use from reducing or eliminating wetlands (S. 2773 Manager's Amendment reported in 2004: WRDA Bill; S. 1987 reported in 2002: Corps Reform Bill). • P&G revisions should eliminate calculation of any economic benefits derived from wetlands draining (NWF and TCS, 2004: Crossroads). • For the UMR-IWW feasibility study, the Corps should aim toward more comprehensive and integrated assessment of the navigation system's effects on the environment as well as NED. Further, environmental improvements—not just mitigation—should be examined as part of the navigation study (NRC, 2001: Inland Navigation). • Federal procedures for calculating costs and benefits of beach nourishment and protection are overly restrictive. The rules governing C-B analysis, and the choices among alternative project designs and implementation strategies, should account for the true social costs and benefits in decision-making, including recreational benefits and beneficial effects on beaches outside the project area (NRC, 1995: Beach Nourishment). • To reduce the vulnerability of flood damages, the Administration should adopt flood damage reduction guidelines based on a revised P&G which would give full weight to social, economic and environmental values and assure that nonstructural alternatives are given equal consideration (IFMRC, 1994: Sharing the Challenge). • Feasibility studies should identify local, regional and national economic cost and benefits (S. 2773 Manager's Amendment reported in 2004: WRDA Bill). • The ecological, health and other social effects of flood damage reduction studies, and the tradeoffs between them, should be quantified to the extent possible and included in the NED Plan (NRC, 2000: Risk and Uncertainty). • Criteria to assess water quality effects of Corps projects should be developed and applied to project planning (Zilberman, 1993: EPA Review).
NER & NED/NER Planning	<p>The objective and scope of the NER mission has not been clearly defined</p> <ul style="list-style-type: none"> • Details regarding the scope and purposes of the Corps' roles within ecosystem restoration are not clearly defined. Formulating and evaluating alternatives focused on restoring hydrologic and geomorphic components of aquatic ecosystems is an

Table 2.1 Criticisms of Planning Principles	
Planning Principle	Summary Criticisms (in bold)/Specific Comments, by Source (in bullets)
	<p>appropriate role for the Corps. The Corps' primary environmental missions should be to restore hydrologic and geomorphic processes in large river and coastal systems. The Corps could also help operationalize its NER evaluation account with hydrologic and geomorphic outcome measures. Appropriate measures will be site-specific and a function of project goals (NRC, 2004: New Opportunity).</p> <p>Tradeoff procedures and plan selection rules for single purpose NER and combined NED/NER planning need to be clarified in order to support integrated planning for economic and environmental outputs.</p> <ul style="list-style-type: none"> • The Corps has chosen to not rely solely on benefit-cost analysis for making the final selection of an ecosystem restoration alternative and also employs non-monetary measures. In its desire to ensure that restoration is not viewed entirely in economic terms, however, the agency has not adequately emphasized that restoration measures can yield traditional NED benefits. For example, restoration measures such as wetlands rehabilitation or removing obstacles from a stream can reduce flood peaks and thus may yield NED flood damage reduction benefits. However, such benefits are not reported or considered in justifying restoration measures. Planning guidelines should recognize that restoration and nonstructural measures yield benefits traditionally understood as NED benefits, and these should be calculated and used in the incremental analysis (NRC, 2004: New Opportunity). • The Corps should continue its efforts to facilitate the systematic integration of information provided in the NED and NER accounts through the application of tradeoff analysis (NRC, 2004: River Basins). • Contrary to existing guidance for NED/NER planning, plan costs that jointly serve NED and NER (such joint cost should be the norm for integrated NED/NER planning) should not be "allocated" for efficiency analysis. All monetary and non-monetary effects of plans should be evaluated together. Specifically, CEA/ICA should be implemented using net dollar NED effects and non-dollar NER effects. And consistent with the way the Corps at one time did multipurpose planning for multiple NED purposes, plan justification for NED/NER projects should involve a two-part test. First, each purpose in a plan must be shown to be justifiable as a separable element based on purpose-specific benefits that exceed separable purpose costs. Second, a subjective determination must be made that the combination of NED and NER benefits yielded by the plan is worth total plan costs (Stakhiv et. al., 2003: Environmental Benefits). • The tradeoff explicitly described in the Corps restoration guidance is between net NED and NER outputs. If increased NER output comes at the expense of NED, guidance calls for an incremental analysis to display and justify NED costs incurred to satisfy increased NER outputs represented in non-monetary terms. In the case of permanent evacuation and associated measures that produce both economic and environmental outputs, NED benefits yielded should be included as financial cost offsets for the tradeoff analysis (Shabman, et al, 1997: Permanent Evacuation).

