HOW PROJECT SELECTION IN THE CORPS OF ENGINEERS IS AFFECTED BY BENEFIT-COST RATIO (BCR) ANALYSIS

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Executive Summary

This report analyzes certain aspects of benefit-cost analysis (BCA) as conducted by the U.S. Army Corps of Engineers (USACE) and assesses how they differ from current methodology for BCA in general. The various topics to be investigated in this report were delineated by the National Waterways Foundation as potential problem areas or potential deviations from the state of the art for BCA.

Primary Takeaway

The Benefit-Cost Analysis should consider the costs and benefits to society, not just the difference in transportation costs. When the public invests money in a project, it should benefit society to the greatest degree possible.

Primary Takeaway

There are a number of externalities that are commonly used in BCA for non-USACE infrastructure projects that are not included in the USACE guidance.

There are a number of positive externalities resulting from navigation projects that could be evaluated but are not currently included.

The first part of this report reviews and contrasts the official guidance issued by USACE with guidance issued by the Environmental Protection Agency (EPA), Department of Interior (DOI)/Bureau of Land Management (BLM), and the U.S. Department of Transportation (US DOT) Transportation Investment Generating Economic Recovery (TIGER) Grant Program.[1] Here are the takeaways that were identified for each aspect of BCA:

- Externalities that may be included.
    - USACE guidance is very narrowly focused on transportation cost savings.
    - There are a number of externalities that are commonly used in BCA for non-USACE infrastructure projects that are not included in the USACE guidance.
    - There are a number of positive externalities resulting from navigation projects that could be evaluated but are not currently included.
    - The TIGER grant program has established a methodology for evaluating many of the positive externalities.
    - EPA analysts are encouraged to ask, “Which benefit categories are especially salient to particular stakeholders?” This question is not raised in USACE BCAs.
- How externalities that cannot be monetized are addressed.

[1] The TIGER Grant Program was replaced by the Better Utilizing Investments to Leverage Development (BUILD) Grant Program in 2018. Most of the provisions of the TIGER program that relate to project economics and evaluation were carried forward.

    - Circular a-4[2] recognizes that the most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate.
    - BLM recognizes that although qualitative discussions do not allow for comparisons of monetized economic value estimates, they provide an effective means to communicate the range of economic values associated with a proposed project or action.
    - TIGER guidance encourages the analyst to include benefits that are not monetizable and even those that are not quantifiable. However, it does not discuss how these benefits influence final project selection.
    - USACE includes qualitative discussions to assist with the analysis, but they are not the principle decision factors.
- The use of discount rates.
    - The USACE practice of mixing real and nominal discount rates tends to understate discounted present values (PVs). The same concern exists for TIGER guidance. This negatively affects benefit-cost ratios (BCRs) since benefits tend to occur further into the future than costs and are therefore more heavily discounted.
    - This practice reduces the number of long-term projects that pass the BCR test.
    - The discount rate that each agency must use is mandated by Congress.
    - The rate for the other agencies has been significantly higher than the rate used by USACE for a number of years, which tends to produce more conservative estimates of benefits for those agencies.
- The use of confidence levels or risks in BCA.
    - There is a wide range of discretion analysts may use to deal with risk and uncertainty.
    - Agencies tend to focus on specific aspects of BCA that tend to have better underlying data or a longer history in project work.
    - USACE adjusts costs to reflect the risk of uncertain funding, but does not do so for benefits.
    - EPA has been criticized for focusing on just one variable or source of uncertainty at a time when several sources were at play.
    - It is important to highlight where the greatest source of uncertainty lies, since estimates cannot be more precise than their most uncertain component.
    - DOI guidance explicitly deals with climate change issues; the others do not.
    - Estimates should be displayed as ranges rather than as most likely point estimates.

[2] Circular a-4 was promulgated by the Office of Management and Budget (OMB) and applies to agencies initiating regulatory actions

    - IEPA's use of break-even analysis would be easily adaptable and useful in USACE studies when evaluating externalities that are difficult to monetize or forecast.
- The effect of the timing of funding.
    - Delays in funding strongly influence the net economic value of a project.
    - Delays as short as three years can double the social cost of a project by increasing costs while delaying benefits.
    - In USACE BCAs, an optimal funding stream is assumed such that the project is not penalized for future funding decisions unrelated to the project. This approach almost certainly guarantees that the cost estimates for a project will not be accurate.
- Requirements and effects of peer review.
    - All the agencies recognize the importance of an external peer review.
    - Historically, the use of independent expertise has been less common in USACE than in some other agencies.
    - EPA only requires peer review of scientific work that is relied upon in its BCA, not the BCA itself.
    - EPA encourages peer review at the planning stage; the other agencies do not.

There is one important distinction among the agencies in the ways projects are actually implemented. TIGER Grant projects are competing for funds from a fixed pool. USACE projects must be specifically funded by Congress. EPA and DOI/BLM projects may not require a significant appropriation by Congress, and therefore do not focus as heavily on project cost.

The second part of this report discusses the potential effect of cost adjustments and project delays on project benefits. Significant cost increases may severely reduce the probability that a project will be fully funded. In extreme cases, such as the Olmsted Lock and Dam Project, they may even affect the viability of other unrelated projects. Furthermore, significant cost increases and delays may cast doubt on the project's viability in the eyes of industries that do or could use rivers for freight transportation. There is currently no prescribed treatment of these issues in USACE analyses, although they have been discussed in some instances. Unfortunately, most of the discussion in USACE analyses focuses on the cost side of the project and not the potential effect of a loss of benefits or a loss of confidence in the system.

The third part of this report looks at three example project feasibility reports and assesses how those reports might have been different had they incorporated the best practices identified in the agency reviews. These are the takeaways identified in the assessments:

- Montgomery Point Lock and Dam Feasibility Report—1990 (*1*) and Limited Reevaluation Report—1993 (*2*).

    - These reports present costs and benefits as average annual values, with some inconsistencies in the discounting methodology. If the costs and benefits were reported as PVs, the BCR would improve from 1.1 to 4.8, using the same interest rate as the study. Using the real discount rate would further improve the BCR to 7.7.
    - Externalities are limited to cost reduction benefits, shift of mode benefits for diversions that would otherwise take place without the project, operations and maintenance (O&M) cost reductions, and unemployment benefits. The benefits for mode diversions only consider the increased cost of transportation, not the negative externalities generated by the mode shift.
    - USACE concludes that interest rates would have to rise above historical levels to affect the justification of the project. This fails to consider the fact that projects compete against each other on a national scale, so an interest rate that leads to a higher BCR might, in fact, affect the ability of the project to be funded.
    - The study did a good job of identifying the most important variables in terms of sensitivity. It does not include any discussion of how a delay in the project start date might affect the viability of the project.
    - There is no mention of a peer review of this study.
    - Externalities that could not be monetized were not discussed in the report.
- Upper Ohio Navigation Study—2014 (*3*).
    - The total costs and benefits are reported as annual average values rather than PVs, so it is not possible to analyze BCRs as they are usually reported. Additionally, the values reported are the differences between costs and benefits in the with-project condition versus the without-project condition. The focus on incremental costs and benefits does not enable a reader to determine if the total project cost is justified or how the relative return on investment compares to other alternatives.
    - Externalities are presented and quantified, but according to guidance from headquarters, these externalities could not be used to justify the project. Furthermore, only roadway congestion was allowed in the formal evaluation, and then only in terms of the cost of transportation.
    - Externalities that could not be monetized were not discussed in the report.
    - The report deals with uncertainty and sensitivity in detail. It examines the effects of different price levels, discount rates, base years, and projected traffic levels. Risk is never explicitly addressed, although it appears to be incorporated into cost estimates.
    - The effect of delayed start dates on the cost of the project was analyzed. However, the report assumes the same nominal benefits and only adjusts them by using different discount rates. The analysis does not examine the risk of delaying or stretching out the funding of the project.

    - The report was peer reviewed and revised to address the comments. There was only one major finding, and it related to the assumptions used to calculate downtimes between failure and repairs.
- Chickamauga Lock Feasibility Report—2002 (*4*) and Limited Reevaluation Report—2016 (*5*).
    - The total costs and benefits are not reported as PVs, so it is not possible to analyze BCRs as they are usually reported. The focus on incremental costs and benefits does not enable a reader to determine if the total project cost is justified or how the relative return on investment compares to other alternatives.
    - The treatment of externalities is very limited and does not include several externalities that are explicitly accounted for in TIGER grant guidance and other agencies. In fact, in light of the change in the level of economic activity in the area, they are entirely omitted in the 2016 report.
    - Recreation benefits foregone because of lock closures are included in the formal BCA. Unit day values are used to estimate the benefits.
    - The report concludes that because the traffic base has fallen, shipment patterns have changed, and much of the without-project condition unscheduled closure re-routing around the lock that was anticipated in the feasibility analysis is no longer expected to occur; therefore, external costs due to modal diversions are inconsequential.
    - The sensitivity analysis identifies traffic demand forecasts as one of the major factors affecting the need for lock improvements and discusses them in detail. The use of congestion fees was considered in this report. Since this alternative has never been implemented on a navigation project, there is no experience for judging its actual performance. The report notes that there is a high risk that it would not perform as well as the theoretical model.
    - The study does a good job of illustrating the effect of different interest rates on the economics of the project.
    - The study did a good job of identifying the most important variables in terms of sensitivity. It does not include any discussion of how a delay in the project start date might affect the viability of the project.
    - This report discusses the effect of the timing of funding, although it makes the case this effect should not be included in the BCA.
    - There is no mention of a peer review of this study.
    - Externalities that could not be monetized were not discussed in the report.
    - Because of a lack of detail, it is not possible to determine if discount rates are used appropriately.

- The report illustrates the effect of less-than-optimal funding on the cost of the project.
- The choice of a discount rate can have a profound effect on the project's economic viability.

Importance of Discount Rates

Interest rates have a profound effect on the economic viability of projects.

This review leads to the following high-level observations:

- The manner in which the costs and benefits are presented makes it virtually impossible for the reader to understand whether they are reasonable or not. A presentation illustrating PVs rather than annual average incremental costs would make it easier to understand how a given project compares to projects outside the USACE's purview and would make it easier to determine if the project investment is justified. Additionally, tables showing the costs and benefits by year would enable the reader to do an independent assessment of their accuracy and the effect of interest rates.
- Sensitivity issues seem to be fairly well addressed.
- Externalities are very limited when compared to their treatment by other agencies.
- Interest rates have a profound effect on the economic viability of projects.
- The assumption that projects will be funded in a timely fashion almost guarantees that the actual performance of the project will not be in line with the BCA. However, as USACE notes in its studies, the only way to compare projects effectively is to assume full and timely funding and determine the economic viability of the project on that basis.

Cost and Benefits

The manner in which the costs and benefits are presented makes it virtually impossible for the reader to understand whether they are reasonable or not.

Finally, in the fourth chapter the report discusses the use of Remaining Benefit-Remaining Cost (RBRC) ratios for evaluating funding decisions for ongoing projects. With an RBRC approach, the remaining project costs are assessed, the benefits are reassessed, and downsides associated with decreasing funding to an ongoing construction project become clearer. Key takeaways from this analysis include:

- RBRC is appropriate because it considers the fact that investments have already been made. To forego additional investment and thereby lose a large portion, if not all, of the benefits of the project would essentially be a waste of scarce funds. Projects that need only a part of the total cost to realize benefits should show benefit-cost ratios that are superior to projects that have not yet been initiated.

- The other agencies evaluated in this report do not re-evaluate projects or actions once they are under way.
- None of these other agencies specifically use RBRC, but the TIGER grant program does allow a project to be subdivided into components, some of which may be completed by other parties. In some respects, that results in “prior investments” by other parties that would be akin to partial construction funding on USACE projects.
- The initial BCA is the justification for pursuing a project. Once the project is initiated, the justification has been approved and the project should be taken to completion. Re-evaluating a project that is already under construction could cause the BCR to change significantly and affect its funding. This change would be a direct result of delays in completing the construction rather than the underlying justification for initiating the project. Providing full funding up front would eliminate confusion over the project’s merits and provide a clearer management path for major construction projects.
- This research aimed to assess the pros and cons of using the RBRC rather than the BCR metric.

Introduction and Background

This report analyzes certain aspects of benefit-cost analysis (BCA) as conducted by the U.S. Army Corps of Engineers (USACE) and assesses how they differ from current methodology for BCA in general. The specific aspects to be included in this report were delineated by the National Waterways Foundation as potential problem areas or potential deviations from the state of the art for BCA.

The report is organized into the following four chapters:

1. An analysis that reviews and contrasts the official guidance issued by USACE with guidance issued by the Environmental Protection Agency (EPA), Department of Interior (DOI)/Bureau of Land Management (BLM), and the US DOT Transportation Investment Generating Economic Recovery (TIGER) Grant Program.[3] The following specific aspects of BCA are included:
   - Externalities that may be included.
   - How externalities that cannot be monetized are addressed.
   - The use of discount rates.
   - The use of confidence levels or risks in BCA.
   - The effect of the timing of funding.
   - Requirements and effects of peer review.
2. An assessment of the possible effects on project benefits of cost adjustments and project start delays—focusing on actual benefits and not benefit-cost ratio (BCR).
3. Three examples of how BCA for USACE projects would be affected by the incorporation of best practices from the selected agencies. The report reviews the following three projects and discusses how best practices might have affected the results:
   - Upper Ohio Navigation Study, Pennsylvania, Final Feasibility Report and Integrated Environmental Impact Statement (EIS).
   - Montgomery Point Lock and Dam Feasibility Report, Desha County, McClellan-Kerr Arkansas River Navigation System and Limited Reevaluation Report.
   - Chickamauga Lock Feasibility Report and Limited Reevaluation Report.
4. A discussion of Remaining Benefit Remaining Cost (RBRC) Analysis and its implications for funding USACE projects.

It is important to recognize the difference between BCA and EISs or Economic Impact Analyses (EIAs). The following simple definitions are used in this document:

[3] The TIGER Grant Program was replaced by the Better Utilizing Investments to Leverage Development (BUILD) Grant Program in 2018. Most of the provisions of the TIGER program that relate to project economics and evaluation were carried forward.

- **BCA:** A BCA is a systematic evaluation of the economic advantages (benefits) and disadvantages (costs) of a set of investment alternatives. A BCA tries to answer the question: What additional benefits will result if this alternative is undertaken, and what additional costs are needed to bring it about? The main objective of a BCA is to translate the effects of an investment into monetary terms and to account for the fact that benefits generally accrue over a long period while capital costs are incurred primarily in the initial years.
- **EIS:** An EIS is a report addressing the potential effects on the environment of a proposed government project. An EIS will outline proposed actions, possible alternatives, and the potential environmental impacts of the alternatives. There is no attempt to express these impacts in monetary terms.
- **EIA:** EIA is a methodology for evaluating the impacts of a project, program, or policy on the economy of a specified region. EIA typically shows impacts on jobs, income, operating costs, productivity, and competitiveness—and their distribution among industries and regions and over time.

The focus of this report is exclusively on BCA.

Costs and Disbenefits

BCA practitioners often refer to disbenefits. Costs refer to capital investment in a project, while disbenefits refer to the negative effects of a project (negative externalities). Different agencies describe these concepts differently, but the underlying concepts are the same.

Review of the Guidance from the Three Selected Agencies in Comparison to USACE

Introduction and Background—USACE Methodology

Unfortunately, there are no existing standard-setting organizations for BCA, although there is a large volume of literature on the pros and cons of various approaches to dealing with issues inherent in BCA. BCA is controversial because it is necessarily based on subjective decisions on what should (or should not) be included as benefits and costs, as well as how they ought to be evaluated. Common objections to using BCA as a decision rule for ranking investment priorities include:

- There may be important equity considerations in the distribution of costs and benefits that are not addressed by maximizing the difference between total benefits and total costs.
- Benefit and cost estimates may contain significant uncertainties. They are usually over a long period of time with linear growth rates that may not reflect the actual growth.
- It may not be possible to use money as a measure of all relevant costs and benefits (e.g., biodiversity, ethical issues).

The literature consistently points out that BCA should be used only as one criterion in reaching final judgment on a proper alternative; criteria such as stakeholder opinions, political preferences, equity, and non-market values such as biodiversity are important factors in water resources investments and policy decisions that are not captured in BCA.

The size of net benefits—the absolute difference between the projected benefits and costs—indicates whether one policy is more efficient than another. The ratio of benefits to costs is not a meaningful indicator of net benefits and should not be used for ranking purposes. Considering such ratios alone can yield misleading results.

The ratio of benefits to costs is not a meaningful indicator of net benefits and should not be used for ranking purposes.

Current state-of-the-art guidance attempts to deal with each of these concerns.

USACE planning guidance defines the federal objective and plan selection criterion for civil works project planning as follows (*6*):

> The Federal Objective
>
> (a) The Federal objective of water and related land resource project planning is 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.

(b) Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and of those that may not be marketed.

(c) The Federal Objective for the relevant planning setting should be stated in terms of an expressed desire to alleviate problems and realize opportunities related to the output of goods and services or to increased economic efficiency (*7*).

Plan Selection

(a) The alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment[4] (the NED plan) is to be selected unless the Secretary of a department or head of an independent agency grants an exception when there is some overriding reasons for selecting another plan, based on other Federal, State, local and international concerns (P&G, Chapter I, Section X).

The objective is not to determine the value of the waterway transportation system, but to determine the value to changes in the waterway transportation system.

USACE structures its BCAs in accordance with *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, often referred to as Principles and Guidelines (P&G). Detailed USACE guidance is embodied in the Planning Guidance Notebook (PGN), formally listed as Engineering Regulation (ER) 1105-2-100. Additional guidance was provided by the Council on Environmental Quality in 2009. An update to the P&G was released in 2013 (*8*). The P&G relies heavily upon predictive models and monetization techniques as the basis for water resources investment decisions.

Four agencies are required to follow the P&G: Bureau of Reclamation, Natural Resources Conservation Service, Tennessee Valley Authority, and USACE.

The P&G established four accounts:

- National Economic Development (NED)—displays changes in the economic value of the national output of goods and services.

[4] The P&G states, "Protection of the Nation's environment is to be provided by mitigation of the adverse effects of each alternative plan" [P&G, Chapter 1, Section VI, 1.6.1(g)]. In particular, mitigation measures are presumed to satisfy the environmental protection constraint, and the costs of these measures are included in the calculation of net economic benefits of alternative plans.

- Regional Economic Development (RED)—displays changes in the distribution of regional economic activity (e.g., income and employment).
- Environmental Quality (EQ)—displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans.
- Other Societal Effects (OSE)—displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation, and others.

The P&G does not place equal weight on the four accounts. The NED account is the most significant of the four accounts and is the only mandatory account used to evaluate federal water projects. Components of the other three accounts are often included in the NED account when they are monetized, but they are not considered as equivalent objectives (*9*). The P&G further emphasizes the importance of the NED account by instructing USACE to choose the NED-maximizing alternative unless "there are overriding reasons for recommending another plan, based on other Federal, State, local or international concerns" (*9*). Specifically, the P&G requires that the plan that reasonably maximizes net national economic benefits consistent with protecting the nation's environment be selected unless an exception is granted. Ultimately, therefore, USACE's project recommendation largely rests on whether or not the project's NED benefits outweigh its NED costs.

The NED account is the only mandatory account used to evaluate federal water projects.

In the USACE BCA framework, the base economic benefit of a navigation project is the reduction in the value of resources required to transport commodities. This could be accomplished in the following ways:

- Cost reduction benefits for commodities for the same origin and destination and the same mode of transit, thus increasing the efficiency of current users.
- Shift of mode benefits for commodities for the same origin and destination providing efficiency in waterway or harbor traversed.
- Shift in origin and destinations that would provide benefits by either reducing the cost of transport, if a new origin is used or by increasing net revenue of the producer, if a change in destination is realized. This benefit cannot exceed the reduction in transportation costs achieved by the project.
- New movement benefits when there are additional movements in a commodity or there are new commodities transported due to decreased transportation costs.
- Induced movement benefits, which are the value of a delivered commodity less production and transportation costs when a commodity or additional quantities of a commodity, are produced and consumed due to lower transportation costs.

While other alternatives may also be identified, the NED alternative is the only alternative required by the P&G. The NED alternative may ultimately not be the alternative selected because a community or local sponsor may select a different plan. If a community implements a plan that goes beyond NED, however, that community is responsible for some or all of the additional costs.

Prior reviews of USACE methodology indicate the need for (*10*):

- A set of analytical methods that are not restricted to transportation activities, but which capture the whole of the supply chain benefits and costs that are attributable to transportation infrastructure improvements.
- The reconciliation of long-standing differences in the determination of planning horizons, discount rates, and other financial parameters.

The remainder of this chapter examines how three agencies handle these issues in comparison to the USACE's practices. The agencies are:

- BLM (DOI).[5]
- EPA.
- DOT, TIGER Grant Program.

The specific issues that are explored include:

- Externalities included in the BCA.
- Treatment of externalities that cannot be monetized.
- Use of discount rates.
- Use of confidence levels or risk analysis.
- The effect of the timing of funding.
- Peer review.

For each issue, the remainder of this chapter explains the current USACE practice and then discusses how the other agencies approach the topic.

