MEMORANDUM REPORT FOR THE NRC COMMITTEE ON IMPROVING PRINCIPLES AND GUIDELINES FOR WATER RESOURCES PLANNING

SUBJECT: Crosswalk of WRDA 2007 Directives for Revising Civil Works Project Planning Guidance and Conclusions and Recommendations of NRC Committee Reports on Water Resources Project Planning

May 15, 2008

1. Background

Section 2031(b)(3) of the Water Resources Development Act of 2007[1] (WRDA 2007) directs the Secretary of the Army to revise, within 2 years of the date of enactment, the "principles and guidelines" set forth in the main guidance document used by the U.S. Army Corps of Engineers (Corps) for preparing civil works project planning studies.[2] That section of WRDA 2007 also outlines various considerations to be followed for developing the guidance revisions. Other sections of WRDA 2007 that may relate to the principles and guidelines revisions include Section 2031(a), "national water resources planning policy;" Section 2033(b), "planning process improvements;" Section 2033(d), "calculation of benefits and costs for flood damage reduction projects;" and Section 2036(a)(3), "mitigation for fish and wildlife and wetlands losses." Table 1 outlines the directives contained in these WRDA sections, with substantive planning concepts and tools highlighted in bold.

The Secretary of the Army has set forth an aggressive schedule for the guidance revisions that seeks to first revise the "principles and standards" portions of the guidance that primarily address conceptual issues for the formulation, evaluation, and selection of project plans. This is to be followed by revisions to the "guidelines" portion of planning guidance that will address the detailed analytical techniques and procedures for their implementation in planning studies.

Section 2031(b)(4) of WRDA 2007 specifies that the Secretary of the Army, in carrying out the revisions the principles and guidelines, shall consult with various federal agencies as well as the National Academy of Sciences (NAS). To facilitate consultation with the NAS, the Corps has entered into an agreement with the National Research Council (NRC) Water Science and Technology Board to establish a "Committee on Improving Principles and Guidelines for Water Resources Planning by the U.S. Army Corps of Engineers" (NRC Committee). The NRC Committee's primary charge is to review the proposed revisions to the principles and standards portion of the guidance, and provide recommendations for improving the revisions.

[1] Public Law 110-114, November 8, 2007.

[2] Water Resources Council. 1983. *Economic and environmental principles and guidelines for water and related land resources implementation studies.* U.S. Government Printing Office, Washington, DC.

To assist the NRC Committee in meeting this charge, the Corps agreed to supply it with a summary document that reviews criticisms of Corps planning studies, and recommended changes to planning guidance meant to alleviate the perceived deficiencies in planning studies. Toward that end, the Corps has provided the NRC Committee with a 2005 working paper[3] that surveyed criticisms of Corps planning studies and recommendations for guidance revisions made by various commentators, including various NRC committee reports on water resources project planning. That working paper 1) surveyed and summarized criticisms in the ways in which the Corps formulates, evaluates, and selects project plans to recommend for funding, and 2) examines the extent to which the identified criticisms can be directly linked to provisions in Corps planning guidance.

However, the 2005 working paper did not address every planning concept mentioned in WRDA 2007; as one example, the concept of "adaptive management" was not addressed by the paper. Further, the working paper did not consider all NRC reports that deal with water resources project planning. Accordingly, the intent of the memorandum report presented herein is to help fill these gaps in the 2005 working paper with respect to the conclusions and recommendations of NRC reports on water resources planning that relate to the substantive planning concepts specifically mentioned in WRDA 2007. Both the 2005 working paper and this memorandum report were prepared by Paul Scodari of the Corps' Institute for Water Resources.[4]

2. Purpose, Scope and Organization

This memorandum report provides a crosswalk of those sections of the reviewed NRC reports on water resources planning that relate to the WRDA 2007 directives for planning guidance revisions and planning practice. The purpose of the crosswalk is to provide a roadmap for the NRC Committee in its review of past NRC reports that address the substantive planning concepts and tools mentioned in the Act.