Table 2.2 Criticisms of Planning Guidelines	
Planning Guidance	Summary Criticism (in bold)/Specific Comments, by source (in bullets)
NED Evaluation: Navigation	<p>For deep draft navigation planning, NED evaluations fail to consider the effects that deepening one port might have on other ports.</p> <ul style="list-style-type: none"> • Justifiably, the Corps is not supposed to consider traffic simply shifted from one port to another as a benefit when calculating NED benefits potential of project alternatives. But neither should the Corps ignore the impacts that deepening one port has on neighboring ports. For example, three ports are within 300 miles of one another on the south Atlantic coast. The Corps assumes that each of these ports will maintain a constant share of the predicted increase in traffic if all three ports are deepened. Yet if all three are deepened, the three ports will not be fully utilized, wasting hundred of millions of dollars. Congress should direct the Corps to consider its navigation projects within a comprehensive and inter-modal framework, such as viewing overall transportation needs in a regional or national context (NWF and TCS, 2004: Crossroads). • The Corps should work with the NAS to revise the P&G to do regional, multi-port analysis that thoroughly considers regional economic and environmental benefits, including the effect of overcapacity in the region (S. 1987 reported in 2002: Corps Reform Bill). • There is a race to the bottom among US ports to deepen harbors in the hopes of attracting an emerging class of mega-ships. Though some deep draft harbors are necessary, not every port need be deep to be economically competitive. Widespread, uncoordinated harbor deepening projects will likely result in a huge overcapacity. To halt this race to the bottom, taxpayer and environmental advocates are pushing for regional port planning measures to guide future port development (TCS and NWF, 2000: Troubled Waters). <p>For both deep draft and inland navigation planning NED evaluations fail to consider the extent to which project benefits may be distributed outside the country.</p> <ul style="list-style-type: none"> • The PGN should be revised to incorporate more explicit provisions about the spatial and distributional dimensions of costs and benefits (NRC, 2004: Analytical Methods). • The Corps' NED analyses of navigation projects assume that if transportation cost savings result from a deeper channel or harbor, all of those savings will trickle down to the US economy. Yet if there is less than full competition in the use of the navigation infrastructure, some benefits may be retained by the shipping firms, which may include foreign entities. But the Corps does not study the level of competition that exists to determine if predicted savings will indeed be passed on to US entities and thus contribute to national economic development. P&G revisions should improve economic analyses of port projects by requiring an estimate of how economic benefits derived from transportation costs savings will be distributed to the US economy (NWF and TCS, 2004: Crossroads). • While maritime projects must produce a NED benefit to the general public, the Corps now broadly defines general public as anyone,