Externalities That May Be Included

Introduction

Many economic activities provide incidental benefits that represent net increases in national economic efficiency to parties other than those for whom the project was intended. Activities or actions by one party that are not reflected in market prices and that affect the well-being of another party are termed *externalities.* A negative externality is an activity that imposes

[5] DOI is careful to emphasize that the Principles and Requirements, Interagency Guidelines, and Agency-Specific Procedures are statements of policy, not regulations, and are intended to articulate expectations for the internal management of the government.

uncompensated costs on other people (*11*). A positive externality is just the opposite—it is a positive effect an activity imposes on an unrelated third party.

USACE Guidance

Engineering Circular (EC) 1105-2-409 states "…(E)valuation of inland navigation improvements should not only address effects on transportation savings but also security, safety, and environmental advantages or disadvantages with respect to other models of transport...Any alternative plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four Principles and Guidelines evaluation accounts" (*6*). However, the guidance states, "the base economic benefit of a navigation project is the reduction in the value of resources required to transport commodities." The lowered cost of transport is assumed to be the dominant source of social willingness to pay for improved navigation services.

One of the most repeated criticisms of current USACE methodologies is that they incorrectly bias benefit estimates downward through their asymmetric treatment of external costs and benefits (*10*). Non-NED benefits are the primary reason for the political support that ports and waterways receive at the state and local level and may more realistically portray the real benefits that ports and waterways provide (*12*).

Since 1983, the P&G have allowed the consideration of externalities within the project evaluation process. However, their values are seldom included directly as NED benefits and therefore do not typically enter into benefit-cost calculations. Other benefits are only considered when selecting between projects if the NED BCR is greater than 1.0.

Other benefits are only considered when selecting between projects if the NED BCR is greater than 1.0.

The PGN focuses heavily on direct benefits as the justification for a project. The primary direct benefits are listed in the introduction to the guidance. The category of other direct benefits is also discussed in the guidance. Other direct benefits are the incidental direct benefits of a project. The other direct benefits to be included in the NED benefit evaluation are the incidental effects of a project that increase economic efficiency by increasing the output of intermediate or final consumer goods over and above the direct outputs for which the plan is being formulated. For example, a project planned only for flood damage reduction and hydropower purposes might reduce downstream water treatment costs; this reduction in costs would be shown as another direct benefit in the NED account (*13*). The P&G encourages planners to estimate and consider such benefits in planning studies when technically possible and practical.

There are a number of externalities that are commonly used in BCA for non-USACE infrastructure projects that are not included in the USACE guidance. For example, the PGN does not allow the inclusion of reduced highway fatalities in calculating navigation benefits. Further, with the manufacturing and assembly efficiencies that industries have gained over the years, shipping and logistics have significant impact on just-in-time operations. These highly significant impacts are mostly ignored in USACE analyses. There are several other categories of benefits that the approach disregards, including the impacts on highway transportation, environmental impacts of modal shifts in freight movements, and potential community-level benefits related to recreation and water supply.

Commonly Used USACE Acronyms

P&G: Principles and Guidelines – The general concepts to be incorporated into project analyses by USACE and certain other agencies.

PGN: Planning Guidance Notebook (Engineering Regulation 1105-2-100) – The detailed instructions and requirements for USACE analyses. This document provides the necessary details for implementing P&G requirements.

NED: National Economic Development Benefits: The benefits upon which an alternative may be justified. They primarily consist of transportation cost savings.

BCR: The ratio of net benefits divided by net costs. It must be greater than 1 for an alternative to be considered.

The EQ account ostensibly allows for the inclusion of non-NED benefits in the analysis. 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" (*13*). The specific environmental effects and the methods for quantifying or assessing them are not described and can vary widely between projects.

The P&G relegated environmental considerations to a constraint. This policy means that USACE, where it believed it was feasible, had to identify, measure, and monetize the environmental effects of its projects if they were to be included within the NED account. However, given the reduced importance of the environmental account vis-à-vis the NED account, USACE has been under little pressure from the administration to develop techniques for monetization of environmental goods and services, and therefore has not done so.

There are important positive externalities associated with water transportation. It is generally segregated from other activity so that most populations experience very few effects that are directly related to water transportation in comparison to highway or rail transportation (collisions, other accidents or congestion, view-shed incursions, noise, pollution, etc.). Moreover, water transportation often involves the consumption of less fuel per ton-mile, so

fuel consumption and related pollutant emissions are generally less than for other freight modes (*10*).

Table 1 illustrates the types of benefits, both NED and non-NED, that typically flow from waterway projects.

Table 1. Benefit Categories of Inland Waterway Investments.

Benefit Category	Benefit	USACE Guidance	Remarks
Waterways User Benefits	Shipper cost savings	Included	Should be classified by commodity groups
	Time savings	Included	Should be applied based on shippers
	Accident reduction	Included	Baseline should capture potential increase from current levels
	Growth in usage	Included	Should be tied to national forecasts of freight flow
	Induced demand	Included	Currently included as a part of growth. Needs to be based on a modal diversion model.
Other Transportation and Public Benefits	Highway congestion reduction	Not included	Needs to be included based on modal diversion
	Highway safety improvement	Not Included	Based on highway traffic models
	Pavement maintenance savings	Not included	Based on highway traffic models
	Increased linkages	Included	To be done at a transportation network and mobility level
	Environmental impacts	Included	Include water quality, air quality impacts of changes (including trucks)
Cross-Sector Benefits	Benefits to Utility Sector	Not included	Based on local demands
	Benefits to Water Supply and Sanitation	Not included	Based on local demands
	Benefits to Tourism Sector	Not included	Based on local demands
	Benefits to Recreational Services Sector	Not included	Based on local demands
Wider Economic Impacts	Short-term and long-term job creation	Included	To be included as additional insight, not as a benefit because it is already included
	Community development impacts	Not included	Based on local potential

Source: (*14*)

USACE has taken a specific position on congestion benefits. It is summarized in a February 2006 memorandum (*10*):

> …..Road effects resulting from navigation projects, while measurable as NED effects, must be considered indirect project effects. These indirect NED effects cannot be used in project formulation, scaling, or NED plan selection, nor should they be used to justify a project on an NED basis.

The wording is somewhat confusing, but guidance issued for other indirect effects indicates that such effects can only be considered once an alternative is proven to have a BCR greater than 1 based on the NED account. In other words, these benefits cannot be used to justify an alternative; they can only be used in evaluating a set of qualified alternatives.

A recent study sponsored by the National Waterways Foundation lists the following externalities that are currently not considered in USACE BCAs:

- **Recreation impacts** – the total regional value-add from visitor expenditures at all USACE recreational facilities.
- **Flood damages avoided** – property flood damages prevented by the national system of dams, some of which contain navigation locks, and some of the others were authorized to support navigation.
- **Hydropower generation** – the value of the gross revenue generated at USACE and TVA hydroelectric dams.
- **Irrigation cost savings** – savings to farmers and irrigators due to the availability of sufficient pool water for irrigation.
- **Water supply value** – value of water taken from the Ohio River Basin as a water supply to residential, commercial, and industrial consumers.
- **Sewage assimilation cost savings** – savings in treatment costs due to the higher pool levels required for navigation.
- **Property values** – the premium attached to real estate on or near navigable water due to the presence of the waterway.
- **Congestion and safety impacts** – the social value of reductions in congestion and accidents due to using barge rather than an alternative transport mode; may include direct and indirect economic effects, including consequences to shipper savings as congestion increases.
- **Environmental impacts** – the social value of reductions in pollution; may include direct and indirect economic effects.
- **Mosquito control** – the operational savings from the lower cost biological method of control resulting from TVA dams controlling water levels; possibly, in addition, the benefit to society of more effective disease control (*15*).

The treatment of costs is discussed in detail in the USACE guidance. The P&G's treatment of costs is much more limited than the methodology used by the other agencies. One cost that is frequently overlooked is the increases in transportation costs during the time the project is

closed for rehabilitation or replacement. Figure 1 lists the costs that are typically included in the NED calculation.

Implementation Costs
Post-authorization planning and design costs
Construction costs, construction contingency costs
Administrative services costs
Fish and wildlife habitat mitigation costs
Relocation costs
Historical and archaeological salvage operations costs
Land, water, and mineral rights costs
Other Direct Costs
Implicit costs of displaced resources
Uncompensated NED losses
Negative externalities

Figure 1. Allowable NED Costs.

The category of other direct costs consists of the costs of resources directly required for a project or plan, but for which no dollars are expended. These non-market costs fall into three categories: implicit costs of displaced resources, uncompensated NED losses, and negative externalities (*9*).

Department of the Interior/BLM

U.S. Department of the Interior (DOI) uses a wide range of potential benefits as discussed in their *Agency Specific Procedures*. Two types of benefits—use and nonuse—are allowed in their studies. The category of use is further divided into direct and indirect categories. The direct use category refers to human physical interaction and involvement with resources such as timber extraction and logging. Indirect use refers to resources that are passively used to support humans or are an intermediary to what humans directly use. Examples are carbon sinks, flood control, pollination, and waste assimilation from wetlands. Nonuse values refer to what people are willing to pay to preserve or enhance a resource even though they may never use that particular resource. While there is much discussion of how to evaluate these uses and effects, there is no specific guidance on which uses and effects should be included in BLM studies.

The analysis of the Klamath River Dam Removal Project provides a good illustration of the range of benefits that are typically analyzed in DOI studies. The list includes:

- Irrigated agriculture.
- Commercial fishing.
- Hydropower.
- Ocean sport fishing.
- In-river sport fishing.
- Reservoir recreation.
- Refuge recreation.
- Whitewater recreation.
- Nonuse values.
- Real estate.

DOT TIGER Grant Program

The TIGER grant program enables project sponsors at the state and local levels to obtain funding for multimodal, multijurisdictional projects that are more difficult to support through traditional DOT programs. TIGER can fund port and freight rail projects, for example, which play a critical role in the nation's ability to move freight, but have limited sources of federal funds.

TIGER allows the inclusion of a number of externalities/benefits that are not mentioned on USACE guidance. For example, TIGER allows:

- Value of statistical life.
- Value of injuries.
- Property damages.
- Values of travel time for 11 categories.

The first three categories come under the umbrella of safety, while the last category reflects various aspects of the cost of transportation time. TIGER also includes technical methodologies for quantifying environmental externalities (social cost of carbon), nominal-real value conversions, and conversion of accident data to an abbreviated injury scale (AIS).[6]

A typical BCA in a TIGER grant application measures the following benefit categories:

- Monetary.
    - Travel time savings.
    - Vehicle operating cost reductions.
- Non-monetary.
    - Safety improvements.
    - Emission reductions, including greenhouse gases.

[6] In the latest round of TIGER grants, much of the guidance and values for determining the social cost of carbon was removed.

In recent grant cycles, the BCA has been expanded to include benefits due to a reduction in noise impacts (*16*).

Table 2 summarizes the externalities/benefits eligible for consideration.

Table 2. Externalities/Benefits Eligible in TIGER Grant Applications.

Long-Term Outcome	Types of Societal Benefit
Quality of Life	Land Use Changes that Reduce Vehicle Miles Traveled (VMT)
	Increase Accessibility
	Property Value Increases
Economic Competitiveness	Travel Time Savings
	Operating Cost Savings
Safety	Prevented Accidents (Property Damage), Injuries, and Fatalities
State of Good Repair	Deferral of Complete Replacement
	Maintenance and Repair Savings (Project reduces maintenance costs or extends life of asset)
	Reduced VMT from Not Closing Bridges
Environmental Sustainability	Environmental Benefits from Reduced Emissions

The guidance instructs applicants to consider external costs, such as noise, increased congestion, and environmental pollutants resulting from the use of the facility or related changes in net usage on other facilities in the same network in the analysis (*17*).

EPA

EPA's guidance incorporates the requirement of Circular a-4, which was promulgated by the Office of Management and Budget (OMB) and applies to agencies initiating regulatory actions. The circular states that the analysis should look beyond the direct benefits and direct costs of the rulemaking and consider any important ancillary benefits and countervailing risks. An ancillary benefit is a favorable impact of the rule that is typically unrelated or secondary to the statutory purpose of the rulemaking (e.g., reduced refinery emissions due to more stringent fuel economy standards for light trucks) while a countervailing risk is an adverse economic, health, safety, or environmental consequence that occurs due to a rule and is not already accounted for in the direct cost of the rule (e.g., adverse safety impacts from more stringent fuel-economy standards for light trucks) (*18*).

In the agency guidance, EPA analysts are encouraged to frame their analysis by asking:

- Which benefit categories are likely to differ across policy options, including the baseline option?
- Which benefit categories are likely to account for the bulk of the total benefits of the policy?

- Which benefit categories are especially salient to particular stakeholders? Monetized benefits in this category are not necessarily large and so may not be captured by the first two criteria (*19*).

EPA BCAs include impacts on production, employment, profitability, plant closures, and industry competitiveness. The guidance discusses implicit costs (the costs of resources directly required for a project or plan, but for which no dollars are expended) in detail. Implicit costs may include the value of current output lost because inputs are shifted to pollution control activities from other uses, as well as lost future output due to shifts in the composition of capital investment.

EPA has developed methods to calculate mortalities and deaths from pollutions and monetize the health effects via open source procedures (Environmental Benefit Analysis and Mapping System-Community Edition [BenMAP-CE]). Circular a-4 points out that it is true that lives saved today cannot be invested in a bank to save more lives in the future, but the resources that would have been used to save those lives can be invested to earn a higher payoff in future lives saved. Additionally, studies indicate that people prefer health gains that occur immediately to identical health gains that occur in the future (*18*).

EPA includes a wide range of implicit costs and negative externalities in its BCAs. For example, EPA has calculated the external costs of passenger transportation using the following components (*20*):

- Air pollution.
- Oil use.
- Water pollution.
- Noise.
- Congestion.
- Accidents.
- Highway service costs.
- Unpriced parking.
- Inefficient highway user taxes and fees.

Summary

Table 3 summarizes the differences in the positive externalities USACE and the other three agencies typically include in BCAs.

Table 3. Summary Comparison of Benefit Categories Other than Transportation Cost Savings Allowed or Used in Projects Benefit Estimation.

Category	USACE Inland Navigation	US DOT TIGER	EPA	DOI/BLM
Value of a statistical life	No	Yes	Yes	No
Morbidity risk	No	No	Yes	No
Mortality risk	No	No	Yes	No
Value of injuries	No	Yes	No	No
Property effects	No	Yes	Yes	Yes
Value of time	For shippers	Yes	No	No
Maintenance	No	Yes	No	No
Emissions	No	Yes	Yes	No
Noise		Yes		
Social cost of carbon	No	Yes	Yes	No
Species population	No	No	Yes	Yes
Food production	No	No	Yes	No
Recreation	No	No	Yes	Yes
Ecosystem	No	No	Yes	Pilot testing
Aesthetics improvements	No	No	Yes	Yes
Archaeological	No	No	No	Yes
Water Quality	No	No	Yes	Yes
Hydropower	No	No	No	Yes

Takeaways

1. USACE guidance is very narrowly focused on transportation cost savings.
2. There are a number of externalities that are commonly used in BCA for non-USACE infrastructure projects that are not included in the USACE guidance.
3. As illustrated in Table 1, there are a number of positive externalities resulting from navigation projects that could be evaluated.
4. The TIGER grant program has established a methodology for evaluating many of the positive externalities.
5. EPA analysts are encouraged to ask, “Which benefit categories are especially salient to particular stakeholders?” This question is not raised in USACE BCAs.

How Externalities That Cannot Be Monetized Are Addressed

Introduction

Some externalities may not be readily monetizable, but they still have an economic value (*21*). Others must be evaluated in non-economic terms.

USACE Guidance

USACE analysts are not required to include the EQ and OSE accounts in their analysis. When included, the PGN detailed guidance stipulates that for both the EQ and OSE accounts, effects are to be measured and recorded in non-monetary terms.

The PGN directs that when there is no monetary measure of benefits but project outcomes can be described and quantified in some dimension, cost effectiveness analysis can be used to assist in the decision-making process. Cost effectiveness analysis seeks to answer the question: Given an adequately described objective, what is the least-costly way of attaining the objective? The ability to identify the least costly alternative among several having the same outcome is very useful. However, cost effectiveness analysis cannot establish that any project is worthwhile. In practice, cost effectiveness is typically applied to environmental restoration projects rather than navigation projects, as described below.

In addition to the four accounts discussed earlier (EQ, OSE, NED, and RED), the PGN established a concept of a national ecosystem restoration (NER) mission, through which outputs from ecosystem restoration projects contribute to the federal objective of USACE civil works. The objective of the NER mission is to increase the quantity and quality of desired ecosystem resources, as measured in biophysical rather than monetary terms. Analysts are directed to focus on cost-effectiveness and incremental cost analyses (rather than BCA) that relate non-monetary NER outputs against NED costs.

The importance of NER in the federal objective is on par with NED and the PGN *implied,* through its statement about joint formulation of NER and NED in multipurpose projects, that the Federal objective of Civil Works planning is maximization of national welfare through optimum combination of NER and NED (*22*).

In the last several decades, economists have increasingly conceptualized and applied the economic valuation paradigm to changes in environmental services and human health and safety risks. In fact, environmental and human health risk valuation represents an extensive research program within economics, and its participants often argue that the techniques they have developed provide a preferred way to measure people's willingness to pay for environmental services and reductions in health risks for public policy analysis. Given this, and the longstanding tradition of BCA in civil works planning, some commentators argue that USACE should move toward representing more fully the range of expected project effects in monetary terms. These commentators often point to efforts by other federal agencies to monetize public policy effects on environmental services and human health and safety risks (*6*).[7]

[7] For example, the U.S. EPA has increasingly tried in its regulatory impact analyses to provide monetary estimates for regulatory effects on human morbidity and mortality risks and, to a much lesser extent, for environmental services.

EPA

The guidance in Circular a-4 states that it will not always be possible to express in monetary units all of the important benefits and costs of a proposed action. When it is not, the most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate. If the non-quantified benefits and costs are likely to be important, the analyst should conduct a threshold or break-even analysis to evaluate their significance. Threshold or break-even analysis answers the question: How small could the value of the non-quantified benefits be (or how large would the value of the non-quantified costs need to be) before the rule would yield zero net benefits? In addition to threshold analysis the analyst should indicate, where possible, which non-quantified effects are most important and why (*18*).

The challenge of valuing non-market goods that do not have prices is to relate them to one or more market goods that do (*19*). If monetization is not feasible, quantification should be attempted through use of informative physical units. If both monetization and quantification are not feasible, then these issues should be presented as non-quantified benefits and costs (*18*).

DOI/BLM

Ecosystem goods and services include a range of human benefits resulting from appropriate ecosystem structure and function, such as flood control from intact wetlands and carbon sequestration from healthy forests. Some involve commodities sold in markets, for example, timber production. Others, such as wetlands protection and carbon sequestration, do not commonly involve markets, and thus reflect nonmarket values (*23*).

BLM guidance suggests that nonmarket values can be described in several ways, which vary in specificity, validity, and level of effort. From least to most effort, these methods include:

- Describing the values qualitatively.
- Citing quantitative estimates of this type of benefit from other sites (*benefit transfer*).
- Conducting a new study for the site and activity in question (*23*).

> The BLM's King Range National Conservation Area's Resource Management Plan has a short discussion of nonmarket values of recreation to supplement market information in the socioeconomic portion of the Affected Environment chapter (*23*).

A wide range of nonmarket environmental values can be associated with a site or landscape, involving both direct uses (such as the value of a mountain bike trip) and passive uses (such as the value attributed to the existence of the Grand Canyon). Ignoring passive uses can result in substantially underestimating total economic value. However, using stated preference methods to develop technically defensible estimates of passive use values can be more challenging than estimating direct use values (*23*).

Qualitative discussions serve the important purpose of defining the effects of management actions on human well-being using economic terms, and can help in the development of a relative ranking of plan alternatives based on societal preferences. Although qualitative discussions do not allow for comparisons of monetized economic value estimates, they provide an effective means to communicate the range of economic values associated with BLM-managed lands (*21*).

DOT TIGER Grant Program

TIGER guidelines indicate that if an applicant cannot monetize certain benefits or costs, it should quantify them using the physical units in which they naturally occur where possible. When an applicant is unable to either quantify or monetize the benefits, the sponsor should describe the benefits qualitatively (*24*).

Takeaways

1. Circular a-4 recognizes that the most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate.
2. BLM recognizes that although qualitative discussions do not allow for comparisons of monetized economic value estimates, they provide an effective means to communicate the range of economic values associated with a proposed project or action.
3. TIGER guidance encourages the analyst to included benefits that are not monetizable and even those that are not quantifiable. However, it does not discuss how these benefits influence final project selection.
4. USACE includes qualitative discussions to assist with the analysis, but they are not the principle decision factors.

The Use of Discount Rates

Introduction

One of the decisions that critically influence the outcome of a BCR is the choice of a discount rate to transform future benefits and costs into present values (PVs). Projects evaluated with a lower discount rate are more likely to pass the BCR test than projects evaluated using a higher rate (explained below) (*9*).