A total of 22 NRC reports on water resources planning published from 1992 to 2006 were reviewed to identify NRC committee conclusions and recommendations that relate to the substantive planning concepts and tools outlined in WRDA 2007 (as highlighted in bold in Table 1). Section 3 of this memorandum report lists the NRC reports reviewed for the crosswalk. Section 4 then provides a series of tables that identify the page numbers of the reviewed NRC reports that relate to each of the substantive planning concepts and tools mentioned in WRDA 2007. Those tables are followed by a brief narrative that identifies in very general terms the conclusions and recommendations of the reviewed NRC reports that relate to the substantive planning concepts and tools mentioned in Act.

[3] Scodari, Paul. 2005. *Survey and analysis of criticisms of Corps planning and links to planning guidance.* Working Paper. U.S. Army Corps of Engineers, Institute for Water Resources.
[4] Paul.f.scodari@usace.army.mil (703.428.6336).

Table 1. WRDA 2007 Directives on Substantive Issues for Corps Project Planning	
Section/Title	**Directive (with key concepts in bold)**
Sec. 2031(a) National Water Resources Planning Policy	It is the policy of the United States that all water resources projects should reflect national priorities, encourage economic development, and protect the environment by— (1) seeking to **maximize sustainable economic development**; (2) seeking to a**void the unwise use of floodplains and flood-prone areas** and **minimizing adverse impacts and vulnerabilities** in any case in which a floodplain or flood-prone area must be used; and (3) **protecting and restoring the functions of natural systems** and **mitigating damage to natural systems**
Sec. 2031(b)(3) Principles and Guidelines, Considerations	In developing revisions to the principles and guidelines…the Secretary shall…ensure that the principles and guidelines address, the following: (A) The **use of best available economic principles and analytical techniques**, including **techniques in risk and uncertainty analysis**. (B) The **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) The **assessment and evaluation of the interaction of a project with other water resource projects and programs within a region or watershed**. (E) The use of contemporary water resource paradigms, **including integrated water resource management and adaptive management**. (F) **Evaluation methods that ensure that water resources projects are justified by public benefits**.
Sec. 2033(b), Planning Process Improvements	The Chief of Engineers— (1) shall adopt a **risk analysis approach to project cost estimates** for water resources projects; …
Sec. 2033(d), Calculation of Benefits and Costs for Flood Damage Reduction Projects	A feasibility study for a project for flood damage reduction shall include, as part of the calculation of benefits and costs— (1) a **calculation of the residual risk of flooding** following completion of the proposed project; (2) a **calculation of the residual risk of loss of human life and residual risk to human safety** following completion of the project; (3) a **calculation of any upstream or downstream impacts** of the proposed project; and (4) **calculations to ensure that the benefits and costs associated with structural and nonstructural alternatives are evaluated in an equitable manner**.
Sec. 2036(a)(3), Mitigation for Fish and Wildlife and Wetlands Losses	Mitigation Requirements— (A) In General—**To mitigate losses to flood damage reduction capabilities and fish and wildlife** resulting from a water resources project, the Secretary shall **ensure that the mitigation plan for each water resources project complies with the mitigation standards and policies established pursuant to the regulatory programs administered by the Secretary**.

3. NRC Reports Reviewed

A total of 22 NRC reports were reviewed for the crosswalk. These include reports relating to water resource project planning in general as well in reports relating to specific, placed-based planning contexts. A listing of the 18 reviewed NRC reports that presented findings or conclusions relating to one or more of the WRDA directives are presented in subsection 3.1. A listing of the four reviewed NRC reports for which no substantive discussion of any of the WRDA 2007 planning directives was found is presented in subsection 3.2.