Table 2.2 Criticisms of Planning Guidelines	
Planning Guidance	Summary Criticism (in bold)/Specific Comments, by source (in bullets)
	<p>both U.S. and foreign, who might realize a financial benefit from the project. The logic is that any and all savings to foreign steamship operators will be passed undiminished through the economic chain and cascade totally down to the US public. Careful study of this issue would probably find that the cascade of incremental retained profits from each stage in the supply chain ultimately reduces the net savings to US consumers to about 50-60% or less of the initial Corps-claimed savings. Corps guidance should be revised to eliminate the current project bias reflected in the definition of the general public that inappropriately assumes 100% of any transportation costs savings are instantaneously received by the US public (Williams, 2002: Citizen's Critique).</p>
NED Evaluation: Flood Damage Reduction	<p>The P&G establishes different methods for estimating flood damage reduction benefits from structural alternatives and nonstructural options involving evacuation/relocation that lead to lower estimated benefits associated with the latter.</p> <ul style="list-style-type: none"> • Corps policy and P&G guidance presume that, with evacuation/relocation alternatives, the costs of flood damages are capitalized into the value of the structures to be relocated, so the costs of purchasing floodplain structures thus already incorporates the flood damage reduction benefits of relocation. The Corps guidance assumes that real estate markets work perfectly to incorporate the value of expected damages, but empirical studies suggest that the risks of floodplain occupation are not reflected in real estate values. Moreover, the Corps guidance for estimating benefits of evacuation/relocation is at odds with FEMA guidance for estimating that the benefits of that agency's nonstructural flood damage reduction programs. The issue of ensuring consistency of methods and procedures for estimating the benefits of flood damage reduction activities within and across federal agencies merits careful consideration by the administration and Congress (NRC, 2004: Analytical Methods). • There is a significant bias against nonstructural solutions, such as buyouts and open space creation, within the Corps planning process. Congress recognized these biases in 1999, but the resulting law was vague and the Corps' interpretation preserved the status quo (NWF and TCS, 2004: Crossroads). [The reference is to Section 219(a) of WRDA 1999, which directs the Corps to calculate benefits of nonstructural flood damage reduction using methods similar to those used in calculating the benefits for structural projects, including similar treatment in calculating losses avoided.] • This committee concluded that it was important to include the benefits of flood damages avoided in nonstructural project benefit-costs analysis, and that the risk of such damages was often not fully reflected in lower values of floodplain property. The committee recommends that these benefits be included in project benefit-cost analysis through a standardized framework and methods. The P&G should be updated to eliminate biases or disincentives that work against nonstructural approaches, and to ensure that the benefits of flood damages avoided by nonstructural approaches are consistently and uniformly considered (NRC, 1999: New Directions). • Critics of the P&G have consistently asserted that the NED evaluation is biased against permanent evacuation, because avoided property damages, which is the benefit measure for water control structures, is not used for computing NED benefits for permanent evacuation. The review completed for this study concludes that the P&G approach to NED benefit estimation for permanent evacuation is valid, if the P&G assumptions hold. The Corps should develop a method to collect and evaluate evidence that P&G assumptions are violated. If the assumptions are thought to be violated a procedure for making adjustments to the NED calculation should be established (Shabman, et al., 1997: Evaluation of Permanent Evacuation).