Discount rates are used to determine how much a series of future cash flows is worth as a single lump sum value today. Cash flow tomorrow is not worth as much as it is today. As prices rise over time, a dollar will not buy as much in the future compared to what it can buy today. Second, there is uncertainty in any projection of the future. Cash today has no such uncertainty. Because cash flow in the future carries a risk that cash today does not, the analyst must discount future cash flow to compensate for the risk taken in waiting to receive it. A higher discount rate implies greater uncertainty/risk and lowers the PV of future cash flows.

The main rationales for the discounting of future impacts in BCA are:

- Resources that are invested will normally earn a positive return, so current consumption is more expensive than future consumption. The investor is giving up that expected return on investment when he/she consumes today.
- Postponed benefits also have a cost because society generally prefers present to future consumption.
- Additionally, if consumption continues to increase over time, as it has for most of U.S. history, an increment of consumption will be less valuable in the future than it would be today, because the principle of diminishing marginal utility implies that as total consumption increases, the value of a marginal unit of consumption tends to decline (*18*).

USACE Guidance

The PGN directs the analyst to compute all costs at a constant price level and at the same price level as used for the computation of benefits. In other words, all costs and benefits should be stated in terms of the value of a dollar at a specific point in time. Current costs should be inflation-adjusted (real) costs based on the price level at the time of the analysis. Project cost estimates will also be developed on an inflated dollar basis and discounted to the price level at the time of the analysis (*13*). These inflated-dollar estimates will provide an idea of the dollar amount that will need to be appropriated at a given point in the life of the project.

USACE (and other agencies to which the P&G apply) rely on the discount rate established under the Water Resources Act of 1974 (WRDA 1974) that establishes a rate based on "the average rate of interest payable by the Treasury on interest-bearing marketable securities of the United States..." (*10*).

The discount rate used under the P&G is a nominal rate. The nominal rate is tied to nominal values, where economic units are measured in terms of purchasing power as of the date in question. Stated another way, a nominal value reflects the effects of general price inflation. Costs and benefits can also be stated in real (or constant) dollar values, where economic units are measured in terms of constant purchasing power. A real value is not affected by general price inflation. Real values can be estimated by deflating nominal values with a general price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index (*18*).

The actual discount rate used for civil works studies is calculated annually by the U.S. Treasury using a prescribed formula, and is published each year by USACE Headquarters as an Economic Guidance Memorandum (EGM). The EGM for Fiscal Year 2017 states that the discount rate used in evaluating water resource projects is set annually by Congress (Section 80 of PL 93-251), based on the cost of government borrowing. The U.S. Department of the Treasury computes it as the average market yields on interest-bearing marketable securities of the United States that have 15 or more years remaining to maturity. The computed rate is effective as of 1 October of

each year. It is based on yield data for the entire previous fiscal year, and thus the discount rate for a fiscal year is based on average yields during the previous fiscal year. According to law, the rate may not be raised or lowered more than one quarter of one percentage point in any year.

The current PGN guidance has often been criticized because it double adjusts the values reported in feasibility studies. The average Treasury rates that are its foundation include both a real return to security holders *and* an expected rate of inflation. Under PGN guidance, this discount rate is then applied to real values that have already been adjusted to reflect the impacts of expected inflation. All else being equal, this necessarily results in a systematic understatement of the PV of future benefits or costs. Since most costs occur early in project cycles and benefits occur much later, the calculation of BCRs are systematically biased downward (*10*).

In the planning and authorization phases, the nominal discount rate in the EGM is used to convert flows of benefits into a PV number, but the original dollar value statistics are converted into real data as mandated by the 1983 guidelines. In a Congressional Research Service study, it is concluded that "(g)iven the temporal distribution for many USACE projects (i.e., near-term costs and long-term benefits), this practice reduces the number of long-term projects that pass the benefit-cost ratio test" (*9*). Interestingly, for budgeting purposes, USACE uses the 7 percent discount rate that is mandated for other federal agencies by OMB Circular A-94.

To illustrate the problem with mixing real values and nominal rates, consider the example (B) illustrated in Figure 2 (Note: SR= Short Run and LR=Long Run).

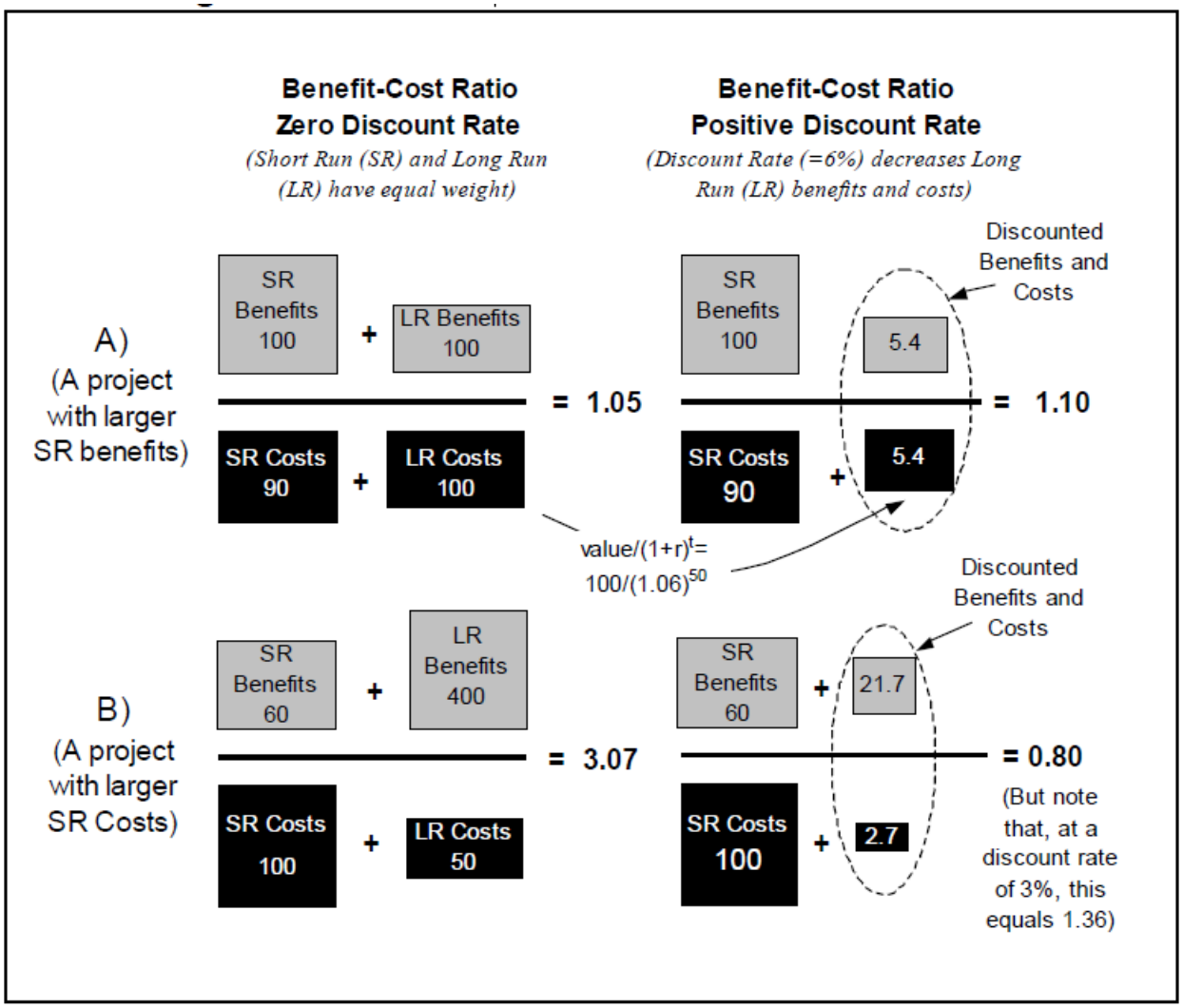


Figure 2. BCRs and the Discount Rate (9).

In this example, long run benefits are shown in real dollars (benefits = $400) and are discounted using a real discount rate of 6 percent over a period of 50 years. At a real discount rate of 6 percent, discounted long-run benefits equals ($400/(1+.06)50) or $21.72. When a nominal discount rate is used to discount nominal dollars, the result is similar. Using the same cost and benefit values in Figure 2 and an expected inflation rate of 2 percent, the nominal discount rate would be 8 percent (i.e., real discount rate + expected rate of inflation). The nominal value of $400 in 50 years would be ($400*(1+.08)50) or $1,076.64. As shown in Figure 2, discounting the nominal value of $1,076.64 with a nominal discount rate (8 percent) results in a value similar to the result found when discounting real dollars with a real discount rate. However, mixing real and nominal figures overstates or understates the discounted PV. When USACE discounts 400 real dollars using a nominal discount rate of 8 percent, it understates the project's discounted PV ($9 instead of $23) by removing inflation from the dollar value and not from the discount rate. Given the temporal distribution of benefits and costs for many USACE projects (i.e., near-

term costs and long-term benefits), this practice reduces the number of long-term projects that pass the BCR test (*9*).

Unlike most federal agencies, USACE and the three other water resource agencies are required to follow the P&G and conduct water project evaluations using a discount rate dictated by specific planning guidelines rather than the base rate set by OMB. The USACE methodology runs contrary to accepted economics and the broader guidance provided by the OMB. Any period of sustained expected inflation is likely to bias analytical results inappropriately to the detriment of water-related infrastructure investments.

Circular a-94 (OMB)[8]

The pre-tax return on investment is the rate of return on private-sector investments, adjusted for inflation. Most federal BCAs use a discount rate based on this approach as established by OMB. OMB believes that this rate is appropriate for evaluating public investments because it accounts for the displacement of private investment. This method is based on the idea that investing in private markets is the best alternative use of capital to using the capital to fund federal projects. Using this rate of return allows policymakers to compare the project's rate of return to what return might have come from investing the same capital in private markets (*9*).

However, some economists argue that the private sector rate of return may reflect individual rather than societal premium for risk. This argument is based on the perspective that people may be more willing to accept risks as a group than as individuals. Therefore, a rate based purely on the pre-tax return on investment may overestimate the discount rate, thereby making it more difficult to obtain a BCR of greater than one, particularly for long-lived projects (*9*).

EPA

Circular a-4 states that when regulation primarily and directly affects private consumption (e.g., through higher consumer prices for goods and services), a lower discount rate is appropriate. If we take the rate that the average saver uses to discount future consumption as our measure of the social rate of time preference, then the real rate of return on long-term government debt may provide a fair approximation (*18*).

According to Circular a-94, when a general inflation assumption is needed, the rate of increase in the Gross Domestic Product deflator from the Administration's economic assumptions for the period of the analysis is recommended. For projects or programs that extend beyond the six-year budget horizon, the inflation assumption can be extended by using the inflation rate for the sixth year of the budget forecast (*18*).

[8] Circular a-94 specifically exempts decisions concerning water resource projects (guidance for which is the approved Economic and Environmental P&G for Water and Related Land Resources Implementation Studies)

Agencies, such as the EPA, which conduct BCAs of proposed regulations, are required to use the base rate set by OMB Circular A-94. (Water projects are exempt from Circular A-94, so they do not use the OMB's base discount rate) (*9*).

As a default position, OMB Circular A-94 states that a real discount rate of 7 percent should be used as a base-case for regulatory analysis. The 7 percent rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy. It approximates the opportunity cost of capital,[9] and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector. Circular A-94 also recommends using other discount rates to show the sensitivity of the estimates to the discount rate assumption (*18*).

EPA guidance cautions against using adjustments to the discount rate to incorporate riskiness into the calculation of costs and benefits. According to the guidance, incorporating the risk of future benefits and costs into the social discount rate not only imposes specific and generally unwarranted assumptions, but it can also hide important information from decision makers (*19*).

TIGER Grant Program

Applicants should discount future benefits and costs to PVs using a real discount rate of 7 percent, following guidance provided by OMB in Circular A–94. Applicants may also provide an alternative analysis using a real discount rate of 3 percent as a sensitivity analysis. They should use the latter approach when the alternative use of funds to be dedicated to the project would be for other public expenditures, rather than private investment. (A review of historical rates indicates that the last time the real rate approached 7 percent was in 2000, when it stood at 6.8 percent.) Applicants should not add in the effects of inflation to the estimates of future benefits and costs prior to discounting. As noted earlier, using an interest rate (such as 7 percent) that is higher than the real discount rate tends to bias project economic results downward (*17*).

DOI/BLM

DOI guidance calls for adherence to the federal requirements stated in Circular A-94. However, there are a number of other approaches (e.g., Ramsey, hyperbolic, Gamma) that could be considered in the context of sensitivity testing, if appropriate. Intergenerational effects, such as methods that employ a declining discount rate, may be used in cases of long-lived federal investments or investments that have substantial costs and/or benefits near the end of the period of analysis. Use of these alternative approaches should be discussed with the Department's Office of Policy Analysis.

[9] The opportunity cost of capital is the incremental return on investment that a business foregoes when it elects to use funds for an internal project, rather than investing cash in a marketable security.

Takeaways

1. The USACE practice of mixing real and nominal discount rates tends to understate the discounted PVs. The same concern exists for TIGER guidance. This negatively affects BCRs since benefits tend to occur further into the future than costs.
2. This practice reduces the number of long-term projects that pass the BCR test.
3. The discount rate that each agency must use is mandated by Congress.
4. The rate for the other agencies has been significantly higher than the rate used by USACE for a number of years, which tends to produce more conservative estimates of benefits for those agencies.

The Use of Confidence Levels or Risks in BCA

Introduction

A useful definition of risk for planning purposes is the likelihood of a specific magnitude of a harmful outcome occurring in the future. Uncertainty is used to express doubt or lack of knowledge about a positive (beneficial) or negative (harmful) outcome. Uncertainty comes from the statistical variability of key parameters and an incomplete understanding of important relationships.

One of the caveats listed in numerous literature sources is that it is not appropriate to incorporate an uncertainty premium into the discount rate. Risk and uncertainty need to be dealt with explicitly and transparently. Modeling assumptions and reporting of numerical values should convey information about the accuracy of the estimates (*25*).

USACE Guidance

In typical BCA work, adjustments to risk and uncertainty in project evaluation can be characterized as general or specific. General adjustments include the addition of a premium rate to the interest, overestimation of costs, underestimation of benefits, and limitations on the period of analysis. Such general adjustments are usually inappropriate for public investment decisions because they tend to obscure the different degrees of uncertainty in different aspects of projects and programs. Specific adjustments, including explicit assessments of different degrees of risk and uncertainty in particular aspects of a project or program and specific adjustments to them are preferable (*13*).

USACE regulation ER 1110-2-1302 (*26*) requires projects where the total project cost including inflation is $40 million or greater, or complex smaller projects having numerous work elements with differing unknown conditions and uncertainties, to perform a detailed risk analysis in accordance with current USACE requirements. This detailed method includes risk identification, quantitative and qualitative study, and sensitivity analysis using a Monte Carlo simulation method. The risk analysis identifies and documents the conditions, uncertainties, and the evaluation

> USACE risk analysis focuses almost exclusively on costs and traffic forecasts.

methodology used to determine the assignment of contingency cost factors (*26*). (Note: In practice, USACE risk analysis focuses almost exclusively on costs and traffic forecasts.)

ER 1110-2-1302 was brought about by inefficient funding wherein project construction can be strung over very long time periods. This results in the risk of losing funding and for the possibility of inflation impacts and other factors. Project costs can rise significantly in response to the risk factor. However, no such adjustments are made to project benefits. The consistent treatment of costs and benefits could result in marked differences in benefit-cost calculations.

In USACE BCA, benefits are computed in accordance with the P&G and developed for the most likely scenario without a confidence level applied. This is in contrast to the USACE treatment of costs where funding risks and conservative contingency values are included in the development of the total project cost estimates, thus increasing the estimated amount.

The P&G addresses uncertainty and recommends its mitigation through general recommendations for sensitivity analysis. It calculates project benefits on the basis of the most probable scenario for both with- and without-project conditions.[10] For inland navigation, it states that despite the assumption that supply and demand schedules are considered to be independent, in fact, they are not. A primary example is a situation where there is high variance in delay at high levels of lock utilization, and the shippers' response to uncertain delay may be different from their response to an expected shipping cost (delay). The P&G recommends acknowledging this source of uncertainty in benefit estimates and offers three mitigation techniques:

1. Establishing consistent sources of data.
2. Expanding the data gathering.
3. Performing a sensitivity analysis by estimating a range of benefits based on current (non-projected or no growth) input values for tonnage, rates, fleet, interest rate, and user charges.

It is also suggests that planners produce high and low projections as well as with- and without-project estimates of impacts for project costs and benefits. Finally, it is stated that "risk and uncertainty attached to the hypothesized outcomes can be reduced by clearly revealing areas of uncertainty" (*12*).

The 2009 guidelines state that qualitative discussions of the benefits could[11] 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 are 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.

[10] USACE tends to use the terms "with-project" and "without-project" where the typical BCA terminology is "build" and "no-build."

[11] Note the use of the word "could." This is not required.

Breakeven analysis could be used in cases where risk or valuation data are 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 EQ 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 EQ and ecosystem services.

The PGN directs the analyst to recognize and quantify the variability of project outcomes, including trade-offs between risk and cost. The PGN goes on to stipulate that most risk and uncertainty aspects of projects cannot be characterized by probability distributions based on well-established empirical data. The NED account treats uncertainty in two ways. First, general guidelines are outlined in the supplemental to Chapter 1, which states that NED project benefits must be calculated on the basis of the most probable with-project and without-project conditions. The guidelines note that the first step in dealing with this problem is to describe why the project or specific aspects of it are uncertain, as well as the time periods in which different degrees of uncertainty are likely. A range of reasonably likely outcomes can then be described by using sensitivity analysis—the technique of varying assumptions as to alternative economic, demographic, environmental, and other factors, and examining the effects of these varying assumptions on outcomes of benefits and costs. In some cases and in some stages of planning, this approach, when accompanied by a careful description of the dimensions of uncertainty, will be sufficient. It can be accompanied by descriptions of design adjustments representing various attitudes toward uncertainty (*13*).

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 (*7*).

The following variables should be explicitly incorporated in USACE risk-based analysis: 1) commodity forecasts, 2) alternative mode costs, 3) reliability of existing and proposed structures, and, 4) system delays associated with capacity constraints. Additional variables can be incorporated if appropriate for individual study areas. Districts are expected to incorporate risk-based analysis procedures in all inland navigation studies. Until risk-based procedures are fully developed, districts are expected to, at a minimum, perform sensitivity analysis of key variables.

The 2009 guidance recommends using 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 (*7*).

Much of the USACE guidance has focused on the cost side of BCA. As an illustration, in 2009, General Riley issued the following directive (*27*):

> In accordance with the Corps Actions for Change (ref.la), to more accurately identify and mitigate cost and schedule risk to our customers and Congress, this memorandum directs the use of specific cost risk analysis methods for the development of contingency on Civil Works Total Project Cost. This is applicable for all decision documents requiring Congressional authorization for projects exceeding $40 million.

ER 1110-2-1302 provides further direction. In risk analysis studies using the Monte Carlo process for the larger, more complex projects, the contingencies should be presented with confidence levels and associated contingencies (10 percent confidence increments as a minimum). For cost product development, the contingencies reflecting an 80 percent confidence level will be reported. Management does have flexibility to use a different confidence level (higher or lower) with detailed justification documenting the rationale for variance from the 80 percent confidence level. Items to consider in choosing the confidence level could be life safety, project complexity, national priority, and/or likelihood of mitigating risks. In any case, the chosen value should be justified within the risk analysis and main reports (*26*).

Project benefits do not receive the same treatment. As noted earlier, project benefits are calculated and presented on the basis of the most probable with-project and without-project conditions. This presents a point estimate that does not explicitly address uncertainty and does not examine the sensitivity of the results to the underlying assumptions.

One of the most recent inland waterway studies conducted by USACE provides insight into current thinking and practices. The 2012 Olmsted Economics Update includes several important risk and uncertainty related revisions:

- New without- and with-project cyclical maintenance assumptions.
- Updated benefit estimates to a 1 Oct 2011 price level (for comparison against the newer construction cost estimates).
- Three FY 2012 federal discount rates used for discounting and amortization.
- Risk and uncertainty analyses based on construction cost contingencies using current federal discount rates.
- Traffic demand forecasts based on five forecast scenarios developed based on industry expectations and current and future federal policies.

- Traffic congestion effects generated through a vessel level simulation that accounts for vessel arrival and processing time variability.
- Reliability of the existing and proposed structures in terms of sensitivity analysis of the with- and without-project maintenance costs and service disruptions.

EPA

In a 2010 evaluation of its treatment of risk and uncertainty, EPA was criticized for its handling of the issues (*25*):

> EPA's recent Regulatory Impact Analyses (RIA) present the results of its uncertainty analyses in piecemeal fashion rather than providing an overall, comprehensive statement of the uncertainty in its estimates.

One of the major issues in the review was that EPA's analyses tended to focus on just one variable or source of uncertainty at a time, when actually several sources of uncertainty were in play simultaneously. "…[N]o estimate can be considered best if only one of the large number of uncertainties is included in the analysis producing that estimate" (*28*). The guidance does not deal explicitly with potential interdependencies.