3.1 Reviewed NRC Reports that Address WRDA Planning Directives

- Progress toward restoring the Everglades: The first biennial review. 2006. (Everglades Review 2006)

- Review of the Lake Ontario-St. Lawrence River studies. 2006. (Lake Ontario 2006)

- Water resources planning for the Upper Mississippi River and Illinois Waterway. 2005. (Planning UMR-IWW 2005)

- US Army Corps of Engineers water resources planning: New opportunity for service. 2004. (New Opportunity 2004)

- Adaptive management for water resources project planning. 2004 (Adaptive Management 2004)

- River basins and coastal systems planning within the US Army Corps of Engineers. 2004. (River Basins 2004)

- Analytical methods and approaches for water resources planning. 2004. (Analytical Methods 2004)

- Managing the Columbia River: Instream flows, water withdrawals, and salmon survival. 2004. (Columbia River 2004)

- Review of the USACE restructured Upper Mississippi--Illinois River Waterway feasibility study. 2004. (UMR-IWW Report 1 2004)

- Review of the USACE restructured Upper Mississippi-Illinois River Waterway feasibility study, second report. 2004. (UMR-IWW Report 2 2004)

- The Missouri River ecosystem: Exploring the prospects for recovery. 2002. (Missouri River 2002)

- Inland navigation system planning: The Upper Mississippi River-Illinois Waterway. 2001. (Inland Navigation 2001)

- Compensating for wetland losses under the Clean Water Act. 2001. (Compensating Losses 2001)

- Risk analysis and uncertainty in flood damage reduction studies. 2000. (Risk & Uncertainty 2000)

- New directions in water resources planning for the US Army Corps of Engineers. 1999. (New Directions 1999)

- New strategies for America's watersheds. 1999. (New Strategies 1999)

- Flood risk management and the American river system: An evaluation. 1995. (American River 1995)

- Restoration of aquatic ecosystems. 1992. (Aquatic Restoration 1992)

3.2 Reviewed NRC Reports that Do Not Address WRDA Planning Directives

- Science of instream flows: A review of the Texas instream flow program. 2005.

- River Science at the US Geological Survey. 2006.

- Report of a workshop on predictability and limits to prediction in hydrologic systems. 2002.

- Improving American river flood frequency analyses. 1995.

4. Crosswalk of WRDA 2007 Planning Directives and Reviewed NRC Reports

4.1 Crosswalk Tables

Tables 2-5 below identify the page numbers of the reviewed NRC reports that speak to the various substantive planning concepts and tools outlined in WRDA 2007. Table 2 provides a crosswalk for the so-called "216" NRC reports on Crops water resources planning studies that were prepared pursuant to Section 216 of WRDA 2000. Table 3 presents a crosswalk for other reviewed NRC reports published 2004-2006; Table 4 presents a crosswalk for reviewed NRC reports published 1999-2002; Table 5 presents a crosswalk for reviewed NRC report published 1992-1998.

Table 2. Sections of NRC 216 Study Reports Relating to WRDA Directives				
WRDA Directive	**New Opportunity 2004**	**Adaptive Management 2004**	**River Basins 2004**	**Analytical Methods 2004**
Sec. 2031(1) National Water Resource Policy Planning				
Maximize sustainable economic development	Pages 18-20, 59-60			Pages 6-7, 40-43
Avoid unwise use of floodplains & minimize vulnerabilities				Pages 53-55
Protect & restore functions of natural systems & mitigate damage	Pages 5, 7, 56-59		Pages 7-8, 63-80	
Sec. 2031(b)(3) Principles and Guidelines Considerations				
Best available economic principles & analytical techniques	Pages 5-6, 59-60		Pages 95-99	Pages 60-67
Risk and uncertainty Analysis				Pages 93-95, 114-115
Assessment & incorporation of public safety in formulation				Pages 53-55, 60
Methods that reflect value for low-income communities				
Methods that reflect value of nonstructural approaches				Pages 55-60
Evaluation of project interactions with other projects within a region or watershed	Pages 48-68		Pages 3-8, 81-136	Pages 92-93, 114-115
Use of integrated water resource management	Pages 20-23		Pages 3-8, 81-136	Pages 92-93, 114-115
Use of adaptive management	Pages 23-27	Pages 1-51	Pages 130-132	Pages 76-77
Methods that ensure projects justified by public benefits				
Sec. 2033(b) Planning Process Improvements				
Risk analysis approach to cost estimation				
Sec. 2033(d) Calculation of Benefits and Costs for Flood Damage Reduction Projects				
Residual risk of flooding				
Residual risk to human life and safety				
Upstream or downstream impacts	Pages 20-23		Pages 3-8, 81-136	Pages 92-93, 114-115
Equitable evaluation of structural & nonstructural approaches				Pages 55-60
Sec. 2036(a)(3) Mitigation Requirements				
Mitigate losses to flood damage a reduction capabilities	Pages 7, 76-77			
Mitigate losses to fish & wildlife				