Table 2.2 Criticisms of Planning Guidelines	
Planning Guidance	Summary Criticism (in bold)/Specific Comments, by source (in bullets)
	<p>NED evaluations of agricultural benefits may be inflated to the extent that they use output prices that are distorted by federal subsidies.</p> <ul style="list-style-type: none"> • Feasibility studies shall exclude from the estimate of benefits and costs any increase in direct federal payments or subsidies (S. 2773 reported in 2004: WRDA Bill). • When benefits involve agricultural commodities, in many cases it is more appropriate to assess benefits net of subsidies and other government support (Zilberman, 1993: EPA Review). <p>The effects of structural water control alternatives for flood damage reduction are not adequately represented in planning studies because residual flood damages (e.g., from events that exceed design capacity) are not accounted for.</p> <ul style="list-style-type: none"> • In NED calculations for flood damage reduction projects, the Corps fails to account for the residual risk associated with projects—that is, the potentially catastrophic risk of flooding if projects fail, if flood waters exceed design capacities, or if changes in the watershed reduce the level of protection provided (NWF and TCS, 2004: Crossroads). • Urban flood damage benefits guidelines do not seem to adequately recognize with-project residual risk of flooding. The interactions of land use intensity with changes in flood risk may deserve greater attention in the P&G (Zilberman, 1993: EPA Review).
NED Evaluation: Environmental Quality Effects	<p>Project planning makes no attempt to estimate the value of environmental improvements or damages in monetary (NED) terms.</p> <ul style="list-style-type: none"> • The Corps frequently fails to account for the value of sustainable environmental protection, and ignores the value of services provided by natural water systems and wetlands. P&G revisions should improve BCA to fully account for all costs, including environmental damages, and more accurately assess predicted benefits of alternatives, including those provided by natural environment (NWF and TCS, 2004: Crossroads). • The P&G guidance for using environmental valuation techniques is out of date. The Corps should continue efforts to improve the scope, reliability and applicability of nonmarket valuation methods (NRC, 2004: Analytical Methods). • The Corps should continue to develop protocols and standards for incorporating environmental benefits and costs into project planning in a manner comparable to that for traditional NED benefits and costs (NRC, 2004: River Basins). • The corps should strive to improve and further develop analytical methods for valuing benefits/detriments to the environment of water projects (NRC, 1999: New Directions). • The P&G needs to be clearer on stating that environmental effects that can be monetized should go into the NED account, and those that cant should be recorded in the EQ account (Fisher, 1993: EPA Review). • The P&G should give more attention to valuing water quality reductions and other environmental costs. There is unmistakable bias in that the P&G devotes 70+ pages to benefits assessment and only 5 pages on NED costs. The cost/benefit dichotomy is misleading,

Table 2.2 Criticisms of Planning Guidelines	
Planning Guidance	Summary Criticism (in bold)/Specific Comments, by source (in bullets)
	<p>since with greater attention to environmental consequences, a project may increase or decrease economic outputs, and in either case the evaluation procedures should be the same (Griffin, 1993: EPA Review).</p> <ul style="list-style-type: none"> • One reason P&G does not adequately address nonmarket valuation (particularly for EQ effects) is that the P&G are devoted almost exclusively to measuring consumer surplus for price changes, with virtually nothing said about measuring surplus from quality changes. Greater effort should be made toward describing how EQ effects can be included in the NED account, by including the determination of the value of quality or attribute change through either TCM or more broadly, CVM (Larson, 1993: EPA Review).
Accounting for Risk and Uncertainty	<p>Project evaluations produce point estimates of costs and benefits that wrongly suggest that predicted effects are highly certain.</p> <ul style="list-style-type: none"> • Corps should adopt a long-term focus toward enhancing and expanding use of R&U analysis (NRC, 2004: Analytical Methods). • Feasibility studies should include an analysis of benefits and costs that identifies areas of risk and uncertainty (S. 2773 reported in 2004: WRDA Bill). • The Corps should revise the P&G to incorporate new techniques for R&U analysis (S. 1987 reported in 2002: Corps Reform Bill). • For navigation dredging projects, Corps guidance on economic assessments should be revised to oblige key assumptions (about commerce growth rates, vessel loading factors, etc.) to be “most probable” outcomes rather than “most optimistic.” Suggest performing sensitivity (or uncertainty) analyses to illustrate the extent to which the computed project benefits and BCR are impacted by the variations (uncertainty) in the assumptions (Williams, 2002: Citizen’s Critique). • The P&G should be updated to reflect new techniques in R&U analysis developed since 1983 (NRC, 1999: New Directions). • One important need for advancing watershed management is to develop practical approaches for considering R&U in real world decision-making (NRC, 1999: New Strategies). • The new corps R&U procedures for flood control projects are innovative and timely; however, there is concern about the specific ways in which uncertainty is currently represented and included in the calculation of average flood damages and residual risks (NRC, 1995: Flood Risk Management). • Since impacts cannot be predicted with certainty, planners should develop alternative scenarios, assign them some subjective probabilities, and obtain expected outcomes as well as outcomes that may occur at certain statistically significant levels (Zilberman, 1993: EPA Review). • The stated definitions of risk (known probability distributions) and uncertainty (no objectively known distributions) may be misleading. Indeed, the discussion of uncertainty indicates that probability can be described subjectively. This is correct and this Bayesian approach is what makes the stated distinction between risk and uncertainty meaningless (Fisher, 1993: EPA Review). • The R&U supplement is useful, but the distinction made between R&U made early is not carried through. The methods described apply to situations involving risk, yet the reference throughout is to R&U (Larson, 1993: EPA Review). • R&U should be included in the evaluation process. At a minimum, B and C should be weighted according to likelihood of occurrence, i.e., in expected values (Mazzotta and Opaluch, 1993: EPA Review).