In EPA guidance, break-even analysis is one alternative that can be used when either risk data or valuation data are lacking. Analysts who have per unit estimates of economic value but lack risk estimates cannot quantify net benefits. They can, however, estimate the number of cases (each valued at the per unit value estimate) at which overall net benefits become positive, or where the policy action will break even. This estimate then can be assessed for plausibility either quantitatively or qualitatively. Policy makers will need to determine if the break-even value is acceptable or reasonable (*19*).

> Estimates cannot be more precise than their most uncertain component…The analysis should report estimates in a way that reflects the degree of uncertainty and not create a false sense of precision.

Circular a-4 indicates that in some cases, the level of scientific uncertainty may be so large that the analyst can only present discrete alternative scenarios without assessing the relative likelihood of each scenario quantitatively. Estimates cannot be more precise than their most uncertain component. Thus, the analysis should report estimates in a way that reflects the degree of uncertainty and not create a false sense of precision (*18*).

Whenever possible, the analyst should use appropriate statistical techniques to determine a probability distribution of the relevant outcomes. Analysts are instructed to use a numerical sensitivity analysis to examine how the results of the analysis vary with plausible changes in assumptions, choices of input data, and alternative analytical approaches. They are instructed

to apply a formal probabilistic analysis of the relevant uncertainties, possibly using simulation models and/or expert judgment as revealed, for example, through Delphi methods (*18*).[12]

Uncertainty is present in the assessment of all of the factors EPA considers when making regulatory decisions, including technology availability and economic factors. Those uncertainties, however, are rarely analyzed or explicitly accounted for in EPA's regulatory decisions. Similarly, factors such as public sentiment, environmental justice, and the political climate influence EPA's decisions, but the uncertainty in those factors is rarely accounted for in EPA's decisions. EPA also does not discuss the uncertainty in any of those factors in its decision documents as thoroughly as it does the uncertainty in human health risk estimates (*29*).

DOI/BLM

DOI directs analysts to include a description of the nature, likelihood, and magnitude of risks (including quantitatively where feasible), as well as the uncertainties associated with key supporting data, projections, and evaluations of competing alternatives. Climate change, future land use, and adaptive management can all be considered in the context of analyzing risk and uncertainty (*30*).

Additional direction is provided for climate change. Conditions resulting from a changing climate should be identified and accounted for in the planning process; uncertainties associated with climate change should be identified, described, and quantified where possible. This includes addressing the extent to which varying degrees of uncertainty are associated with climate change impacts on water resources. Analysis of climate change impacts should be informed by both historical records and models of projected future impacts of an altered climate on water resources (*30*).

TIGER Grant Program

The TIGER documentation does not provide explicit guidance on the use of confidence levels or the analysis of risk.

Circular a-94

Useful information would include the key sources of uncertainty; expected value estimates of outcomes; the sensitivity of results to important sources of uncertainty; and where possible, the probability distributions of benefits, costs, and net benefits.

Major assumptions should be varied and net PV and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions.

[12] The Delphi technique is aimed at generating consensus. It solicits opinions from groups in an iterative process of answering questions. After each round, the responses are summarized and redistributed for discussion in the next round. A consensus is reached through a process of convergence involving the identification of common trends and inspection of outliers.

As in agency-specific guidance, Circular a-94 stipulates that in general, variations in the discount rate are not the appropriate method of adjusting net PV for the special risks of particular projects (*31*).

Non-agency Specific Observation

The final report for National Cooperative Freight Research Program Project 22 emphasized that it is important to identify factors that are subject to fluctuate and show projected conclusions as a range, not a single result (*10*).

Takeaways

1. There is a wide range of discretion analysts may use to deal with risk and uncertainty.
2. Agencies tend to focus on specific aspects of BCA that tend to have better underlying data or a longer history in project work.
3. USACE adjusts costs to reflect the risk of uncertain funding, but does not do so for benefits.
4. EPA has been criticized for focusing on just one variable or source of uncertainty at a time when several sources were at play.
5. It is important to highlight where the greatest source of uncertainty lies, since estimates cannot be more precise then their most uncertain component.
6. DOI guidance explicitly deals with climate change issues; the others do not.
7. Estimates should be displayed as ranges rather than as most likely point estimates.
8. IEPA's use of break-even analysis would be easily adaptable and useful in USACE studies when evaluating externalities that are difficult to monetize or forecast.

The Effect of the Timing of Funding

USACE Guidance

In USACE BCAs, an optimal funding stream is assumed such that the project is not penalized for future funding decisions unrelated to the project. This implies that the economic benefit of the project is divorced from the ability to acquire adequate funding in a timely fashion. However, this approach almost certainly guarantees that the cost estimates for a project will not be accurate.

In USACE BCAs, an optimal funding stream is assumed such that the project is not penalized for future funding decisions unrelated to the project. This approach almost certainly guarantees that the cost estimates for a project will not be accurate.

In a recent analysis of the cost of project delays, HDR, Inc. estimated that during the first five years of a project's life, one year of delay of a new construction project is tantamount to losing an average of 37 cents on every dollar invested; in other words, the benefits that are not realized because of delay are equivalent to 37 percent of the project cost. Rehabilitation projects, when delayed, cost close to 17 cents on the dollar in the early years. In effect, this

suggests that a delay of three years in a construction project effectively doubles the social cost (14).[13] The study reviewed the projects listed in Table 4.

Table 4. Representative Inland Waterway Project Completion Date Performance.

Project Type	Name	Location	Original Investment (in 2011 $M)	Original Completion Date Anticipated	Actual Completion Date (or Recent Estimate)
Construction	Olmsted	Olmsted	$775	2006	2023
	Lower Monongahela	Allegheny, Washington and Westmoreland counties, PA	$556	2004	2031
	Kentucky	Gilbertsville, KY	$533	2008	2041
	Chickamauga	Chattanooga, TN	$267	2010	2036
	McAlpine	Louisville, KY	$220	2002	2009
	Marmet	Kanawha, WV	$230	2007	2009
Rehabilitation	Upper Miss 25*	Winfield, Missouri	$52	1997	1999
	London (including lock extension)	London, WV	$17	2003	2003
	Emsworth	Pittsburgh, PA	$78	2011	2014
	Lockport**	Lockport, IL	$137	2013	2013
	Markland	Warsaw, KY	$31	2010	2012

*The data for original completion date anticipated for this project were not available. For the purpose of analysis, the project team assumes it should have been finished two years ahead of actual completion date.
**This project has not been finished yet and its completion date has not been revised. Therefore, the HDR project team assumed this project has no delay.

Takeaways

1. Delays in funding strongly influence the net economic value of a project.
2. Delays as short as three years can double the social cost of a project by increasing costs while delaying benefits.
3. In USACE BCAs, an optimal funding stream is assumed such that the project is not penalized for future funding decisions unrelated to the conduct of the project. This approach almost certainly guarantees that the cost estimates for a project will not be accurate.

[13] Although not explicitly defined in the report, this appears to refer to benefits that are not realized (hence increasing the cost to society) during the delay.

Requirements and Effects of Peer Review

Introduction

An independent peer review is typically conducted by qualified individuals (or organizations) who are independent of those who performed the work and who are collectively equivalent in technical expertise to those who performed the original work (i.e., peers). Peer review is conducted to ensure that activities are technically defensible, competently performed, properly documented, and consistent with established quality criteria. Peer review is an in-depth assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and conclusions pertaining to the scientific or technical work product, and of the documentation that supports them. Peer review also may provide an evaluation of a topic where quantitative methods of analysis or measures of success are unavailable or undefined (*32*).

Given the level of sophistication in planning studies today, the participation of independent experts is often useful in ensuring that methods employed are consistent with current and credible thinking and practice. In today's planning environment, independent expert advice is also essential for credibility (*33*).

USACE Guidance

As mandated by EC 1165-2-214, Independent External Peer Review (IEPR) is required for project studies where any of the following project characteristics are true:

- Significant threat to human life.
- Where the estimated total cost of the project, including mitigation costs, is greater than $200 million.[14]
- The governor of an affected state requests a peer review by independent experts.
- The director of civil works or the chief of engineers determines that the project study is controversial due to significant public dispute over either the size, nature, or effects of the project or the economic or environmental costs or benefits of the project.

Per 33 U.S. Code § 2343, "The peer review shall occur during the period beginning on the date of the signing of the feasibility cost-sharing agreement for the study and ending not more than 60 days after the last day of the public comment period for the draft project study, or, if the Chief of Engineers determines that a longer period of time is necessary, such period of time determined necessary by the Chief of Engineers; and shall be accomplished concurrent with the conducting of the project study."

It goes on to stipulate: "After receiving a report on a project study from a panel of experts under this section and before entering a final record of decision for the project, the Chief of Engineers shall consider any recommendations contained in the report and prepare a written

[14] The EC states the threshold is $45M but that was subsequently adjusted in WRDA 2014 to $200M (See Planning Bulletin PB 2016-02)--- 33 U.S. Code § 2343

response for any recommendations adopted or not adopted. A report on a project study from a panel of experts under this section and the written response of the Chief of Engineers shall be included in the final decision document for the project study… [Nothing in this section shall be construed to affect any authority of the Chief of Engineers to cause or conduct a peer review of a water resources project existing on November 8, 2007.]"

This review may include, for example, economic and environmental assumptions and projections, data, economic analysis, environmental analysis, and other factors. In fact, there is now a heavy emphasis on peer review at USACE with significant funds dictated to this phase of each project.

USACE analysts are encouraged to use experts to review many aspects of the planning studies or at least to serve on advisory bodies charged with ensuring that defensible methods and assumptions are used. They can also be called upon to recommend planning approaches, techniques, and tools and to assist operating staff in their use. External experts may help USACE contend with a long-term decline in the size of its planning staff that is likely to be compounded by impending retirements. Used properly, systematic peer review of USACE planning studies will help ensure that the methods used represent best practices, that assumptions are reasonable and justifiable, and that plausible options for achieving national goals are not being overlooked.

GAO reported that "peer reviews have resulted in some technical improvements to study reports but generally have not changed the Corps' decisions about project alternatives, in part because the peer review process occurs too late in the project study process to affect decision making...Corps officials were not aware of any project studies for which the study outcome changed as a result of peer review…The Corps generally conducts peer review after the draft feasibility report has been completed" (*34*).

Some parts of the peer review process, such as responding to panel comments, may add time to the study schedule.

Section 2034 of the Water Resources Development Act of 2007 requires that certain USACE civil works project studies undergo IEPR to assess the adequacy and acceptability of the methods, models, and analyses used. According to GAO, the USACE's process for determining whether a project study is subject to peer review is more expansive than section 2034 requirements because it uses broader criteria; this has resulted in peer reviews of studies that are outside the scope of section 2034. In addition, the process USACE uses does not include the flexibility provided in section 2034 to exclude certain project studies from peer review. Moreover, some studies are undergoing peer review that do not warrant it.

Planning centers of expertise and district officials estimate that obtaining the contract and executing the peer review generally take about one year. Some of these processes occur

concurrently with other aspects of the project study, but some parts of the peer review process, such as responding to panel comments, may add time to the study schedule.

The process of responding to peer reviews is a lengthy one. The process begins with district officials drafting a written response, which they provide to the panel. USACE's response to the peer review recommendations includes a detailed description of the steps that USACE has taken or will take to incorporate the recommendations into the project study. The contractor then convenes a teleconference at which district officials discuss the draft response with panel members. After this discussion, the panel members provide written feedback—backcheck responses—to USACE stating whether they agree with the district's response.

The district then finalizes its response to the recommendations and forwards the response to its division office. After its review, the division forwards the response to headquarters, where the response is finalized. The final written response is generally published at the same time as the final decision document for the project study. The time between completion of the peer review report and public availability of USACE's written response therefore varies greatly depending on the individual project. In some cases, peer review reports have been completed for more than three years without a final response from USACE having been made public.

DOI/BLM

Each bureau within the DOI must establish a peer review process for a standard BCA. The peer review must accompany the final analysis developed according to *Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies* (*30*).

BLM study managers are directed to establish an independent team of technical experts to conduct any necessary reviews of the investigation or study. Peer reviews will be conducted in accordance with the Information Quality Act of 2001, OMB requirements, and Department and Reclamation policies (*35*).

EPA

Peer review of all scientific and technical information that is intended to inform or support Agency decisions is encouraged and expected in accordance with the Agency's Peer Review Handbook. Peer review is not restricted to the nearly final version of work products; in fact, EPA believes that peer review at the planning stage can often be extremely beneficial.

Peer review of scientific and technical work products that support regulations is an important, fundamental step in policy setting and regulatory development processes. A regulation itself is not subject to the Peer Review Policy. If a regulation is supported by a scientific and technical work product(s), however, that underlying work product(s) should be peer reviewed if it does not meet exemption criteria outlined in the handbook (which would not be expected to affect the activities discussed in this report).

Sometimes peer review leads to recommendations for new information and analyses that would alter the work product and thus modify the scientific/technical basis for the action or

rule it supports. For this reason, a completed peer review is desirable before issuing any regulatory proposal for public comment. If that is not possible logistically because of court or statutory deadlines, or other appropriate reasons, every effort should be made to complete the peer review before the close of the comment period.

If an Economic Analysis or Regulatory Impact Analysis uses accepted, previously peer-reviewed methods in a straightforward manner, it does not undergo additional peer review. Economic Analyses prepared to support major or economically significant regulations typically do not utilize innovative or untried economic methods. It is unnecessary to conduct peer reviews of straightforward applications or transfers of accepted, previously peer-reviewed economic methods or analyses (including those published in peer-reviewed journals). Therefore, Economic Analyses that are developed using these procedures do not normally undergo an additional peer review, even those Economic Analyses prepared in support of major and economically significant rules.

Takeaways

1. All the agencies recognize the importance of an external peer review.
2. Historically, the use of independent expertise has been less common in USACE than in some other agencies.
3. EPA only requires peer review of scientific work that is relied upon in its BCA, not the BCA itself.
4. EPA encourages peer review at the planning stage; the other agencies do not.

Potential Effect of Cost Adjustments and Project Delays on Project Benefits

Introduction and Background

Risk and uncertainty analysis in the USACE environment focuses almost exclusively on the risk of lock failure and the accuracy of traffic forecasts; these two items affect the cost savings that could be attributed to the project. In the USACE world, risk denotes probabilistically driven unscheduled events (lock closures/failures). However, there is reason to believe that significant cost adjustments and project delays (independently or in concert) may reduce or even eliminate project benefits. This is another element of risk that affects project viability.

As noted in Task 1, USACE's treatment of risk and uncertainty focuses heavily on the cost side of BCA. Project benefits are reported for the most likely with- and without-project conditions. The 2009 guidelines state that qualitative discussions of the benefits could[15] 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 are 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.

Potential Effects of Cost Adjustments and Delay

Significant cost adjustments may affect a project's viability in several ways:

1. In an era of severely constrained funding sources for inland waterway projects, significant cost increases may severely reduce the probability that a project will be fully funded. In extreme cases, such as the Olmsted Lock and Dam Project, they may even affect the viability of other unrelated projects. Based on the funding approaches established by the Administration and by OMB, it is quite possible that a project's priority could be diminished significantly because of the impact its funding would have on the ability of Congress to fund a desired suite of projects. Lack of funding either 1) delays the start of benefits or 2) eliminates benefits altogether.
2. Significant cost increases and delays may cast doubt on the project's viability in the eyes of industries that use or could use rivers for freight transportation. In such cases, businesses may decide to change transportation options (which will increase the cost of business), forego capital investments, relocate the business, or close the business.

In the 2002 Chickamauga Feasibility Report (one of three examined in detail in this document), specific reference is made to the issues raised in 2) above. The report states, "In the case of the Upper Tennessee segment, where the navigation system is constrained by industry perceived reliability problems and inadequate lock size at Chickamauga, existing waterway traffic is

[15] Note the use of the word "could." This is not required.

considered to be inadequate to identify traffic demands for a reliable or improved system. This is particularly important when the future could involve a larger replacement lock at Chickamauga. In this sense, the Chickamauga analysis bears similarity to the analysis of a new waterway. In an attempt to fully capture the traffic demands for an improved system, an extensive market analysis was undertaken" (*36*).

In the section on demand forecasting, the following observation was made. "Further investigations revealed that reliability of the Chickamauga project is an important concern of both existing and potential users of the system. Existing shippers are reluctant to expand their waterway traffic and potential shippers are reluctant to commit their businesses to using waterway transportation when that option is viewed as unreliable" (*36*).

In fact, there was hard evidence of the negative effect of unreliability. "The reliability issue becomes even more evident during and after closures at the Chickamauga facility. Because of a planned 30-day closure in August 1999, some shippers using the waterway made a permanent switch to overland modes, citing the impact of the long closure and their concerns about the reliability of the lock. One public terminal lost customers permanently to overland modes due to the shutdown. Other companies made permanent switches to overland modes for parts of their shipments/receipts. During a survey meant to gauge shipper reactions to closures of various durations, several shippers indicated a preference to shift permanently to overland modes, rather than endure lengthy closures" (*36*).

The analytical approach found in the Chickamauga study was not seen in the other studies. The literature review revealed a methodology of assessing these types of effects that was proposed in a report issued by the Institute for Water Resources in 2005—*Monte Carlo Analysis of SP – Off – RP Data*. The methodology is based on the fact that a change in the respondent's choice can occur only if the attributes of the chosen alternative are made worse or the attributes of the non-chosen alternatives are improved. By determining the extent to which the attributes of the chosen alternative must be worsened or the attributes of non-chosen alternatives improved to induce the respondent to change, the underlying preferences of the respondent are revealed.

In a separate 2004 IWR report*, Shippers' Responses to Changes in Transportation Rates and Times: The Mid-American Grain Study*, the sensitivity of shippers along the Upper Mississippi and Illinois Waterway to changes in rates and times was evaluated by interviewing shippers—369 completed interviews were accomplished. Interestingly, 26 percent of the surveyed shippers reported that they would have to shut down if the mode and origin/destination pairs that they currently use were not viable. The authors of the report concluded that when choosing a location for a new facility, shippers' choices are highly sensitive to transportation costs. Seventy-six percent of the surveyed shippers would choose a location that had lower transportation costs but higher investment costs over a location with higher transportation costs and lower investment costs (within the range of costs considered). Additionally, they concluded that facility location is fairly insensitive to transportation costs and times in the short

run, but that in the long run, when new facilities are built, the location choice is highly sensitive to transportation costs.

The 2012 Olmsted Economics Update included several import risk and uncertainty related revisions. Notice the heavy emphasis on cost:

- New with- and without-project cyclical maintenance assumptions.
- Updated benefit estimates to a 1 Oct 2011 price level (for comparison against the newer construction cost estimates).
- FY 2012 federal discount rates used for discounting and amortization.
- Risk and uncertainty analyses based on construction cost contingencies using current federal discount rates.
- Traffic demand forecasts based on five forecast scenarios developed based on industry expectations and current and future federal policies.
- Traffic congestion effects generated through a vessel level simulation that accounts for vessel arrival and processing time variability.
- Reliability of the existing and proposed structures in terms of sensitivity analysis of the with- and without-project maintenance costs and service disruptions.

Examples of How BCA for USACE Projects Would Be Affected by the Incorporation of Best Practices from the Selected Agencies

Introduction

In this section, the treatment of the individual elements examined in Task 1 is analyzed for each of the case study reports. The manner in which other agency practices or best practices discussed in Task 1 would or could affect these elements is discussed. Where feasible, the potential magnitude of the effect is presented in monetary terms. The chapter is organized by case study; that is, each case study is discussed in its own subchapter section.

Montgomery Point Lock and Dam Feasibility Report—1990 and Limited Reevaluation—1993

Project Description

The McClellan-Kerr Arkansas River Navigation System stretches 445 miles from the head of navigation at Tulsa's Port of Catoosa on the Verdigris River to the mouth of the White River at its confluence with the Mississippi River. A system of 17 locks and dams controls water depths upstream of the first lock on the system (at the time of the report), Norrell Lock and Dam. The structure separates the White River Entrance Channel from the upper reaches of the system. At the time of the original study, water levels on the White River Entrance Channel were unregulated by locks and dams and were controlled primarily by the elevations (stages) of the Mississippi River.

The 10-mile segment from the mouth of the White River at the Mississippi River to the Norrell Lock and Dam were considered to be of critical importance to navigation on the remainder of the McClellan-Kerr Arkansas River Navigation System, since water depths in this reach were uncontrolled.

The navigation problems at the White River Entrance Channel were the result of changes in the Mississippi River. These changes resulted in lower Mississippi River stages for a given flow rate of water than occurred when the navigation system was designed and constructed. In summer 1988, stages were 6 feet lower than the stage used for the design of the navigation system. Consequently, navigation restrictions were imposed for approximately 6 months. These restrictions included reduced drafts, lengths and widths of tows, daylight hours navigation only, and escorted service. The only solution that was found to work was a lock and dam near the mouth of the White River.

The original project feasibility report was published in November 1990. It was subsequently updated in 1993 to update traffic forecasts and cost estimates. Specifically, the reevaluation incorporated the latest tonnage and origin destination data, updated transportation rates, and modifications to the tonnage forecasts that resulted from the tonnage projections review. The alternatives under consideration and the methodology remained the same.