Table 2. Sections of NRC 216 Study Reports Relating to WRDA Directives				
WRDA Directive	**New Opportunity 2004**	**Adaptive Management 2004**	**River Basins 2004**	**Analytical Methods 2004**
Comply with regulatory standards				

Table 3. Sections of Other NRC Reports Published 2004-2006 Relating to WRDA Directives						
WRDA Directive	**Everglades Review 2006**	**Lake Ontario 2006**	**Planning UMR-IWW 2005**	**Columbia River 2004**	**UMR-IWW Report 2 2004**	**UMR-IWW Report 1 2004**
Sec. 2031 National Water Resource Policy						
Maximize sustainable economic development						
Avoid unwise use of floodplains & minimize vulnerabilities						
Protect/restore functions of natural systems & mitigate damage				Pages 105, 201	Pages 4-7, 28-32	
Sec. 2031(b)(3) Principles and Guidelines Considerations						
Best available economic principles & analytical techniques			Pages 5-6, 32-36			Pages 29-30
Risk & uncertainty analysis					Pages 7-9, 44-48	Pages 15-16, 24-25
Assessment & incorporation of public safety in formulation						
Methods that reflect value for low-income communities						
Methods that reflect value of nonstructural approaches					Pages 5-7, 49-58	
Evaluation of project interactions with other projects					Pages 1-3, 18-27	Pages 3-4, 19-21, 27
Use of					Pages 1-3,	Pages 3-4,

Table 3. Sections of Other NRC Reports Published 2004-2006 Relating to WRDA Directives						
WRDA Directive	**Everglades Review 2006**	**Lake Ontario 2006**	**Planning UMR-IWW 2005**	**Columbia River 2004**	**UMR-IWW Report 2 2004**	**UMR-IWW Report 1 2004**
integrated water resource management					18-27	19-21, 27
Use of adaptive management	Pages 106-129, 163-179	Pages 11-12, 118	Pages 4-5, 28-32	Pages 183-185	Pages 7-9, 44-48	Pages 28-29
Methods that ensure projects justified by public benefits						
Sec. 2033(b) Planning Process Improvements						
Risk analysis approach to cost estimation						
Sec. 2033(d) Calculation of Benefits and Costs for Flood Damage Reduction Projects						
Residual risk of flooding						
Residual risk to human life and safety						
Upstream or downstream impacts					Pages 1-3, 18-27	Pages 3-4, 19-21, 27
Equitable evaluation of structural & nonstructural approaches						
Sec. 2036(a)(3) Mitigation Requirements						
Mitigate losses to flood damage reduction capabilities					Page 176	
Mitigate losses to fish & wildlife						
Comply with regulatory standards						

Table 4. Sections of NRC Reports Published 1999-2002 Relating to WRDA Directives						
WRDA Directive	**Missouri River 2002**	**Inland Navigation 2001**	**Compensating Losses 2001**	**Risk & Uncertainty 2000**	**New Directions 1999**	**New Strategies 1999**
Sec. 2031 National Water Resource Policy						
Maximize sustainable economic						Pages 259-260