Table 2.2 Criticisms of Planning Guidelines	
Planning Guidance	Summary Criticism (in bold)/Specific Comments, by source (in bullets)
Discount Rate	<p>The discount rate used for project evaluations is inconsistent with the (7%) rate that OMB requires for the evaluation of other federal programs, rules and activities.</p> <ul style="list-style-type: none"> • Feasibility study evaluations of project costs and benefits should apply discount rate consistent with that used by other federal agencies for water resource projects (S. 2773 reported in 2004: WRDA Bill). • NAS 216 (analytical methods): Noting that PGN says that non-monetary restoration effects should not be discounted, it says that it does not seem wise to reject discounting simply because the units are physical rather than financial (NRC, 2004: Analytical Methods). • The outdated P&G undermines B-C analyses through a flawed discount rate that leads to inaccurate and faulty project justification. Congress should direct the Corps to revise its discount rate formula to ensure that it approximates marginal, pre-tax returns on an average long-term private sector investment and that reflects true R&U associated with 50-year life projects (NWF and TCS, 2004: Crossroads). • The President's budget for FY2004 directs the Corps to ranks the suite of recommended projects in the project using measures of project costs and benefits recalculated using a 7% discount rate (OMB, 2003: President's Budget). • The discount rate formula in Section 80 of the 1974 WRDA is not based on economic theory. OMB presently establishes a 7% discount rate for the evaluation of other public investments, and this rate approximates the marginal pretax rate of return on these projects. Congress should either establish a discount rate based on sound economic theory or allow the Corps to apply the rate used to evaluate other federal investments (Dickey, 2002: Congressional Testimony).

Appendix D: EPA Residual Risk Assessment Steps¹⁸⁸

EPA residual risk assessment is a detailed-multi step process. The phases of residual risk analysis consist of six steps. Likewise P&G EPA starts with a formulation of the problem. For a given emission source category, firstly they describe the context and scope of the problem. However, EPA also defines its management goals with the legal requirements and limitations for the process. In addition to the careful analysis of management objectives and legal constraints, EPA uses readily available data extensively to document the problem while inviting stakeholders' participation in the process.

The second and third steps require the analysis of health effects of the concerned emission source of hazardous air pollutants (HAPs), and they analyze the exposure to those pollutants. Exposure analysis looks at the factors that are crucial to the risk assessment outcome. Those outcomes are routes of exposure and the HAPs emitted along with the nature of populations or environments being affected by the exposure. After analyzing factors contributing to risk assessment outcomes, EPA determines the characters of the residual risk, which considers the nature, magnitude and uncertainty of any risks.

The fourth stage answers the question of whether the human health risk is acceptable for the specific case of exposure & emission of HAPs. If the EPA's analysis answers the question that humane health is present at an acceptable level, then the residual risk assessment process stops at the fourth stage. If the answer is negative, the fifth step works through the information available to evaluate the management options sufficiently¹⁸⁹. The evaluation of management options takes into account the residual risks, costs, economic impacts, feasibility, energy, safety, and other related factors. If the information available is not sufficient enough to completely evaluate the options, the process continues with a more thorough analysis to understand the associated impacts with those management options. When available information helps analysts to evaluate impacts of risk management options to prevent unacceptable human or environmental risks, the residual risk assessment is complete.