The first thing to note with the reports is that they do not follow the basic principles of BCA. There is a major methodological problem with the calculation of benefits and costs for the various alternatives. Standard BCA requires that all costs and benefits be reported as the PV of their respective streams as of a given date. The Montgomery Point reports attempt to amortize the cost of the project over the life of the project, much as a loan payment amortizes a loan. In a standard BCA, costs incurred as of the base year should simply be reported as the cost and not amortized. Furthermore, this study does not discount the payments used to amortize the cost of the project over its life. However, other costs and benefits ARE discounted. This has the effect of severely inflating the cost of the project. More details are provided in the section on discount rates.

Externalities Included

There are very few externalities included in this study. The benefits attributable to each alternative plan are the same in both the original study and the reevaluation. They represent the change in total system transportation savings with the project over the without-project condition. The total annual benefits for each plan include cost reduction benefits (including reduced lightering, elimination of delays, and reduced escort boat requirements), shift of mode benefits for diversions that would occur in the without-project condition, O&M cost reductions (reduced dredging), and unemployment benefits during construction (other benefits). The benefits for shift of mode only include the increased cost of transportation and not the externalities associated with landside movements. The remaining benefits are all direct benefits and are not externalities.

Other benefits include dredging cost reductions ($6.572 million for two alternatives and $3.387 million for the third), unemployment benefits of $679,000, and elimination of escort boat service, $47,000. The unemployment benefits only include labor that is part of the construction project, and is therefore not an externality. The other two benefits are direct benefits related to the project.

The study states that the reduction in dredging that the plans provide would make significant positive contributions to the EQ account. However, these benefits are not explored in detail.

The study goes on to say that positive contributions to the OSE account would result from all alternative plans because of the increased safety they would provide. With the pools formed behind the structures, more depth would be available reducing the possibility of groundings and accidents. This improvement in safety is not quantified.

In summary, this study focuses on the cost of transportation and dredging-related expenses. While it mentions beneficial externalities, it does not examine them in detail and does not quantify them. According to USACE guidance, waterway accident reduction is an allowable benefit and should be analyzed, but it was not analyzed in this case. The study did not analyze any of the negative externalities that would be generated by diversions from water to land,

such as fatalities, injuries, pavement maintenance expense, and environmental impacts (primarily emissions), nor did it examine water utility or recreational usage.

The DOI/BLM allows several externalities that might be relevant in this case: irrigation, fishing, and recreation. DOI also allows for nonuse values—what people are willing to pay to preserve or enhance a resource even though they may never directly or indirectly use that particular resource. DOI also considers aesthetics improvements to be a valid topic to investigate.

The TIGER grant program provides values that can be used for the value of statistical life, value of injuries, property damages, value of travel time, social cost of carbon, and the conversion of accident data to an abbreviated injury scale. Each of these would be relevant to this study.

EPA allows the inclusion of impacts on production, impacts on employment, impacts on profitability and plant closures, and impacts on industry competitiveness. These all appear to be relevant to this study because of the danger that in the absence of any project the entire McClellan-Kerr Navigation System might be shut down. EPA takes the social cost of emissions one step further than TIGER and allows for the calculation of morbidity and mortality risk. As with DOI/BLM, EPA also considers aesthetics improvements as an allowable benefit. None of these items was included in this study.

EPA asks its analyst to ask which benefit categories are especially salient to particular stakeholders. There is no mention in this study of the reasons particular stakeholder groups might want this study.

Finally, this study focuses heavily on the comparison of alternatives, not the specific economic justification of the project. It appears that the need is treated as a given.

Treatment of Externalities That Cannot Be Monetized

There was no formal analysis of non-monetizable externalities. Several of the externalities mentioned in the previous section could be quantified or at least discussed, but are not.

Discount Rates

This study does NOT use discount rates correctly. It amortizes the project cost over the life of a project, treating the cost as a loan that has to be repaid over 70 years. However, it does NOT discount that stream back to a PV, although other costs are discounted, which severely skews the BCR. Therefore, when reporting annual average costs, it severely misrepresents the cost of the project.

USACE uses a 70-year project horizon (through 2070) for estimating benefits and costs for this project, because this life would be consistent with the remaining design life of the McClellan-Kerr Waterway. The interest rate used for discounting in the reevaluation report was 8 1/4 percent, as directed by the EGM.

In the sensitivity analysis, the report states, “The discount rate influences the present value of project costs and benefits and typically has a large influence on project benefits.” The study

explores the sensitivity of project benefits and costs to variations in the discount rate; estimates of transportation savings, reduced dredging costs, and project costs were recomputed for discount rates ranging from 7 to 12 percent. It concluded that variations in the federal discount rate sufficient to alter project justification would require an increase in the discount rate above historical levels.

The rate of 8 1/4 percent used in this study is a nominal interest rate. The World Development Bank (WDB) maintains a record of real interest rates by country for all years starting in 1961 to the present. The WDB interest rate for 1993 (the year the 8 1/4 percent refers to) is 3.5366 percent. For the selected project alternative, USACE summarized the average annual benefits and costs, as shown in Table 5.

Table 5. Montgomery Point Economic Summary.

Item	Plan B
Economic Life, Years	70
Construction Period, Years	4
Interest Rate, Percent	8.875
Interest Rate, Monthly	0.711
Project First Cost	$163,500,000
Interest During Construction	$ 30,721,000
Investment Cost	$194,221,000
Annual Cost:	
Interest*	$ 17,282,000
Major Replacements	$ 145,000
Operation and Maintenance	$ 700,000
Dredging Cost	$ 203,000
System Cost	$ 119,400
Total Annual Cost	$ 18,449,400
Annual Benefits:	
Cost Reduction	$ 10,293,000
Shift of Mode	$ 2,898,000
Other**	$ 7,298,000
Total Benefits	$ 20,189,000
Benefit/Cost Ratio	1.11
Excess Benefits (annual average)	$ 2,039,600

*This is actually principal and interest required to amortize first cost.

**According to USACE, this includes reduced dredging costs ($6.72 million), unemployment benefits of $679.000, and elimination of escort boat service ($47,000).

Had the interest costs been discounted to PV, the BCR would have been 4.8. This is the same BCR that would be reported if the first costs were simply reported at their face value at Time 0 and not included in annual cost.

The researchers reverse-engineered the results and restated the economics in a traditional BCA format. First costs were simply reported at face value at Time 0. A cost stream that would result in an average annual cost of $1,246,000 ($19,643,000 minus $18,397,000) was calculated using the 8.25 percent discount rate. A separate stream that would result in a PV of the $21,037,000 for benefits was also calculated. Table 6 restates the economics in standard BCA format.

Table 6. Standard BCA Summary for Montgomery Point Using 8 1/4 Percent.

Item	Value
PV of the annual cost stream	$ 87,235,012
First costs	$ 194,221,000
PV of all cost	$ 281,456,012
PV of benefits =	$1,473,034,108.35
Benefit Cost Ratio	4.8

If the real discount rate as reported by the WDB (3.5366 percent) had been used, the results would have been as shown in Table 7:

Table 7. Standard BCA Summary for Montgomery Point Using 3.5366 Percent.

Item	Value
PV of the annual cost stream	$ 186,358,184
First costs	$ 194,221,000
PV of all cost	$ 300,911,888
PV of benefits =	$1,876,288,027
Benefit Cost Ratio	7.7

In addition to the discounting problem, the same first costs are estimated for both a 1995 project completion date and a 2000 date, which is highly improbable.

Use of Confidence Levels or Risks

Project summaries and the ultimate project selection in the report are based on the medium commodity forecasts of commodity growth.

The report presents a brief sensitivity analysis. It evaluates four different traffic forecast scenarios. It concludes that the most important variables in the analysis include projections of traffic growth on the waterway (commodity forecasts), the rate of channel deterioration, and

the discount rate, the latter two being the most significant. (The preceding section discusses the treatment of the discount rate.)

To examine how the rate of channel deterioration impacts benefit estimates, three additional scenarios were examined: stabilization of surface profiles at 1986 levels, the without-project condition with a year 2000 start date, and an extreme condition where surface profiles deteriorate to projected 2036 levels by 1995. Benefits are calculated for these scenarios.

The report does not analyze the effect of the construction period taking significantly longer than the proposed plan allows. Cost and benefits that are presented in the summary tables are based on the medium commodity forecast. Net benefits based on high and low forecasts are presented in the sensitivity analysis.

Risk related to costs or benefits is not explicitly addressed in the report. DOI/BLM guidance directs analysts to describe the nature, likelihood, and magnitude of risks and uncertainties associated with key supporting data, projections, and evaluations of competing alternatives. While the USACE report provides a sensitivity analysis, it does not discuss risk (especially not the likelihood that any of the scenarios used in the report will actually occur.) The National Academy of Sciences review of EPA methodology states that factors such as public sentiment, environmental justice, and the political climate influence EPA's decisions, but these factors are rarely discussed or accounted for. USACE does not address them.

A report incorporating DOI/BLM and EPA best practices would provide a better understanding of how likely certain scenarios are to occur and how factors external to the project could affect its success.

Effect of the Timing of Funding

Project economics were calculated for a 1995 start date and a 2000 start date. Both cases presumed full and efficient funding. Interestingly, the same project cost was used for both scenarios even though they are five years apart. Even assuming that the project cost does not change, the HDR report discussed in Task 1 estimates that a project delay of 3 years can double the social cost of a project.[16] Using the BCA summary shown above in Table 6 with the 8.25 percent discount rate, doubling the cost of the project would reduce the BCR from 4.8 to 2.4.

Peer Review

There was no evidence of IEPR in the report and nothing surfaced in the literature scan. Using best practices, a peer review could have been conducted during various phases of the project to ensure the assumptions and actual calculations were acceptable.

[16] Although not explicitly defined in the report, this appears to refer to benefits that are not realized (hence increasing the cost to society) during the delay.

Takeaways

1. If the costs and benefits were reported as PVs using standard BCA reporting, the BCR would improve from 1.1 to 4.8, using the same interest rate as the study. Using the real discount rate would further improve the BCR to 7.7.
2. Externalities are limited to cost reduction benefits, shift of mode benefits for diversions that would otherwise take place without the project, O&M cost reductions, and unemployment benefits. The benefits for mode diversions only consider the increased cost of transportation, not the negative externalities generated by the mode shift.
3. USACE concludes that interest rates would have to rise above historical levels to affect the justification of the project. This fails to consider the fact that projects compete against each other on a national scale, so a higher BCR might, in fact, affect the ability of the project to be funded.
4. The study did a good job of identifying the most important variables in terms of sensitivity. It does not include any discussion of how a delay in the project start date might affect the viability of the project.
5. There is no mention of a peer review of this study.
6. Externalities that could not be monetized were not discussed in the report.

Upper Ohio Navigation Study—2014 (UONS)

Project Description

The upper Ohio River infrastructure is defined as Emsworth, Dashields and Montgomery (EDM) locks and dams. They are the oldest and smallest lock projects on the Ohio River, having been built prior to World War II. Two major problems associated with EDM are deteriorated structural condition leading to reduced service reliability, and insufficient auxiliary lock capacity when the main lock chamber is closed for maintenance or repair.

The EDM locks and dams were originally completed in 1922 to 1936. These facilities provide navigable conditions on the first 31.7 miles of the 981-mile Ohio River and are central in position to the Port of Pittsburgh and the USACE Pittsburgh District's 23 locks and dams on the Allegheny, Monongahela, and Upper Ohio Rivers. Over 91 percent of the traffic passes through all three projects and all three lie within 25.5 miles of one another.

The study does a good job of laying out the requirements USACE must follow and providing the theoretical underpinnings for the analytical approach. In accordance with current USACE policy and guidance, problems and opportunities for ecosystem restoration projects were included as a study purpose along with navigation. Ecosystem restoration projects are typically evaluated as to the non-monetary benefits they provide, which are termed NER benefits, and require cost sharing with a non-federal sponsor. Potential ecosystem restoration projects may be either integral to or independent of the navigation facilities. In formulating a plan that would combine navigation and ecosystem restoration components, any interdependence between the two may lead to necessary tradeoffs in the level of benefits both provide. The best-combined plan may

not be the simple combination of the individually best NED and NER plans, unless the two are completely independent.

Formulation of the without-project condition considered potential ecosystem restoration projects that could be included with the navigation NED plan as a combined plan. Since all of the potential restoration alternatives evaluated were physically and functionally independent of the navigation facilities, there were no tradeoffs to evaluate between the NED and NER accounts. Consequently, the UONS report documents the ecosystem restoration study process and results, but does not recommend a combined plan.

Externalities Included

Several externalities were evaluated in this study, including roadway congestion, fuel usage, accidents, air pollution, and employment. However, guidance provided by USACE Headquarters office limited NED benefits that could be considered in the economic evaluation to roadway congestion. Best practices from the other three agencies (and BCA at large) would include all of the listed elements in the project selection process.

Traditionally, the primary benefit for barge transportation is calculated as the cost savings for barge shipments over the long run compared to the least-costly all-overland alternative routing. For inland navigation analysis, the focus is on the evaluation and comparison of the existing waterway system with three basic alternative measures: 1) increase capacity (decrease transit times and thereby reduce delay costs); 2) increase reliability (replace or rehabilitate aging structures, thereby reduce the probability of structural failure and its consequences); and/or 3) reduce demand (e.g., congestion fees).

The report goes on to say that “NED benefits for a navigation project investment are composed primarily of the reductions in transportation costs attributable to the availability of the improved waterway system…Further benefits accrue from traffic that is transported only because of the lower transportation cost deriving from an improved project, and from creating or enhancing the potential for other productive uses of the waterway, such as the generation of hydropower.”

The report recognizes that main chamber closures lasting more than a couple of days can now result in large queues, high delay, and diversion of shipments often to already congested land transportation corridors. System benefits are the equilibrium transportation savings net of any transportation losses caused by congestion delay or diversion due to scheduled improvement and unscheduled repair closures. The analysis includes only congestion caused by locking or diversion caused by lock outages. It does not consider possible diversions to due increased lockage costs or the unreliability of the system.

Note that these externality costs (diversion costs) are not utilized in the fitness metric and are not part of investment optimization. Beyond USACE’s policy not advocating any of the externality categories as NED, the calculations at this time only address river closure diversions and not unscheduled over-capacity diversions. The report takes the position that the exogenous

calculation of the dollar values of externalities such as emissions and accidents are subject to a considerable amount of uncertainty and sensitive to the mode, routing, and time of day assumptions. As a result, these inputs and the resulting model calculations are much more uncertain than the other model calculations.

The without-project condition normally assumes that the alternative modes have sufficient capacity to move traffic at current rates unless there is specific evidence to the contrary. Even if specific evidence exists, prior approval of an evaluation with restricted overland capacity requires prior approval from headquarters (HQ). A request was made to HQ in 2006 for approval to consider overland capacity constraints in the Upper Ohio study but there was no official response. The unofficial response was to follow the guidance provided by HQ in the Project Guidance Memorandum for the Southwest Arkansas Feasibility Report, which stated (*37*):

> Externalities should not be used to justify a navigation project. These benefits are an add-on after BCR is greater than 1 for traditional benefits. Roadway delays appear to be the only benefits category that is based on a current standard methodology which is sufficient for district to pursue as part of this study.

The current interpretation of the P&G allows the incorporation of travel time impacts into lock construction benefit-cost studies if the BCR for a project is greater than unity. This means that travel time impacts cannot be factored into the project selection process. However, the PGN indicates that a reduction in without-project-condition roadway congestion attributable to diverted traffic is an allowable NED benefit. The literature does not indicate that this inconsistency has been resolved.

Other externalities, such as reduced fuel usage, were also estimated but included in accounts other than NED. This does not follow standard BCA guidelines or the practices of other agencies (especially DOT's TIGER grant program).

It appears that the evaluation of highway and rail related externalities was appropriate, although it was not allowed in the project justification. In this report, the social cost analysis modeled highway mode shift changes in added delay, increased fuel use, increased accidents, increased emissions, and premature pavement damage for the added trucks as well as the impact on resident traffic. First, congestion and speed were forecast in future years for a base case traffic volume and growth rate. Diverted cargo truck traffic due to lock outage was then introduced into the base traffic flows to estimate the traffic and social cost differentials due to lock closure. The measured effects on both the existing and introduced vehicle traffic included the changes in fuel consumed, time spent in transit, air pollution emissions, and crashes. Each of the four effects was given dollar values using data obtained from the American Association of State Highway and Transportation Officials Red Book (User Benefit Analysis for Highways) and the EPA's MOBILE6 and BenMAP models.

For this study, the costs used to estimate each ton of emission reduction from mobile sources are the same values used by EPA for the cost/benefit analysis in the RIA for the new emission standards for trucks and buses, based on the EPA BenMAP model results.

The rail social costs associated with delay, track maintenance, and accidents, due to increased rail traffic, were not identified as measurable or they were incorporated in the RED transportation rate analysis (Appendix 2 to the report) as a component of the transportation rate. The specific method to measure the change in emissions by rail was accomplished by computing the change in route miles multiplied by the average number of tons in the closure period for each origin/destination pair that diverted by rail, producing the net incremental ton mile change.

The change in cost from the reduction in fuel use and accidents through the reduced trip length was included in the RED transportation rate analysis as a component of the transportation rate. The specific method to measure the change in emissions by barge was accomplished by computing the change in route miles multiplied times the average number of tons in the closure period for each origin/destination pair that diverted by rail or truck, producing the net ton-mile change. Cases where shipments between origin/destination pairs waited for the closure to end or where the origin/destination pair closed were given a zero value since no diversion occurred. The net-ton miles were divided by the ton-miles per gallon for towboat operations on the Ohio, Allegheny, and Monongahela Rivers from the 2006 TVA fuel efficiency model. The change in the number of gallons of fuel was carried over to the integration step.

Here, the truck diversion externality (emissions, delay, and accidents), the rail diversion (emissions), the truck routes without delay (emissions and accidents), and barge route reductions (emissions) were summed and divided by the number of diverted tons to arrive at the rate per ton of social cost for each lock closure period.

The loss of employment due to an unreliable navigation system was investigated with regard to the separable effects of the loss of barge transportation and the loss of water supplies for industrial use. Although the study notes that EDM also benefits water supply and recreational needs in addition to the authorized navigation purpose, these benefits (or potential loss thereof) are not analyzed. The report lists several Ohio River designated uses: aquatic life use, public water supply use, contact recreation use, and fish consumption use.

The study places annual dollar values on costs borne by society for both the short and intermediate duration outages.

EPA allows the inclusion of impacts on production, impacts on employment, impacts on profitability and plant closures, and impacts on industry competitiveness. These all appear to be relevant to this study because of the danger that in the absence of any project an important segment of the Ohio River might be shut down. EPA takes the social cost of emissions one step further than TIGER and allows for the calculation of morbidity and mortality risk. As with

DOI/BLM, EPA also considers aesthetics improvements as an allowable benefit. None of these items was included in this study.

Treatment of Externalities That Cannot Be Monetized

Externalities that could not be monetized were not discussed in this report.

Discount Rates

The report explains that compounding and discounting requires the use of an interest rate that represents society's opportunity cost of current consumption. The analysis assumes a 50-year life.

There are inconsistencies in the report that make it very difficult to evaluate the benefit and cost streams. For instance, the fact sheet dated August 8, 2016, at the front end of the report shows benefits and costs in thousands of FY 2009 dollars. Revised Table 9-4 at the end of the report displays values in millions of dollars. The figures are vastly different. For example, the fact sheet shows:

- Incremental annual benefits: $327,200.
- Incremental annual costs: $117,700.

The revised Table 9-4 shows:

- Incremental annual benefits: $433,500,000.
- Incremental annual costs: $64,900,000.

The most probable explanation for the difference is that the fact sheet is really millions of dollars. In the August 2016 fact sheet, the total project first cost is shown as $2,648,471,000. Assuming that the fact sheet is really millions of dollars rather than thousands, the total cost of the project comes to $4.745B dollars (50 × 94.9M), which is almost double the stated first cost. While it might be the case that the difference is due to ongoing operations and maintenance expenses over the life of the project, there is no detail to confirm this. Without this detail, it is not possible to determine a BCR based on total project benefits and costs that could be displayed in a more traditional BCA format.

That said, the report runs through a series of different assumptions for start dates and interest rates. One aspect that is missing is the real discount rate, which was 1.1614 percent for the period in question. However, the approach taken in the report indicates the effect different rates have on the economics of the project.

Use of Confidence Levels or Risks

The report notes that forecasts of the physical condition of critical lock and dam components and traffic demand are uncertain, giving rise to the need for a risk-based analysis to ensure that the study conclusions and recommendations cover the plausible range of future scenarios.

Cost estimates explicitly address risk factors. The risk of lock failure is addressed in detail. Funding constraints delaying the start date of the project, requiring the contracts to be split into multiple contracts or preventing them from being constructed concurrently, were not included in the risk analysis.

In the model used for this report, the various cost categories (waterway savings and system performance statistics) are itemized under four shipper-based equilibrium scenarios (normal-operations, scheduled-maintenance, probabilistic without scheduled maintenance, and probabilistic with scheduled maintenance). The non-probabilistic scenarios are itemized to allow incremental comparison against the probabilistic scenarios to enumerate risk effects. Additionally, multiple forecast scenarios are summarized. The user then manually selects the NED plan from either the probabilistic without scheduled maintenance scenario or the probabilistic with scheduled maintenance scenario with consideration of the forecast scenario variation. Typically, the probabilistic with scheduled maintenance scenario is used with the results between the forecast scenarios averaged.