Table 4. Sections of NRC Reports Published 1999-2002 Relating to WRDA Directives						
WRDA Directive	**Missouri River 2002**	**Inland Navigation 2001**	**Compensating Losses 2001**	**Risk & Uncertainty 2000**	**New Directions 1999**	**New Strategies 1999**
development						
Avoid unwise use of floodplains & minimize vulnerabilities				Pages 10-11		
Protect/restore functions of natural systems & mitigate damage	Pages 84-85					Page 271
Sec. 2031(b)(3) Principles and Guidelines Considerations						
Best available economic principles & analytical techniques					Pages, 7, 68, 73-77, 83-84	
Risk & uncertainty analysis		Pages 63-66, 26-28, 45, 73		Pages 4-8		Page 274
Assessment & incorporation of public safety in formulation				Pages 10-11		
Methods that reflect value for low-income communities						
Methods that reflect value of nonstructural approaches		Pages 66-71, 30-31			Pages 8, 61-63	
Evaluation of project interactions with other projects		Pages 53-54, 80-82			Pages 5, 80-81	Pages 232-252, 275
Use of integrated water resource management		Pages 53-54, 80-82			Pages 5, 80-81	Pages 232-252, 275
Use of adaptive management	Pages 5-6, 18-20, 107-112	Pages 26-28, 30-31, 49, 76-79			Pages 6-7, 31-32	Pages 248-249
Methods that ensure projects justified by public benefits						
Sec. 2033(b) Planning Process Improvements						
Risk analysis approach to						

Table 4. Sections of NRC Reports Published 1999-2002 Relating to WRDA Directives						
WRDA Directive	**Missouri River 2002**	**Inland Navigation 2001**	**Compensating Losses 2001**	**Risk & Uncertainty 2000**	**New Directions 1999**	**New Strategies 1999**
cost estimation						
Sec. 2033(d) Calculation of Benefits and Costs for Flood Damage Reduction Projects						
Residual risk of flooding						
Residual risk to human life and safety						
Upstream or downstream impacts		Pages 53-54, 80-82			Pages 5, 80-81	Pages 232-252, 275
Equitable evaluation of structural & nonstructural approaches					Pages 8, 61-63	
Sec. 2036(a)(3) Mitigation Requirements						
Mitigate losses to flood damage reduction capabilities						
Mitigate losses to fish & wildlife			Pages 94-122			
Comply with regulatory standards						

Table 5. Sections of NRC Reports Published Pre-1999 Relating to WRDA Directives						
WRDA Directive	**American River 1995**	**Aquatic Restoration 1992**				
Sec. 2031 National Water Resource Policy						
Maximize sustainable economic development						
Avoid unwise use of floodplains & minimize vulnerabilities	Pages 183-186, 200-202					
Protect/restore functions of natural systems & mitigate damage		Pages 17-21				
Sec. 2031(b)(3) Principles and Guidelines Considerations						
Best available		Pages 357-				

Table 5. Sections of NRC Reports Published Pre-1999 Relating to WRDA Directives						
WRDA Directive	**American River 1995**	**Aquatic Restoration 1992**				
economic principles & analytical techniques		358				
Risk & uncertainty analysis						
Assessment & incorporation of public safety in formulation						
Methods that reflect value for low-income communities						
Methods that reflect value of nonstructural approaches						
Evaluation of project interactions with other projects						
Use of integrated water resource management						
Use of adaptive management		Pages 332, 357-358				
Methods that ensure projects justified by public benefits						
Sec. 2033(b) Planning Process Improvements						
Risk analysis approach to cost estimation						
Sec. 2033(d) Calculation of Benefits and Costs for Flood Damage Reduction Projects						
Residual risk of flooding	Pages 188-192, 200-202, 215-216					
Residual risk to human life and safety	Pages 188-192, 200-202, 204, 212					
Upstream or downstream impacts						

Table 5. Sections of NRC Reports Published Pre-1999 Relating to WRDA Directives						
WRDA Directive	**American River 1995**	**Aquatic Restoration 1992**				
Equitable evaluation of structural & nonstructural approaches						
Sec. 2036(a)(3) Mitigation Requirements						
Mitigate losses to flood damage reduction capabilities						
Mitigate losses to fish & wildlife						
Comply with regulatory standards						