¹⁸⁸ United States Environmental Protection Agency, Office of Air Quality. (March 1999). *Residual Risk: Report to Congress*. Retrieved from http://www.epa.gov/ttn/oarpg/t3/reports/risk_rep.pdf

¹⁸⁹ Ibid. p.110, Exhibit 20.

Appendix E: Effects of Accounting for Equity on NED

All the possible effects of including equity on an analysis are summarized in the table below, with the type of account in the left column, and the sign of the benefits. A question mark indicates ambiguous sign.

OSE	+	-	-	+	-	+	+	-
RED ^{IN}	+	-	+	-	-	-	+	+
RED ^{OUT}	+	-	+	-	+	+	-	-

NED ^{exist}	+	-	+	-	?	?	?	?
NED ^{rev}	+	-	?	?	?	?	?	?

Key:

OSE	Net equity benefits of the project to the nation
RED ^{IN}	Net benefits that accrue to the project region
RED ^{OUT}	Net benefits that accrue to all regions except the project region
NED ^{exist}	Sum of RED ^{IN} and RED ^{OUT} net benefits of all regions in the nation (not including equity effects, per P&G 1983, and used in UMRCP)
NED ^{rev}	Sum of RED ^{IN} , RED ^{OUT} , and OSE net benefits of all regions in the nation (including equity effects)

When comparing the resulting signs for NED^{exist} and NED^{rev}, two additional possibilities of ambiguous signs are possible under the NED^{rev} when compared to NED^{exist}. This suggests that when equity is monetized and accounted for in BCA, there is potential for positive or negative net benefits when current P&G methods would suggest otherwise.

It is important to note that the magnitude of the benefits determine the ultimate NED sign. The interesting case shown in the table is when including equity in an analysis reverses the NED sign. This is possible in any of the combinations where the sign of NED^{rev} is ambiguous. In trying to determine these cases, the magnitude of an equity effect would need to overcome the combined effect of both regional and national economic effects to shift the result. This is unlikely when the combined regional and national net effect is highly positive or negative; conversely, equity plays a much more important role when the total net benefits of the region and nation are near zero.

Finally, while this example discusses the effects of equity in particular, additional monetized benefits from the environment or health and loss of life effects will interact similarly, increasing uncertainty in expected net outcomes.

Appendix F: Technical Details for the UMRCPP

This appendix contains three parts. The first outlines overall objectives of the UMRCPP, the second provides a table that highlights each of the 14 alternative plans, and the third provides more details on the preferred plan and why it was selected as a result of the reconnaissance study.

Part 1. Objectives of the UMRCPP

The objectives of the UMRCPP were developed, by considering the problems, opportunities, and the language of authorizing legislation to:

- “minimize the threat to health and safety resulting from flooding by using structural and nonstructural flood damage reduction measures;
- reduce damages and costs associated with flooding;
- identify opportunities to support environmental sustainability/restoration goals of the Upper Mississippi and Illinois River floodplains as part of any systemic flood damage reduction plan;
- seek opportunities to address, in concert with flood damage reduction measures, other floodplain specific problems, needs and opportunities to include:
 - continued maintenance of the navigation project and related commercial infrastructure;
 - reduction of nutrient input and sedimentation into the rivers;
 - improved habitat management;
 - bank caving and erosion reduction;
 - improved recreation opportunities; and
 - identify and recommend appropriate follow-on studies.”¹⁹⁰