The report deals with uncertainty and sensitivity in detail. The project economics are presented at different price levels, discount rates, base years, and projected traffic levels. This analysis provides information on the level of uncertainty associated with the values estimated for a number of critical inputs. These include traffic demand projections, lock performance descriptors (capacity and lock availability), and structural reliability. In the case of traffic demand projections, alternative traffic forecast scenarios based upon competing sets of assumptions are presented and analyzed. Lock availability and performance is further described using hazard values and event trees, which is the key input into the Monte Carlo-type simulation that calculates expected future adverse impacts associated with a lock's structural reliability.

The economic analyses were based largely on the results of the mid-level forecast scenario. The alternative plans for improving the existing federal projects at EDM were evaluated, as well, using the high and low forecast scenarios (which were defined as one standard deviation from the estimated demand slope). In addition, in light of the uncertainty surrounding future market and navigation conditions, certain other analyses were considered for the purpose of testing the economic viability of the NED plan to changes in key variables. These included limiting the growth of traffic to the initial 20 years in the forecast period, no growth in commodity traffic beyond the 2007 level, use of the current OMB interest rate of 7 percent, the impact of price elasticity of demand estimates for waterway transportation, and the use of the current fleet rather than the projected fleet. (Limiting the growth of traffic demand to the first 20 years of the period of analysis has the effect of weighting the initial years of the project economic life and de-emphasizing the latter years, which, by their nature involve greater uncertainty.)

However, risk related to costs or benefits is never explicitly addressed in the report. DOI/BLM guidance directs analysts to describe the nature, likelihood, and magnitude of risks and uncertainties associated with key supporting data, projections, and evaluations of competing

alternatives. While the USACE report provides a sensitivity analysis, it does not discuss risk (especially not the likelihood that any of the scenarios used in the report will actually occur.) The National Academy of Sciences review of EPA methodology states that factors such as public sentiment, environmental justice, and the political climate influence EPA's decisions, but these factors are rarely discussed or accounted for. They are not included at all in the USACE report.

A report incorporating DOI/BLM and EPA best practices would provide a better understanding of how likely certain scenarios are to occur and how factors external to the project could affect its success.

The sensitivity of results to different interest rates was also tested. Specifically, results were tested against the current OMB interest rate of 7.0 percent, the 4.125 percent applicable interest rate used in the Civil Works Review Board (CWRB) report, and the current interest rate of 3.125 percent. This appears to be a reasonable treatment of interest rates.

Effect of the Timing of Funding

The project schedule was driven by technical factors that assume that funding will be available when needed, which is the standard assumption underlying all USACE analyses.

The project team stated that cost-time adjustments will be mitigated through application of inflation factors in accordance with the requirements of limit calculations in Section 902 of WRDA 1986. The actual start date of each project will define the appropriation amount. Therefore, the cost and schedule model focuses on risk events that occur during the project as well as ones that extend the duration of the project once started. This risk analysis captures the risks associated with funding caps, which limit construction production during the project. This would be a situation in which limited funds per year decrease the contractor's capabilities, which results in schedule slippages and claims. Risks associated with inflation above the amount allowed by WRDA 902 limit calculations are also included in this analysis, such as excessive fuel or material price increases. Costs include a contingency that was calculated by identifying and assessing the effects of the key cost and schedule risk drivers. All contingencies were calculated to provide an 80 percent confidence that the actual costs will be equal to or below the calculated costs.

The effect of delayed funding or significant cost escalation on project benefits was not analyzed in the report.

Peer Review

The original report included minor revisions to address the comments received through the public review and the concurrent IEPR.

There was only one major finding in the IEPR. The consensus of the CWRB and the IEPR members was that the downtimes between failure and repairs used in the study were based on overly optimistic assumptions that should be reconsidered. USACE revised its report in response to this finding.

Takeaways

1. The total costs and benefits are reported as annual average values rather than PVs, so it is not possible to analyze BCRs as they are usually reported. Additionally, the values reported are the differences between costs and benefits in the with-project condition versus the without-project condition. The focus on incremental costs and benefits does not enable a reader to determine if the total project cost is justified or how the relative return on investment compares to other alternatives.
2. Externalities are presented and quantified, but according to guidance from headquarters, these externalities could not be used to justify the project. Furthermore, only roadway congestion was allowed in the formal evaluation, and then only in terms of the cost of transportation. This does not follow standard BCA guidelines or the practices of other agencies (especially DOT's TIGER grant program).
3. Externalities that could not be monetized were not discussed in the report.
4. The report deals with uncertainty and sensitivity in detail. It examines the effects of different price levels, discount rates, base years, and project traffic levels. Risk is never explicitly addressed, although it appears to be incorporated into cost estimates.
5. Although the study notes that EDM also benefits water supply and recreational needs in addition to the authorized navigation purpose, these benefits (or potential loss thereof) are not analyzed.
6. The effect of delayed start dates on the cost of the project was analyzed. However, the report assumes the same nominal benefits and only adjusts them by using different discount rates. The analysis does not examine the risk of delaying or stretching out the funding of the project.
7. The report was peer reviewed and revised to address the comments. There was only one major finding, and it related to the assumptions used to calculate downtimes between failure and repairs.

Chickamauga Feasibility Report—2002) and Limited Reevaluation Report—2016

Project Description

Chickamauga Lock and Dam is located at mile 471.0 on the Tennessee River, about 13 miles upstream of the Port of Chattanooga, Tennessee. Chickamauga Lock and Dam is one of 10 multipurpose lock-and-dam projects comprising the Tennessee River navigation system.

The upper Tennessee River segment is considered to begin at the Chickamauga Lock and Darn and extend upstream to its terminus in Knoxville, a distance of 181 miles. Watts Bar and Ft. Loudoun Locks and Dams are located within this segment.

The Chickamauga Lock represents the gateway to the upper Tennessee River Valley. The impetus for studying this lock and dam was (is) the structural deficiencies resulting from physical expansion of the concrete structure. Even with costly aggressive maintenance procedures, this concrete growth threatens the structural integrity of the lock and limits its life.

Both the USACE and the TVA agree that the lock has a finite life limited by economics and safety. At some point, the condition of the lock could cause the TVA Dam Safety Officer to permanently close the lock. Additionally, the current lock size cannot efficiently process modern towing equipment.

A feasibility study for Chickamauga Lock and Dam was released in February 2002. The report recommended the construction of a replacement lock for the Chickamauga project. Section 114 of the 2004 Energy and Water Development Appropriations Act funded a construction start, and subsequent annual appropriations have funded project design, relocations, and cofferdam construction. However, funding was not at requested levels and after FY 2011 was limited because of a low balance in and revenues to the Inland Waterways Trust Fund. With the exhaustion of available funding, all construction activities for the project were ceased in 2013. The Water Resources Reform and Development Act of 2014 and the Achieving a Better Life Experience (ABLE) Act of 2014 reformed the Inland Waterways Trust Fund and provided the opportunity to restore annual funding to the project. As a result, the project received $3.0 million in July 2015 to re-start construction activities. The project received its efficient funding request of $29.9M in the FY 2016 Work Plan, which allowed the award of the critical path Lock Excavation construction contract. Award of follow-on lock contracts will be dependent on future funding. Efficient funding of the project in FY 2017 and beyond would result in bringing the replacement lock online in FY 2022 with-project completion in FY 2023.

A limited reevaluation report was released in January 2009.[17] It updated the construction costs, waterway transportation demands and transportation rates, and changed the without-project condition from a replacement-in-kind assumption (which had been determined the most economical method to maintain the current project footprint) to an advanced maintenance strategy. This report reaffirmed that the Authorized Plan was economically justified with a remaining benefits to remaining benefit to remaining cost ratio of 9.6 to 1 and a total BCR of 4.6 to 1 using the Corps FY 2008 Federal Project Evaluation and Formulation Rate of 4.875 percent.

Another limited reevaluation report was completed in 2016. In that report, the analysis was adjusted late in 2017 through an erratum where additional years of sunk funding were updated and sunk and the federal discount rate was adjusted from 3.125 percent to 2.75 percent. The 2016 report has not been published as of this report, but a draft copy was released to the

> The report emphasized that external cost reductions are non-standard benefits.

[17] A limited reevaluation report is a post authorization report that "provides an evaluation of a specific portion of a plan under current policies, criteria, and guidelines and may be limited to economics, environmental effects, or in rare cases, project reformulation." Previous assumptions are reviewed and updated with techniques such as surveys and sampling to develop a reasonable estimate of current project benefits, provided no significant changes in without- and/or with-project conditions have occurred.

research team. It serves as a revised update of the 2002 feasibility report. Specifically, it updated:

- The definitions of the with- and without-project conditions.
- Engineering reliability data, including cost of repairs and duration of closures.
- Scheduled maintenance cost and service disruption schedules.
- The Authorized Plan cost.
- Traffic demand forecasts.
- Transportation rates and shipper closure response.
- Recreation benefits.
- Overland externalized benefits (impacts avoided).

There was no new plan formulation nor was any new environmental documentation prepared.

Bot the 2009 and the 2016 report had to account for the fact that some work had already been accomplished on the project; therefore, they assess the benefits and costs of continuing the project rather than terminating it, taking into account current policies, criteria, and guidelines. However, project shutdown costs are not included.

For purposes of this document, "report" refers to the 2002 feasibility report with the 2016 updates incorporated into the analysis.

Externalities Included

Benefits in this report are defined as costs avoided when compared to the fix-as-fails base condition.

The costs associated with each alternative include construction costs and non-construction costs including helper boat costs (when justified and may be included at either Chickamauga or/and Watts Bar), alkali-aggregate reaction[18] specific maintenance costs, repair costs, external costs, recreation costs, and transportation costs. (Recreation costs or recreation benefits foregone result primarily from lock closure periods at Chickamauga, when recreational traffic cannot be processed.)

The 2002 study also considered indirect or external costs imposed locally because of waterway traffic diversions. These externalities consisted of: 1) increased congestion, which dominated the calculations; 2) the detrimental health effects of air pollution; 3) increased crashes; 4) increased fuel use; and 5) pavement damage. Reductions in these categories of costs that occur with navigation improvements are treated as benefits to implementation of improvements.

[18] The entire Chickamauga project is plagued with concrete growth resulting from an alkali-aggregate reaction. This reaction creates a gel that absorbs moisture, swells, and expands the concrete. When the concrete is restrained, the growth increases internal stresses, which causes cracking and movement of the concrete monolifts. This movement causes equipment misalignment as well as structural instability.

The report emphasized that external cost reductions are non-standard benefits and were (at the time of the report) undergoing Washington-level review. A final determination on the use of external cost reductions was not received prior to issuance of the 2002 report. Tables presenting the analysis without and with the external cost reductions are presented; however, the plans are formulated based on the data with the external cost reductions omitted. Summary of Screening Level Annual Costs, Benefits, and Net Benefits for Alternative Lock Sizes are presented with and without externalities.

Other benefits evaluated are also presented in Table VII-3: Incremental Annual Benefits for Final Alternative Plans. The categories are helper boat cost reductions and external cost reductions, measured as incremental reductions in highway congestion, emissions, accidents, and highway damages that would result from reductions in diverted traffic with navigation improvements at Chickamauga. Helper boat cost reductions occur because fewer helper boats are required with larger lock sizes. It was estimated that no appreciable increase in recreation traffic would occur because of the alternative improvement plans; therefore, there is essentially no incremental increase in recreation benefits with the alternative plans. External cost reductions stem primarily from reduced congestion, with much of the remainder attributable to reduced emissions. Reductions in highway damages contribute only a minor portion of the external cost reductions.

The analysis in the 2016 report stated that the traffic base has fallen, shipment patterns have changed, and much of the without-project condition unscheduled closure re-routing around the lock that was anticipated in the feasibility analysis is no longer expected to occur. Because of these changes, the social costs are now estimated to be inconsequential, and this category was not included as a closure impact in the 2016 LRR.

In assessing recreation benefits, the 2002 Feasibility Report utilized a unit day method to estimate recreation impact, pursuant to Table 6-29 of the PGN. Project point values were assigned for five subject areas: recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental. The total point score for a Chickamauga recreation experience was 61, which corresponded to a unit value of $18.78. The 2002 Feasibility Report utilized 1990–1998 average recreation passages (4,613) and the assumption that four passengers would be present in each vessel to estimate expected annual visitation (18,452). Visitation was multiplied by the recreation unit value ($18.78) to estimate expected annual recreation benefits ($346,528).

The 2016 report uses the same method as the 2002 Feasibility Report. The specialized recreation project point total of 61 calculated in the 2002 Feasibility Report corresponds to a $26.41-unit day value, as outlined in USACE EGM 16-03. This method was preferred to indexing the 1999 Nashville District recreation study value to FY 2016 prices due to the length of time that has passed since the recreation study was conducted.

The 2011–2015 average recreation passages (2,942), coupled with the assumption that four passengers would be present in each vessel, yields expected annual visitation of 11,768. Expected annual visitation (11,768) multiplied by the EGM 16-03 special recreation unit value ($26.41) yields an expected annual recreation benefit of $310,793.

The DOI/BLM allows several externalities that might be relevant in this case: irrigation, fishing, and recreation. DOI also allows for nonuse values—what people are willing to pay to preserve or enhance a resource even though they may never directly or indirectly use that particular resource. DOI also considers aesthetics improvements to be a valid topic to investigate.

The TIGER grant program provides values that can be used for the value of statistical life, value of injuries, property damages, value of travel time, social cost of carbon, and the conversion of accident data to an abbreviated injury scale. Each of these would be relevant to this study.

Treatment of Externalities That Cannot Be Monetized

There was no formal analysis of non-monetizable externalities.

Discount Rates

This analysis of discount rates focuses exclusively on the content of the 2016 report since it is the latest decision document. The planning horizon used in the 2016 report extends from 2019 through 2071 with a base year of 2022[19] (the year the project is place into service) and uses a 2.75 percent discount rate (the FY 2018 project formulation rate). Dollars are inflated or discounted (as appropriate) to 2016 price levels using 2022 as the base year. Monies expensed through FY 2018 are considered sunk costs when the errata are taken into account; the original version of the report used a cutoff of FY 2016.

The costs that are included and discounted are the annual costs of the authorized plan less the annual costs for the without-project condition. Benefits for the authorized plan come primarily from transportation cost savings, largely from the list of potential/induced traffic that move on the inland waterway system under the with-project condition. Other benefits arise from a reduction in impacts to both commercial and recreation traffic from scheduled and unscheduled closures. Unless otherwise stated, benefits displayed are for the mid-range traffic forecast level.

The newer method of calculating the BCR used in the 2016 report strictly constrains the definition of the cost to only the construction cost and any incremental change in project maintenance costs in the calculation of the BCR.

This study does NOT use discount rates correctly. It amortizes the project cost over the life of a project, treating the cost as a loan that has to be repaid over 52 years. However, it does NOT

[19] The report actually uses 2017–2071 as the period, but errata are inserted in the front of the report that change the period to 2019–2071.

discount that stream back to a PV. Therefore, when reporting annual average costs, it severely misrepresents the cost of the project.

There were some errata included in the 2016 study. They modified the study period to be FY 2019–2071 and updated the discount rate to 2.75 percent. However, the details as presented in the report without the errata shed light on how the BCR was determined. The summary of benefits and costs of the authorized plan using the mid-forecast traffic scenario and without the errata modifications was presented as shown in Table 8.

Table 8. Benefits and Costs of the Authorized Plan.
(Average annual FY 2016 dollars, Mid-forecast scenario)

Item	Discount/Amortization Rate	
	Corps 3.125%	**OMB 7.000%**
Incremental Annual Benefits	$24,163,000	$21,408,000
Incremental Annual Costs		
Remaining (2017–2071)	$2,757,000	$11,988,000
Average Annual Net Benefits		
Remaining (2017–2071)	$21,406,000	$9,420,000
Benefits to Cost Ratio	8.8	1.8
Ratio of Benefits to Total Project Cost (with Sunk Costs)	2.4	0.8

The Net Benefits shown in the table are simply the incremental annual benefits minus the incremental annual costs. The BCR is simply the ratio of the first two numbers.

Although it was not specifically addressed in the study, the effect of modifying the interest rates is clearly reflected in the tables that are presented. In the errata included at the front of the 2016 report, a table is presented that provides the same information using an interest rate of 2.75 percent and a period of evaluation of FY 2019–2071. Table 9 summarizes the information.

Table 9. Benefits and Costs of the Authorized Plan per Errata.
(Average Annual FY 2016 Dollars, Mid-Forecast Scenario)

Item	Discount Amortization Rate – 2.75%	
	Corps 2.75%	**OMB 7.00%**
Incremental Annual Benefits	$24,396,000	$21,158,000
Incremental Annual Costs		
Remaining (2019–2071)	$(671,000)	$5,211,000
Average Annual Net Benefits		
Remaining (2019–2071)	$25,067,000	$15,948,000
Benefits to Cost Ratio	N/A	4.1
Ratio of Benefits to Total Project Cost (with Sunk Costs)	3.4	1.0

This table indicates that when the 2.75 percent rate is applied, there is less cost incurred to build the project than to cancel the project (without-project condition). When higher interest rates are applied, this situation is reversed to the more typical case where additional costs are incurred to build a project. The interest rate clearly affects the economic viability of the project.

Because there are no details on how the incremental annual costs were calculated or what the first costs to complete the project actually are, it is not possible to reverse engineer the data to produce a standard BCA summary.

Use of Confidence Levels or Risks

In the case of the Upper Tennessee segment, where the navigation system is constrained by industry-perceived reliability problems and inadequate lock size at Chickamauga, existing waterway traffic is considered inadequate to identify traffic demands for a reliable or improved system. This is particularly important when the future could involve a larger replacement lock at Chickamauga. In this sense, the Chickamauga analysis bears similarity to the analysis of a new waterway. In an attempt to fully capture the traffic demands for an improved system, an extensive market analysis was undertaken.

The alternative plans for improving the existing project at Chickamauga were evaluated using the most probable future navigation conditions under both the with- and without-project alternatives. In defining these conditions, certain key assumptions and predictions on the future were made. Since future conditions cannot be predicted with certainty, tests were performed to describe the sensitivity of NED plan identification to changes in certain formulation variables.

The forecast of future traffic demands is one of the major factors affecting the need for improvements at Chickamauga. The USACE project team determined that reliability is a key factor in demand. The assumption that potential/induced movements will materialize under the with-project condition transportation system is critical for economic justification of the Authorized Plan. To show the sensitivity of the project to alternative traffic demand forecasts,

net benefits for the alternative lock plans were re-evaluated based on alternative traffic projections.

The use of congestion fees was considered in this report. Since this alternative has never been implemented on a navigation project, there is no experience for judging its actual performance. The report notes that therefore there is a high risk that it would not perform as well as the theoretical model.

Cost contingencies were assigned by the cost engineer based on the risk and/or uncertainty of each individual bid item estimated. However, risks apart from specific cost contingencies are not explicitly addressed in the report. DOI/BLM guidance directs analysts to describe the nature, likelihood, and magnitude of risks and uncertainties associated with key supporting data, projections, and evaluations of competing alternatives. While the USACE report provides a sensitivity analysis, it does not discuss risk (especially not the likelihood that any of the scenarios used in the report will actually occur.) The National Academy of Sciences review of EPA methodology states that factors such as public sentiment, environmental justice, and the political climate influence EPA's decisions, but these factors are rarely discussed or accounted for. USACE does not address them.

A report incorporating DOI/BLM and EPA best practices would provide a better understanding of how likely certain scenarios are to occur and how factors external to the project could affect its success.

Finally, although it is not a true sensitivity test, the method of accounting for sunk costs has a significant effect on the economic results.

Effect of the Timing of Funding

The 2016 report attempted to place the funding question in context. The $116 million contingency for construction costs was developed through a cost risk assessment whose primary driver was funding, or more precisely, the project not receiving an efficient funding stream.

However, the report points out that while this funding risk and its associated cost increase impacts are a real risk due to the method and circumstances of how these inland navigation projects are funded, it may not be appropriate to include these costs in this economic analysis. This is because inefficient funding is solely a government decision that is not reflective of the project, its specific characteristics, or its economic merits.

Simply put, the contention is that the merits of the project are one thing, how it is funded is another, and the two should be separated in these analyses. However, the report does not discuss how delaying project funding might actually affect the viability of the project and at what point such delays may make the project infeasible.

Peer Review

There was no evidence of a peer review in the documentation.