4.2 General Findings of the Reviewed NRC Reports

The brief narrative presented below provides a general sense of the findings and conclusions of the reviewed NRC reports with respect to the WRDA 2007 planning issues for which relevant discussions were identified in one or more of the reports. This narrative is meant to serve only as a general guide to the findings of the relevant issues discussed in the reviewed NRC reports—the NRC Committee will be expected to provide its own interpretation of the relevance and meaning of conclusions and recommendations of these reports.

a) Maximize sustainable economic development

Two issues relating to this water resource management objective are addressed in one or more NRC reports. The first issue relates to current Corps guidance that instructs planners to recommend project alternatives that maximize quantified net economic benefits (benefits minus costs), as measured in dollars in project benefit-cost analyses. The WRDA directive is to maximize *sustainable* economic development; however, none of the reviewed NRC reports specifically defined the meaning of the modifier "sustainable" for economic development. But use of this modifier, together with the identification of other objectives for civil works planning in WRDA 2007, might be interpreted to mean that the benefit-cost decision rule for plan selection in current guidance should be abandoned. That idea is supported by the "216" reports, which conclude that a strict benefit-cost decision rule for project investments should be rejected because, among other reasons, projects often have important effects are not amenable to quantification in dollar terms.

The second issue relates to the meaning of the term "economic development." Current guidance defines "national economic development" as improvement in the economic efficiency of resource use. But some proponents of water resource project view water projects as desirable for stimulating changes in economic activity rather than just reacting to such changes in the interests of promoting efficiency. One of the "216" reports notes this distinction and its implications for project planning.

b) Avoid unwise use of floodplains and flood-prone areas and minimize adverse impacts and vulnerabilities

Several NRC reports address this objective indirectly through recommendations relating to the evaluation of nonstructural flood damage reduction alternatives. Specifically, these reports note if the environmental benefits of nonstructural plans are ignored in project planning, this creates an analytical disincentive for the consideration of such plans (see item g).

One NRC report argues that federal involvement in flood damage reduction projects should be conditioned on use of nonstructural measures by the relevant localities, such as emergency preparedness and evacuation planning, to address residual risks that remain after the project has been implemented.

c) Protect and restore the functions of, and mitigate damages to, natural systems

Several NRC reports state or imply that the Corps' primary environmental mission should be to protect and restore hydrologic and geologic processes in large river and coastal systems as a necessary component for the achievement of biological and ecological goals.

d) Use of best available economic principles and analytical techniques

Several NRC reports argue that the current science and economic valuation methods would support the valuation of both market and non-market ecosystem restoration benefits in monetary terms for Corps planning; thus, the valuation of environmental benefits should be pursued in Corps planning studies whenever possible and practical.

One of the "216" study reports notes that the Corps currently represents ecosystem restoration benefits using non-monetary measures (e.g., habitat units) expressed in average annual terms, but does not employ discounting procedures to account for the time "value" of those outputs according to when they will be realized. That report argues that the discounting restoration benefits should not be dismissed out-of-hand simply because benefit measures are characterized in non-monetary terms.

e) Use of risk and uncertainty analysis

One NRC report notes that while the Corps currently applies risk-based methods of analysis for flood damage reduction studies, methodological improvements are needed

within that context. Further, the improved risk-based methods should be extended to studies involving ecosystem restoration and other civil works purposes.

The various NRC reports dealing with navigation planning for the Upper Mississippi River and Illinois Waterway note that the project analysis rely on long-term forecasting of commodity shipments, which can not be predicted with any confidence. Thus, project analysis should be conducted using scenario analysis that supposes different levels of grain and non-grain shipments on the system under various alternative scenarios, including identification of the factors that would drive each scenario.

f) Assessment and incorporation of public safety in formulation

Several NRC reports argue that plan effects on human life and safety, and the tradeoffs between these effects and other types of project effects, should be evaluated and considered in flood damage reduction studies.

g) Assessment methods that reflect the value of nonstructural approaches

Several NRC reports note the analytical difficulties in assessing the benefits of nonstructural flood damage reduction alternatives, and argue that such assessments are typically biased downward because they do not fully consider the environmental and other possible benefits of nonstructural alternatives. These reports also discuss a potential analytical bias against nonstructural approaches relating to differences in the evaluation of property damages avoided for structural versus nonstructural approaches (see item n).