¹⁹⁰ UMRCPP, p. ES-3-4

Part 2. Summary Comparison of Alternative Plan¹⁹¹

	No Action	Plan A	Plan B	Plan C	Plan D	Plan E	Plan F	
Plan Description	NO ACTION	Confined 500-yr	500-yr		200-yr Ag levee protection	~100-yr Ag levee protection	50-yr min Ag levee protection	Local protection for towns & bridge approaches @ 500-yr
Alternative Plan Evaluation By Account								
NED	No Change							
Benefits		\$19,196,000	\$13,461,000		\$12,990,000	\$11,900,000		
Costs		\$571,538,000	\$314,612,000		\$230,530,000	\$178,190,000		
BCR*		0.03	0.04		0.05	0.07		
EQ**(costs)	No Change		\$470,200,000		\$681,800,000	\$355,500,000		
RED (benefits)	No Change	\$30,381,000,000	\$27,091,000,000		\$22,029,000,000			
OSE	No Change							
	Plan G	Plan H	Plan I	Plan J	Plan K	Plan L	Plan M	
Plan Description	Allow up to 1' rise at Thebes; 500-yr Ag, requires 10,000 acre storage area in Monroe Co.	500-year cost effective buyout	Buyout development in 100-yr floodplain	No development in 500-yr floodplain; buyout development in Ag areas; remove Ag levees	500-yr for Ag with regional critical infrastructure	Local protection for bridge approaches @ 500-yr	Allow up to 1' rise at Thebes; 500-yr Ag, no storage area in Monroe Co., IL	
Alternative Plan Evaluation By Account								
NED								
Costs	\$359,276,000	\$259,453,000		\$184,951,000			\$357,780,000	
Benefits		\$13,461,000					\$16,133,000	
BC		0.05					0.05	
EQ**(costs)		\$451,900,000	\$25,000,000	\$261,000,000			\$213,000,000	
RED (benefits)								
OSE								

* BCR = annualized benefits / annualized costs,¹⁹² note that EQ monetary costs are not included as annualized costs.

**Nonmonetary considerations for the EQ account include secondary development, environmental restoration opportunities, and reductions in both nutrients and sediment

¹⁹¹ Adapted from UMRCP, pp. 99-100

¹⁹² UMRCP, p. 85

Part 3. Technical Details of Preferred Plan, UMRCP Plan H

According to the UMRCP, Plan H performs the best among the alternatives evaluated, because it includes a cost effectiveness consideration, despite falling well below (a BCR of 0.05) the threshold of a BCR of 1.0 or higher. The preferred Plan H would protect urban areas and towns with 500-year levees; for agricultural areas it would provide 500-year levees except where buyouts would be more cost effective. “For Plan H, the construction cost of increasing the system height, typically raising a levee, is compared to the cost of acquisition of the district, and the cost effective option then becomes a part of Plan H for that site. Any district could choose not to be a part of the plan and then the district would stay ‘as is’ or find other resources to improve the existing level of protection.”¹⁹³ However, the Corps cautions that Plan H has yet to be thoroughly vetted with the stakeholders and general public.

Plan D — which includes providing approximately 100-year level protection for agricultural areas and 500-year level protection for urban areas — was a close second, for which a \$22 billion benefit was calculated in the RED account.¹⁹⁴ “The direct impacts from improved flood protection of the project proposals occur in five areas: construction, economic development, land value enhancement, farm income gains, and damages averted.”¹⁹⁵ Plan M — which involves providing 500-year level protection to urban, agricultural, and currently unprotected communities — also appeals to regional stakeholders who are seeking further economic development. However, the UMRCP final report concludes:

There is likely to be limited Federal interest, based upon current guidance, in plan implementation by Federal agencies.... Regional or national oversight (e.g., the Mississippi River Commission) would be required to ensure the plan functions as a system over the implementation and operation phases of the project and project priorities are established to reflect the changing systemic needs.... The States of Illinois, Iowa, and Missouri need to agree on the plan and plan implementation to insure the plan is acceptable. The Corps could provide facilitation and technical support to this effort.”¹⁹⁶

¹⁹³ Ibid, p. 119

¹⁹⁴ The economic analysis described in the UMRCP is not clear whether this regional benefit is included in the national benefit, or whether the regional benefit is offset by a cost in other regions within the nation.

¹⁹⁵ Ibid. Appendix C, p. C-28

¹⁹⁶ Ibid., p. ES-11