Takeaways

1. The total costs and benefits are not reported as PVs, so it is not possible to analyze BCRs as they are usually reported. The focus on incremental costs and benefits does not enable a reader to determine if the total project cost is justified or how the relative return on investment compares to other alternatives.
2. The treatment of externalities is very limited and does not include several externalities that are explicitly accounted for in TIGER grant guidance and other agencies. In fact, in light of the change in the level of economic activity in the area, they are entirely omitted in the 2016 report.
3. Recreation benefits foregone because of lock closures are included in the formal BCA. Unit day values are used to estimate the benefits.
4. The report concludes that because the traffic base has fallen, shipment patterns have changed, and much of the without-project condition unscheduled closure re-routing around the lock that was anticipated in the feasibility analysis is no longer expected to occur; therefore, external costs due to modal diversions are inconsequential.
5. The sensitivity analysis identifies traffic demand forecasts as one of the major factors affecting the need for lock improvements and discusses them in detail. The use of congestion fees was considered in this report. Since this alternative has never been implemented on a navigation project, there is no experience for judging its actual performance. The report notes that there is a high risk that it would not perform as well as the theoretical model.
6. The study does a good job of illustrating the effect of different interest rates on the economics of the project.
7. The study did a good job of identifying the most important variables in terms of sensitivity. It does not include any discussion of how a delay in the project start date might affect the viability of the project.
8. This report discusses the effect of the timing of funding, although it makes the case that this effect should not be included in the BCA.
9. There is no mention of a peer review of this study.
10. Externalities that could not be monetized were not discussed in the report.
11. Because of a lack of detail, it is not possible to determine if discount rates are used appropriately.
12. The report illustrates the effect of less-than-optimal funding on the cost of the project.
13. The choice of a discount rate can have a profound effect on the project's economic viability.

Use of Remaining Benefit-Remaining Cost

Background

This chapter compares the RBRC Ratio metric vs. the BCR metric as a way to evaluate navigation projects under construction. Specifically, this chapter examines the following five key areas:

1. Is this RBRC approach more appropriate once projects are under construction?
2. Do other agencies re-evaluate projects that are already under construction, or is this unique to the Corps of Engineers (USACE)?
3. Do the other agencies analyzed in the study use the RBRC approach?
4. Is there a reason why the USACE sometimes re-evaluates/provides an economic re-evaluation to projects using the BCR metric instead of the RBRC metric?
5. By using the BCR instead of RBRC re-evaluation metric, are results skewed toward halting project construction?

In addition to the questions listed above, this analysis concludes by providing a synthesis of additional findings from previous chapters and offers recommendations regarding the best approach for evaluating USACE navigation projects before they begin construction and after project construction has commenced (*38*).

Introduction

The USACE relies heavily on benefit-cost analysis methods to rank and prioritize its waterway navigation infrastructure projects. As explained in previous chapters, a benefit-cost analysis (BCA) is a process of using theory and data for assessing the benefits and tradeoffs of different alternatives. More precisely, the White House Office of Management and Budget (OMB)[20] defines a BCA as a "systematic quantitative method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects (*39*)." As noted in the previous chapters, types of waterway benefits that can be derived include waterway user benefits (e.g., shipper cost savings, time savings, accident reduction, etc.); other transportation and public benefits (e.g., highway congestion reduction, highway safety improvement, etc.); cross-sector benefits (e.g., benefits to the utility sector, tourism benefits, etc.); and wider economic benefits (e.g., short- and long-term job creation, etc.) (*40*). In a properly conducted benefit-cost ratio (BCR) analysis, the total estimated benefits of a waterway navigation asset over the life of the project are compared to

[20] The White House Office of Management and Budget Circular A-94 established guidelines and discount rates for using benefit cost analysis within federal agencies. Many of the guidelines established in Circular A-94 are still used today.

the total estimated project costs. This can include the up-front capital costs, long-term operations, and maintenance costs.

The USACE has modified the traditional BCR process when analyzing projects that are already under construction. It now uses RBRC ratio, the remaining benefits to the remaining cost ratio, to rank and prioritize construction projects.[21] It is, as the name implies, the ratio of the remaining benefits of a project over the project's remaining costs; costs already incurred are not included. The USACE decided to make this change in order to provide more consistency in project evaluation. In the past, the USACE has established a RBRC threshold for ongoing projects of at least three to one (i.e., total project benefits are 3 times greater than total project costs). The USACE also required new start projects to rank in the top 20 percent of ongoing, budgeted projects of its type (*41*). Table 10 provides a summary of the economic requirements for USACE construction projects by fiscal year for new and ongoing USACE projects (*41*). (A hypothetical BCR calculation for alternative construction projects can be found in Appendix 1.)

The methodological issue with this approach is that it relies exclusively on a narrowly-defined BCA for project ranking and selection. The literature (and common practice) makes it clear that BCA should be considered part of the evaluation process, but not the sole factor. Other such factors might include the absolute amount of net benefits, security, dependency on completion of other projects, and more.

Table 10: Summary of Economic Requirements for Construction Projects, by Fiscal Year

	Threshold	
Fiscal Year	*Threshold for new start projects*	*Thresholds for ongoing projects*
2006	Must rank in the top 20 percent of ongoing, budgeted projects of its type	RBRC must be at least 3 to 1
2007	Must rank in the top 20 percent of ongoing, budgeted projects of its type	RBRC must be at least 3 to 1
2008	Must rank in the top 20 percent of ongoing, budgeted projects of its type	BCR must be at least 1.5 to 1
2009	Must rank in the top 20 percent of ongoing, budgeted projects of its type	BCR must be at least 1.5 to 1
2010-2017	BCR of at least 3.2 to 1	BCR must be at least 2.5 to 1

Source: (*41*).

[21] An illustration that explains the major steps in USACE project development and delivery process can be found in Appendix 4. For more information, see Carter, Nicole T. and Charles V. Stern. Army Corps of Engineers: *Water Resource Authorizations, Appropriations, and Activities*. Congressional Research Service Report No. R41243..

Is the RBRC approach more appropriate once projects are under construction?

While it can be difficult to objectively assess whether the RBRC approach is a more appropriate methodology once projects are under construction, there are limitations to the current approach that hinder ongoing construction projects. For example, as a project's construction proceeds, the RBRC approach emphasizes that an incremental investment will result in the realization of full project benefits, while the failure to invest will eliminate those benefits. Failing to take this into consideration, in turn, can waste the amount of investment already made in the ongoing construction project.

Project uncertainty has been noted by GAO as one reason for misunderstandings between the USACE and local project stakeholders.

While an empirical examination comparing RBRC and BCR methods for ongoing USACE projects was not publicly available, several organizations (e.g., Government Accountability Office (GAO), OMB) have suggested that the remaining benefit/remaining cost (RBRC) process could be an additional method for the USACE to consider once projects are under construction. For Fiscal Year 2017, ongoing construction projects were required to meet a BCR threshold of 2.5. However, this BCR threshold means that some projects might meet that threshold for funding one year but fail to meet it the following year, providing for more uncertainty in the construction of a USACE project. For example, a project could meet the BCR threshold set for Year 1 of construction but fail to meet the BCR threshold set by OMB the following year. This project uncertainty has been noted by GAO as one reason for misunderstandings between the USACE and local project stakeholders (*41*).

Another factor to consider is the discount rates used to conduct the analysis. The interest rate used for establishing the discount rate used by the USACE is tied to the average U.S. Treasury yield for the preceding year. Specifically, according to Economic Guidance Memorandum 7-01, *Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2017,* the discount rate is set in the following manner:

> "The interest rate for discounting, that is, converting benefits and costs to a common time basis, is set each fiscal year in accordance with Section 80 of Public Law 93-251. HQUSACE[22] obtains the rate from U.S. Department of Treasury, which computes it as the average market yields on interest-bearing marketable securities of the United States that have 15 or more years remaining to maturity.

[22] Headquarters, United States Army Corps of Engineers.

> The compound rate is effective as of 1 October of each year. It is based on yield data for average yield data for the entire previous fiscal year, and thus the discount rate for the fiscal year above is based on average yields during the previous fiscal year. According to law the rate may not be raised or lowered more than one quarter of one percentage point in any year." [23]

Appendix 2 provides a listing of discount rates used by federal agencies since 1957.

Under the RBRC approach used before 2006, each USACE division was authorized a set amount of funding. Divisions generally allocated that funding to projects according to two conditions: 1) all projects met administration priorities and 2) construction and investigations (i.e., preconstruction engineering and design) projects that met a certain stage in the construction process had benefits that at least equaled costs (*41*). Importantly, USACE officials at that time provided funding to all ongoing projects.

After 2006, there was a shift toward a more standardized approach regarding project selection and prioritization. The overall effect of this change is that the number of construction and investigation projects declined while the dollar amount requested *per project* increased. For example, according to GAO, from FY 2000-2010 the number of projects included in the USACE budget request decreased by about 52 percent, and the number of investigations projects decreased by about 79 percent. During the same period, the average request per construction project increased from $7.0 million in FY 2001 to $17.3 million in FY 2010, representing a 14.7 percent annual increase over that time. USACE Operations and Maintenance (O&M) projects saw no notable decline during this period (*41*). Since then, annual USACE funding has increased, while the total number of projects that have received funding have remained relatively constant. The most recent budget request for 2018 included no funding for new USACE studies or new construction projects, although it did include funding for ongoing navigation and flood-risk reduction projects with a BCR of greater than 2.5 to 1. As shown in Figure 3 and Figure 4, while annual USACE funding by year and by account has increased overall in the past several fiscal years, Congress, the USACE, and the Administration appear to view maintaining the performance of existing infrastructure as a priority rather than authorizing new start construction projects (*42*).

With an RBRC approach, the remaining project costs are assessed, the benefits are reassessed, and downsides associated with decreasing funding to an ongoing construction project become clearer.

[23] Federal discount rates used for USACE project evaluation from Fiscal Year 1957 to 2017 can be found in Appendix 2.

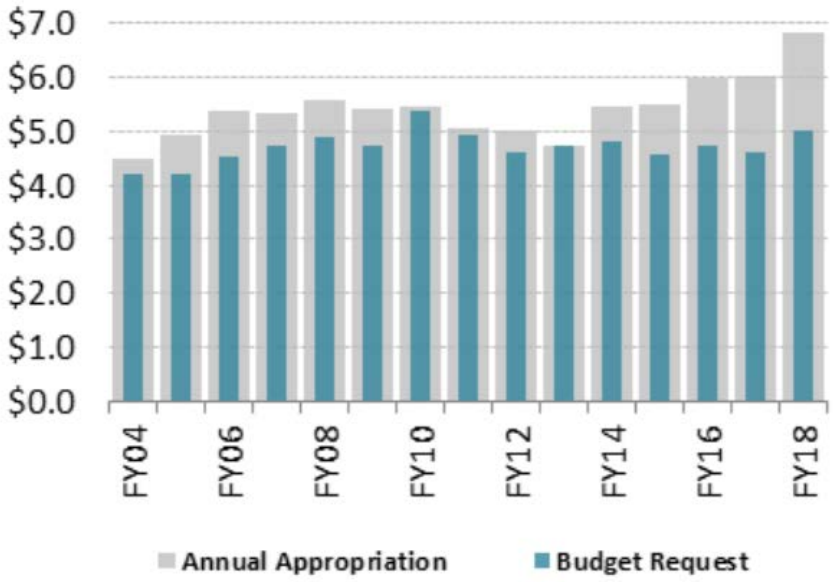


Figure 3: Annual Budget Request and Enacted Appropriations for USACE Civil Works, 2001-2018.

(*Note: Nominal $ in billions.)*

Source: (*43*).

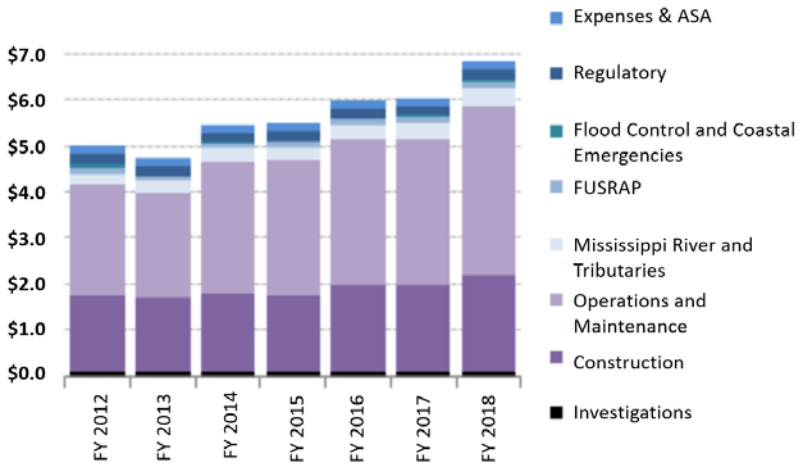


Figure 4: USACE Funding by Account, FY 2012-2018

(Notes: ASA = Assistant Secretary of the Army. Regulatory = Regulatory program for permitting nonfederal activities in or affecting regulated waters and wetlands. FUSRAP = Formerly Utilized Sites Remedial Action Program; Nominal $ in billions)

Source: (*42*).

However, it is also worth noting that the specific approach the Administration has used in formulating its budget requests has been to rely on the BCR as a tool for reducing the number of funded projects in the budget document. This has resulted in the threshold amount being modified from year to year to limit the number of projects selected for approval and not the fact that a reevaluation was performed or that a BCR or RBRC metric was or wasn't used. Regardless, incorporating greater consideration of RBRC analysis can help to provide additional data for USACE and OMB officials to help budget decision makers better assess the unintended consequences of project reevaluation. When USACE performs reevaluations, the benefits of an infrastructure project are reassessed depending on the nature of how the project has changed, while project costs are updated based on inflationary adjustments (See Appendix 3 for more information on different levels of benefits reassessment that must occur.) With an RBRC approach, the remaining project costs are assessed, the benefits are reassessed, and downsides associated with decreasing funding to an ongoing construction project become clearer.

When USACE performs reevaluations, the benefits of an infrastructure project are reassessed depending on the nature of how the project has changed, while project costs are updated based on inflationary adjustments.

Do other agencies re-evaluate projects, or is this unique to the USACE?

Other agencies have considered economic re-evaluation practices for rulemaking—a response in part to decades of directives from the White House and Congress—but none of the agencies reviewed for this analysis (i.e., the Bureau of Land Management, the Environmental Protection Agency, and the Department of Transportation) have re-evaluated projects once they were authorized. There has been a push in recent years to require independent federal agencies to evaluate new *regulations* and periodically re-evaluate existing ones. However, the analytical requirements for evaluating federal regulations are not clear or consistent. As shown in Table 11 below, the depth and coverage of analytical requirements can vary by guidance document, leading to inconsistent practices by independent federal agencies conducting economic evaluation or re-evaluation (*43*).

Table 11: BCA Analytical Requirements Required by Federal Guidance Document.

Guidance Defining Analytical Requirement	Guidance Affects Cabinet Departments and Independent Agencies	Guidance Affects Independent Regulatory Agencies
Executive Order 12866	Yes	No
Circular A-4	Yes	No
Unfunded Mandates Reform Act	Yes	No
National Environmental Policy Act	Yes	Yes
Regulatory Flexibility Act	Yes	Yes
Paperwork Reduction Act	Yes	Yes

Source: (*43*).

As discussed previously, in 2012 the USACE issued new guidance for re-evaluating BCRs for budget development. For new construction projects, this guidance requires an economic analysis to be done every three years; for continuing construction projects, an economic analysis must be done at least every five years (*46*). However, this practice appears to be unique to the USACE. Of the three agencies that were reviewed for this analysis, there were no observed examples of these agencies using standardized economic re-evaluation practices for project prioritization or selection to the extent used by the USACE. While OMB has directed (and some federal agencies have considered) economic re-evaluation of past rules and regulations, none are applying economic-re-evaluation processes for project decisions on an ongoing basis.

Do the other agencies analyzed in the study use the RBRC approach?

The Department of Interior highlights a few of the more common methods of estimating benefits and impacts that can be monetized, such as a BCA. Remaining benefit-remaining cost analyses are not specifically mentioned as a standard methodology. The Environmental Protection Agency follows the OMB guidance expressed in Circular A-4. Circular A-4 describes two analytical approaches: benefit-cost analysis (BCA) and cost-effectiveness analysis (CEA). There is no mention of remaining benefit remaining cost analysis (44).

The Department of Transportation, TIGER Grant Program was replaced by the BUILD Grant Program in 2018. Similar to the TIGER Grant Program, a benefit-cost analysis is required and the program has a process that is akin to a remaining benefit-remaining cost analysis. The BUILD program allows projects to be subdivided into components, some of which may be completed by "parties other than the applicant".

> *"DOT may award funds for a component, instead of the larger project, if that component (1) independently meets minimum award amounts… and all eligibility, requirements…; (2) independently aligns well with the selection*

criteria…; and (3) meets National Environmental Policy Act (NEPA) requirements with respect to independent utility. Independent utility means that the component will represent a transportation improvement that is usable and represents a reasonable expenditure of DOT funds even if no other improvements are made in the area, and will be ready for intended use upon completion of that component's construction. All project components that are presented together in a single application must demonstrate a relationship or connection between them" (45).

Allowing projects to be divided into components makes it possible for a project that is already underway to complete a BCA on one or all of the remaining phases for the grant application. No allowance is made for re-evaluating projects once construction commences.

Is there a reason why the USACE re-evaluates/provides an economic re-evaluation to projects using the BCR metric?

As discussed, there are potential benefits to using the RBRC approach for making project investment decisions, especially for ongoing construction projects. This is in part because RBRC is a ratio that represents the remaining benefits of a project divided by its remaining costs to complete the project. This approach takes into consideration that an incremental investment will result in the realization of full project benefits while the failure to invest will eliminate those benefits. Failing to take this into consideration, in turn, can waste the amount of investment already made in the ongoing construction project (*42)*.

While there may be multiple reasons to explain why USACE officials re-evaluate USACE construction projects on an ongoing basis, one reason appears to best explain this decision: an attempt by USACE officials to better standardize project selection processes used, and to ensure that all decisions are made with updated economic analysis. In response to increasing project demands and declining funding as well as an effort to better compare different types of projects, in 2012 the USACE issued a memorandum citing a recent report by the USACE Engineer Inspector General that found "inconsistencies in both policy and implementation responsibility pertaining to the execution of BCR updates (*46*)."[24] In response to this concern, the USACE outlined that moving forward, a BCR "will be calculated based on the benefits in the latest approved official document, such as the Feasibility Report, Chief of Engineers Report, Limited or General Reevaluation Report (LRR or GRR), Engineering Documentation Report (EDR), or other reports where economics are updated in accordance with ER 1105-2-100 (*46*)."

[24] Researchers were informed that the report is an IG product and the release authority is the Department of the Army IG (DAIG) through the FOIA process.

The USACE further ordered that "an updating of economic benefits and costs should be undertaken in those situations where the Project Delivery Team (PDT) determines changes in project scope and cost warrant a reassessment (*46*)." Specific to continuing construction projects, this guidance also sets time requirements on how often an economic analysis must be conducted and mandates that an economic update should be conducted periodically. Specifically, this guidance requires that if that price level is more than five fiscal years old, USACE guidance mandates that an economic update must be performed so that "BCR and the remaining benefits remaining costs ratio (RBRC) are current and consistent (*46*)." This guidance established non-negotiable time requirements for using updated (i.e., less than five-year-old) economic analysis calculations for developing an overall project BCR.

The 2012 guidance, as summarized in Figure 5 below, requires economic project re-analysis with the level of analysis depending on how the project has changed since the last economic analysis was performed. Level 1 and 2 involve some economic re-analysis, while Level 3 involves a more extensive review, and Level 4 requires a review of the entire BCR.[25]

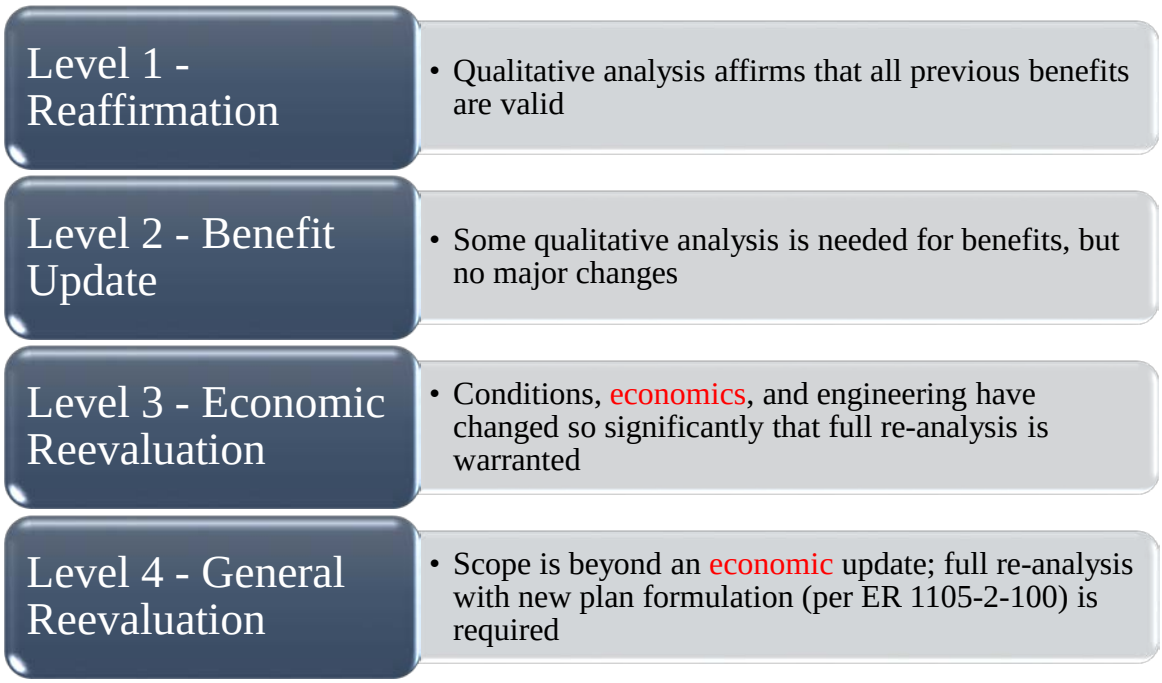


Figure 5: USACE Economic Update Levels.
Source: (*46*).