Several of the various NRC reports dealing with navigation planning for the Upper Mississippi River and Illinois Waterway argue that nonstructural approaches for managing waterway congestion (e.g., congestion pricing) could cost-effectively promote more efficient use of the waterway. Given the low cost and positive net benefits of nonstructural approaches, they should be the first priority for managing congestion on the waterway, and further, the predicted traffic and congestion levels that would result after implementing nonstructural measures should serve as the baseline for measuring the benefits of any structural measures for improving locks on the waterway.

h) Evaluation of the interaction of a project with other projects and programs within a region or watershed

This directive implies use of a “systems approach” to water resource planning that considers how new projects would interact with existing water resource projects and programs to affect water resources, as well as their interaction with broader systems that may not be related to hydrologic systems (for example, the interaction of inland navigation projects with broader transportation systems).

The various “216” reports address this broad systems approach, particularly the report that recommends a “portfolio approach” for planning new water resource investments and consideration of operational changes for existing water resource projects at the

regional scale. Many other NRC reports speak to integrated water resources planning at river basin or coastal system scales, which might be interpreted as a more limited systems perspective focused on project interactions with the regional hydrologic system (see item i).

i) Use of integrated water resource management

As outlined above, this directive can be interpreted to mean use of a systems approach for water resource planning focused on watershed hydrology (often referred to as a "watershed approach" for project planning). Generally, integrated water resource management implies a framework for integrated consideration of multiple water resource objectives and their tradeoffs in project planning, and for evaluating the cumulative environmental impacts of water projects at the watershed sale. Many NRC reports discuss the desirability and components of such an integrated approach for water project planning and evaluation.

j) Use of adaptive management

Many of the reviewed NRC reports advocate adoption of adaptive management concepts for project planning as one way to introduce flexibility and reduce uncertainty in water resources management. In general, these reports advance a process for reviewing and revisiting management objectives over time that emphasizes learning while doing, including use of experiments designed to advance knowledge, and a framework for incorporating new knowledge into future management decisions.

k) Calculations of the residual risk of flooding

One NRC report discusses the importance of estimating and communicating the residual flood risk of project alternatives (e.g., the timing, spatial extent, and depth of flooding), and various possible metrics for communicating that risk to project stakeholders.

l) Calculations of the residual risk to human life and safety

One NRC report discusses the need to estimate and communicate to stakeholders not just the residual flood risk of project alternatives, but also the consequences of that risk, including the likely loss of human life as affected by warning times, evacuation opportunities, and the depth and character of flooding.

m) Calculations of upstream and downstream impacts

Several NRC reports identify the need to identify the watershed-wide impacts of project alternatives in the context of the integrated water resources management approach to project planning.

n) Calculations to ensure that the benefits and costs of structural and non-structural flood damage reduction approaches are evaluated in an equitable manner

Several NRC reports note that current Corps guidance may introduce an analytical bias against nonstructural approaches such as permanent evacuation and relocation, because guidance says that property damages avoided is a claimable benefit for structural flood control approaches, but not in the case of evacuated properties.

o) Mitigate losses to flood damage reduction capabilities

One NRC report argues that water resources management alternatives should include economic mitigation in addition to any needed environmental mitigation. Economic mitigation might include, for example, in-kind replacement of lost services.

p) Mitigate losses to fish and wildlife

The NRC report on compensating for wetland losses under the Clean Water Act stresses the need for a nexus between mitigation plans and impacted resources to ensure that mitigation efforts effectively replace the functional values of the impacted sites.