[25] Additional information regarding the Economic Update Levels and Reporting Requirements discussed in Figure 3 can be found in Appendix 3.

By using the BCR re-evaluation metric, are results skewed toward halting project construction?

Re-evaluating a project that is already under construction using a standard BCA approach rather than RBRC could cause the BCR to change significantly and affect its funding priority. This change would be a direct result of delays in completing the construction rather than the underlying justification for initiating the project, possibly resulting in halting project construction. Continually re-evaluating project BCRs for new and ongoing construction projects can have the potential of introducing uncertainty into the project construction process. This is especially the case for new construction projects that have a relatively low BCR score (i.e., a score between 1.0 and 1.9). For example, if a new construction project was started in year one with a BCR score of 1.8 but the economic evaluation was done several years prior, depending on how the project has changed USACE guidance could require an economic re-evaluation to occur again during project construction.

> It is possible that the required BCR minimum threshold might change during the construction period of a project.

During the economic re-evaluation, it is possible the BCR calculation could decrease from 1.8 to 1.5 (or even below 1.0) depending on changes in estimated project benefits or cost forecasts. Furthermore, it is also possible that the required BCR minimum threshold might change. Changes in the BCR score as mandated by economic re-evaluation could mean that the project drops in its overall priority ranking, resulting in decreased overall project funding.

Takeaways

The responses to questions 1-5 discuss how benefit-cost calculations can lead to different USACE project selection decisions. As explained, choices in how the USACE calculates its project BCR can have a significant effect on which projects receive a greater priority ranking.

Table 12 summarizes the major findings discussed in the previous chapters and additional findings from this chapter (*47*). Further discussion is provided in the paragraphs that follow.

Table 12: Findings from Previous Chapters and Additional Findings.

Original Findings	Additional Findings
USACE takes a narrow view of societal impacts, essentially limiting them to savings in transportation costs.	Not considering societal impacts into BCR benefit calculations can also put ongoing construction projects at a disadvantage.
USACE does not present its findings in terms of all costs versus the present value of all benefits.	Calculating USACE authorization BCRs using the 3% discount rate can sometimes be incompatible with the 7% discount rate mandated by OMB to make budgetary decisions. The overall effect of this can further put ongoing construction projects at a disadvantage.
For the most part, USACE does a credible job of identifying variables with the greatest sensitivity.	No additional finding.
There is much valuable information in the modeling and forecast elements of USACE feasibility reports.	RBRC calculation information could also be considered to help USACE decision makers better understand how ongoing construction projects might be affected by the BCR project prioritization metric.
While USACE has taken the position that the effect of delayed funding should be divorced from the benefit-cost analysis of a project, it would still be worthwhile to show how long a project can be delayed before the funding issues reduce the BCR to less than 1 (or some other trigger point.)	Higher-cost, multi-year construction projects tend to be especially vulnerable to funding uncertainty.

Previous chapters revealed that while in theory a benefit-cost analysis helps policymakers ensure that the benefits of a proposed publicly-funded infrastructure project exceeds total project costs, the USACE' approach results in nearly all of the project benefits accruing from transportation savings only and does not take into consideration other, broader societal effects for each project. This narrow BCR calculation approach differs from practices of other federal agencies. For example, USDOT, in evaluating Better Utilizing Investments to Leverage Development (BUILD) Transportation discretionary grants, awards project funding based on the following project criteria: safety, state of good repair, economic competitiveness, environmental protection, quality of life, innovation, partnership, non-federal revenue for transportation infrastructure investment, demonstrated project readiness, and geographic

diversity among recipients (48). These criteria allow project decision makers to assess project benefits beyond just transportation savings. Critically, this approach helps ensure that projects with higher up-front total costs (but with more total benefits to society) or projects where benefits occur over an extended time period, are fairly compared to projects with lower up-front costs or more immediate benefits.

It is worth noting that the use of discount rates is another area that makes the USACE unique: while many federal agencies follow OMB guidance to evaluate projects using a 7 percent discount rate to calculate project BCRs, the USACE uses an interest rate tied to the average U.S. Treasury yield for the preceding year. The OMB guidance places a typical lock and dam project at a strong disadvantage compared to projects with shorter time frames or more immediate benefits.

The OMB guidance places a typical lock and dam project at a strong disadvantage compared to projects with shorter time frames or more immediate benefits. It is for this reason that RBRC may be a better method for making project evaluation and prioritization decisions.

In addition to the challenges discussed above, unpredictable, inconsistent, and unreliable funding can be a problem that especially affects projects that require multi-year appropriations. This is because a project can receive a high BCR score when it is authorized and should, in theory, continue to receive a high BCR score each year the USACE, Congress, and OMB develop the budget for that year. However, because OMB makes annual budgeting decisions, oftentimes some projects that are fully funded one year may not receive full funding the next year. These funding challenges can cause adverse effects to how an ongoing construction project scores relative to the USACE' other priorities because a reduction in funding can cause significant disruption in the final project completion schedule of ongoing construction projects, which typically results in significant cost escalation.

Final Thoughts and Conclusions

Concluding Thoughts

In theory, a BCA should determine if a proposed investment is acceptable based on its return on investment to society. USACE takes a very narrow view of societal impacts, essentially limiting them to the savings in transportation costs. The other agencies that were investigated in this report encourage their analysts to take a broader view of what is positive or negative for society. In USACE analyses, an NED project can only be selected based on transportation savings. This seems to be a shortsighted approach if the impact on society is relevant. In an era of severe competition for funds, evaluating a more complete range of societal impacts would give navigation infrastructure a better chance of acquiring needed funds.

USACE does not present its findings in terms of the PV of all costs versus the PV of all benefits. The approach of presenting average annual values makes it very difficult to determine if an investment is justified, and if it is, how it compares to other alternative projects. The calculations that take nominal benefits and costs and converts them to average annual values are not presented, so much of the detail behind the project economics is difficult to analyze.

The effect of delayed or less-than-optimal funding is not explored in most USACE analyses. In fact, USACE assumes a timely and efficient flow of funds, which history has shown will not occur. An assessment of the effect of the funding stream on the project would give both the Administration and Congress a better appreciation of the urgency of funding requests.

The three studies that were reviewed in this report do not provide a clear picture of how well the peer review process is working. It appears that getting peer reviewers involved in the assumptions and reporting formats would be of benefit.

For the most part, USACE does a credible job of identifying variables with the greatest sensitivity. If there is a weakness in this area, it is in reporting how these variables influence (or not) the final selection of the NED project alternative. Additionally, when various scenarios are presented, there is no discussion of the likelihood that any given scenario will occur.

There is much valuable information in the modeling and forecast elements of USACE feasibility reports. With a few minor modifications to scope and methodology in terms of the analytical approach, that information could be elevated to an even higher level of importance than it is given today.

While funding decisions should not be incorporated into a BCA, it would still be worthwhile to show how long a project can be delayed before the funding issues reduce the BCR to less than 1 (or some alternate trigger point).

Recommendations

- **Consider following best practices used by other agencies (e.g., USDOT) for incorporating broader impacts beyond just transportation savings (e.g., societal) impacts into BCR calculations.**
  USDOT BUILD transportation discretionary grants are awarded project funding based on the following project criteria: safety, state of good repair, economic competitiveness, environmental protection, quality of life, innovation, partnership, non-federal revenue for transportation infrastructure investment, demonstrated project readiness, and geographic diversity among recipients. By incorporating a wider array of project benefits beyond just transportation savings, the positive benefits of public investment projects become clearer. This is especially the case with higher cost projects, where the up-front costs can mean that a significant amount of benefits over the life of the project must be realized to justify the project. By focusing only on a relatively narrow aspect of the transportation savings that might result from the project rather than other externalities (e.g., wider economic and social impacts), larger projects that could help to significantly improve the nation's waterway system and improve the general welfare over time could be put at a disadvantage to lower cost projects with benefits that are more immediate or shorter-term.

- **Consider the reality of unpredictable and unreliable funding for USACE projects when making project authorization decisions.**
  The unpredictable and unreliable nature of funding USACE waterway projects has been shown to be a long-term challenge for USACE budget planners (*49*,*50*). While the scope of this analysis is on the benefit-cost process (which is considered outside of budgeting decisions), the overall *effect* of unpredictable and unreliable funding means that some projects (particularly ongoing construction projects with barely positive [~1.0 to 1.9] BCRs that are experiencing escalating costs) are most affected by unpredictable funding. In some instances, USACE has built the funding uncertainty into the BCA by inflating costs and adding in contingency factors. However, this is not sound BCA practice—the economics of the project must be evaluated separately from the manner in which Congress may or may not fund the project. Furthermore, it is not clear that techniques used for evaluating projects are consistent with standards used by other federal agencies. Taking into consideration this reality when making budgeting decisions might help the USACE policymakers weigh the full consequences when authorizing a transportation project.

- **Consider revisiting the process discussed in Civil Works Policy Memorandum (CWPM) 12-001, *"Methodology for Updating Benefit-Cost Ratios (BCRs) in Budget Development."***
  The process outlined in CWPM 12-001 guides USACE division officials on how to calculate and update BCRs for USACE waterway projects and was intended to help streamline project selection while taking into consideration the backlog of ongoing USACE projects underway.

As discussed in the points above, however, this methodology requires different levels of economic re-evaluation depending on the extent to which the project has changed since the last time project benefits were assessed. This methodology also does not differentiate economic re-evaluation requirements based on high-cost construction projects versus ongoing projects. As noted in this chapter and previous chapters, higher-cost projects with benefits occurring over an extended period tend to face a disadvantage in this scenario. An approach that recognizes these differences but also allows for RBRC to factor meaningfully in the overall budget prioritization process might be one way to assuage the limitations inherent when comparing high-cost, ongoing construction projects with other O&M USACE projects.

- **Consider incorporating RBRC metrics into project prioritization, especially for projects that tend to be at a relative disadvantage using the current USACE BCR calculation methodology (e.g., ongoing construction projects, etc.)**
  As discussed previously, there is valuable information in the modeling and forecast elements of USACE feasibility reports. RBRC calculation information could also be considered to help USACE decision-makers better understand how ongoing construction projects might be affected by the BCR project prioritization metric.

Appendix 1: Hypothetical BCR Calculation for Two Alternative Construction Projects

Alternatives for reducing transportation costs			
Channel deepening		**Channel widening**	
		Benefits	
Savings due to lower per-unit cost of transporting goods - a deeper channel can accommodate larger vessels	$6,200,000	**Savings due to reduced delays** - a wider channel would allow two-way vessel traffic	$2,500,000
Savings due to reduced delays - deep-draft vessels do not have to work around the tide schedule	$1,400,000	**Savings due to reduced delays** - a wider channel would reduce weather-related delays	$700,000
Savings due to reduced cargo handling costs - there is a reduced need to transfer goods to shallow-draft vessels	$500,000		
Total increased benefits	**$8,100,000**	**Total increased benefits**	**$3,200,000**
		Costs	
Construction and maintenance	**$3,100,000**	**Construction and maintenance**	**$1,700,000**
		Benefit-cost ratio	
	2.61		**1.88**
Eligible for authorization (FY2010)[a]	YES	Eligible for authorization (FY2010)[a]	YES
Eligible for budgeting as an ongoing project (FY2010)[b]	YES	Eligible for budgeting as an ongoing project (FY2010)[b]	NO
Eligible for budgeting as a new start project (FY2010)[c]	NO	Eligible for budgeting as a new start project (FY2010)[c]	NO

Source: GAO Analysis of U.S. Army Corps information.

[a]In order to be eligible for authorization, most construction projects must have a BCR of at least 1.

[b]Projects that do not qualify for budgeting by restoring ecosystems or addressing risk to human life must meet BCR thresholds set by the administration. In fiscal year 2010 the BCR threshold for ongoing projects was 2.5. These examples assume that the projects would not qualify for budgeting for environmental or risk to human life reasons.

[c]In fiscal year 2010 the BCR threshold for new start projects was 3.2. These examples assume that the projects would not qualify for budgeting for environmental or risk to human life reasons.

Appendix 2: Federal Discount Rates for USACE Project Formulation and Evaluation

Fiscal Year	OMB Circular A-47	Senate Document No. 97 (1962)	Water Resources Council (1968)	Water Resources Council (1973)	Principles & Standards (1973)	Section 80 WRDA 1974 (Public Law 93-251)
1957	2.500					
1958	2.500					
1959	2.500					
1960	2.500					
1961	2.625					
1962	2.625	2.625				
1963		2.875				
1964		3.000				
1965		3.125				
1966		3.125				
1967		3.125				
1968		3.250				
1969		3.250	4.625			
1970			4.875			
1971			5.125			
1972			5.375			
1973			5.500			
1974			5.625	6.875	5.625	5.625
1975						6.125
1976						6.375
1977						6.375
1978						6.625
1979						6.875
1980						7.125
1981						7.375
1982						7.625
1983						7.875
1984						8.125
1985						8.375
1986						8.625
1987						8.875
1988						8.625
1989						8.875
1990						8.875
1991						8.750
1992						8.500
1993						8.250
1994						8.000
1995						7.750
1996						7.625
1997						7.375
1998						7.125
1999						6.875
2000						6.625
2001						6.375
2002						6.125
2003						5.875
2004						5.625
2005						5.375
2006						5.125
2007						4.875
2008						4.875
2009						4.625
2010						4.375
2011						4.125
2012						4.000
2013						3.750
2014						3.500
2015						3.375
2016						3.125
2017						2.875

Appendix 3: CWPM 12-001 Economic Update Levels and Reporting Requirements

Update Level	Scope
Level 1 – Reaffirmation (Qualitative analysis affirms that all previous benefits are still valid)	• Qualitative re-verification of key benefit assumptions • Current cost estimates • Minimal effort to verify no new engineering is needed • Discount costs back to price level of last approved report • Show BCR and RBRC • No new plan information • No new NEPA
Level 2 – Benefit Update (Some quantitative analysis is needed for benefits, but no major changes)	• Use sampling to update key data and assumptions • Re-run economic benefit model • Minimal effort to verify no new engineering is needed • Current cost estimates • Show BCR and RBRC at current price levels • No new plan information • No new NEPA
Level 3 – Economic Reevaluation (Conditions, economics, and Engineering have changed significantly that full re-analysis is warranted)	• Collect all new Economic and Engineering data • Fully update benefits • Obtain current cost estimates • Show BCR and RBRC at current price levels • No new plan information • No new NEPA
Level 4 – General Reevaluation (Scope is beyond an economic update)	• Full re-analysis with new plan formulation • Follow ER 1105-2-100

Reporting requirements for each level discussed in the table above are summarized further below.

1. LEVEL 1: Reaffirmation Report
    a. Clearly document authority;
    b. Clearly document scope has not changed since last approved report (i.e. still within Chiefs discretionary authority);
    c. Clearly document all of key economic (benefit) assumptions;

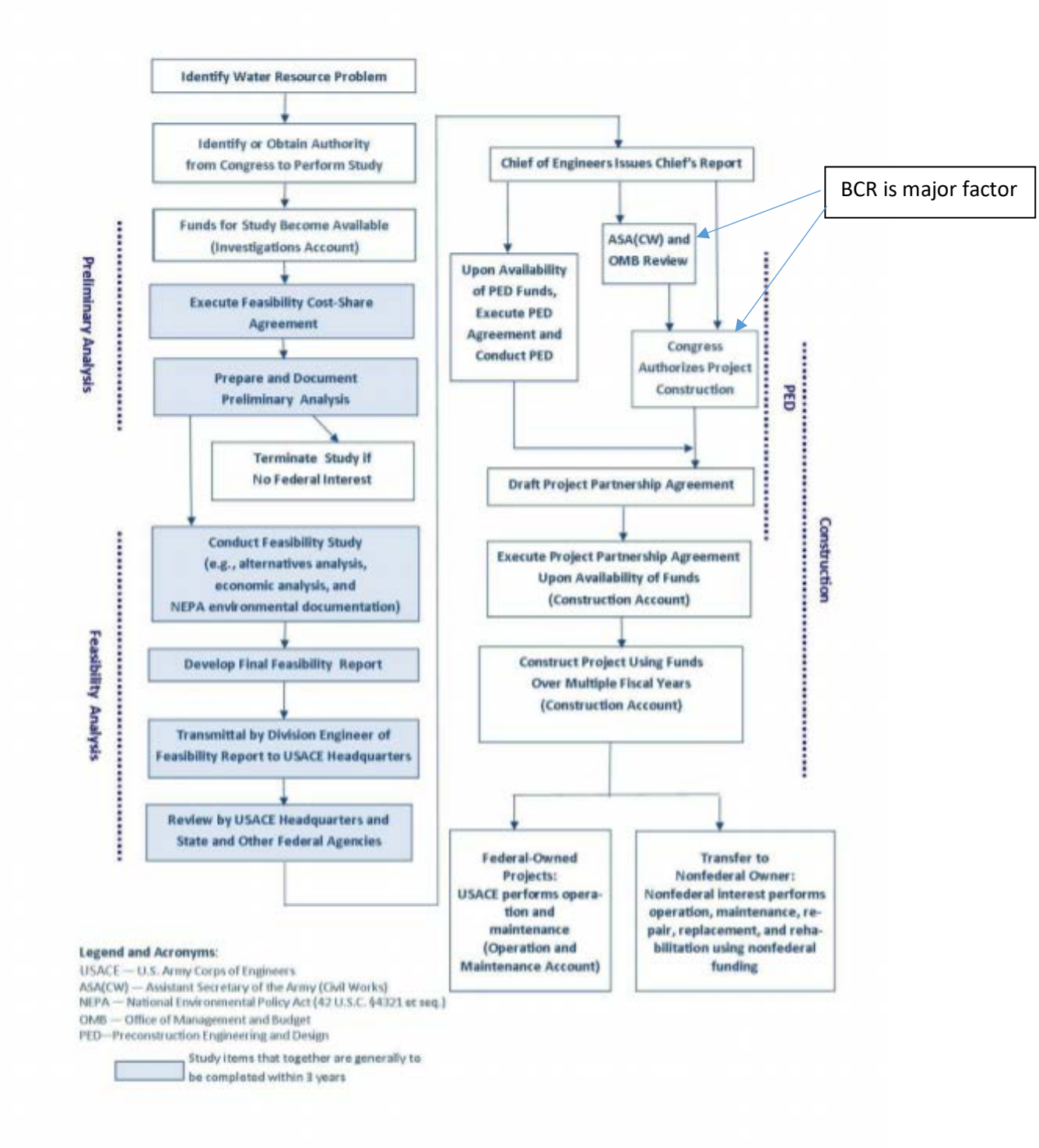
d. Clearly document, through qualitative analysis, that key assumptions have not change since last approved report;
e. Clearly document that engineering does not need updating (e.g. H&H) – if *there is a need, go to at least Level 3;*
f. Display benefits at price level of last approved report;
g. Display updated costs;
h. Discount costs back to price level of last approved report;
i. Display BCR and RBRC for both current discount rate and 7 -percent discount rate;
j. Recalculate 902 Limit and display all of the required tables and fact sheets in Appendix G of ER 1105-2-100;
k. Signed District Approval Sheet (see supplement 2).

2. LEVEL 2 -Benefit Update Report
    a. Clearly document authority;
    b. Clearly document scope has not changed since last approved report (i.e. still within Chiefs discretionary authority);
    c. Clearly document all of key economic (benefit) assumptions;
    d. Clearly document changes in economic assumptions o Use sampling to update economic data. Re-run economic model to update benefits to current price level;
    e. Clearly document that Engineering does not need updating (e.g. H&H) -*if there is a need, go to at least Level* j;
    f. Display benefits at current price levels;
    g. Display updated costs;
    h. Display BCR and RBRC for both current discount rate and 7-percent discount rate;
    i. Recalculate 902 Limit and display all of the required tables and fact sheets in Appendix G of ER 1105-2-100;
    j. Signed District Approval Sheet (see supplement 2).

3. LEVEL 3 -Economic Reevaluation Report (ERR)
    a. Clearly document authority;
    b. Clearly document scope has not changed since last approved report (i.e. still within Chief's discretionary authority);
    c. Clearly document all of key economic (benefit) assumptions;
    d. Collect all necessary economic and engineering data for full reassessment of benefits;
    e. Re-run economic model using updated economic and engineering data;
    f. Display benefits at current price levels;
    g. Display updated costs;
    h. Display BCR and RBRC for both current discount rate and 7 -percent discount rate;
    i. Recalculate 902 Limit and display all of the required tables and fact sheets in Appendix G of ER 1105-2-100;
    j. Signed District (see supplement 2).

4. LEVEL 4 - General Reevaluation Report (GRR)
    a. Follow ER 1105-2-100

Appendix 4: Major Steps in USACE Project Development and Delivery Process



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