NORTH DAKOTA
STATE WATER COMMISSION

North Dakota Guidance for Economic Analysis of Flood Control and Water Conveyance Projects

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Preface

The North Dakota Guidance for Economic Analysis (EA) of Flood Control and Water Conveyance Projects was developed with a State Economic Development (SED) perspective in mind. SED analysis is concerned with incremental changes in the value of a good or service from the State of North Dakota's perspective, and the costs that bring about that change. SED analyses lead to project evaluation metrics such as benefit-cost ratios (BCR), Net Present Value (NPV), and others that enable projects to be compared and analyzed from the perspective of net value to the state. By Legislative mandate, these types of analyses have been determined to be appropriate and necessary – when the state is being asked to make investments as a cost-share partner.

NORTH DAKOTA
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I. Introduction and Overview

In 2017, the North Dakota Legislature required the State Water Commission (SWC) to include economic analysis in their project reviews and inform the SWC of such findings. In order that project sponsors and their consultants could conduct those analyses, the SWC prepared this guidance which is conceptually similar to Federal guidance but from the State's perspective.

1.1 Background - ND Legislation and Statutes

The 65th (2017) Legislative Assembly passed House Bill 1020 – the North Dakota State Water Commission's budget bill. Section 21 of that bill provided for a new section of North Dakota Century Code (NDCC), Chapter 61-03. Specifically, NDCC 61-03-21.4 requires:

> The State Engineer shall develop an economic analysis process for water conveyance projects and flood-related projects expected to cost more than one million dollars, and a life cycle analysis process for municipal water supply projects. When the State Water Commission is considering whether to fund a water conveyance project, flood-related project, or water supply project, the State Engineer shall review the economic analysis or life cycle analysis, and inform the State Water Commission of the findings from the analysis and review.

The 65th Legislative Assembly also passed HB 1374, providing definitions for "economic analysis" and "water conveyance project" in NDCC 61-02-02.

> *Economic analysis* means an estimate of economic benefits and direct costs that result from the development of a project.
>
> *Water conveyance* project means any surface drainage works, bank stabilization, or snagging and clearing of watercourses.

1.2 Purpose

Economic analysis (EA) is a critical element of water resources planning because it not only evaluates the economic justification of alternative plans but it can assist in plan formulation. Although economic analysis is traditionally performed by economists, the implications of the economic analysis (which often can dictate whether a project is implemented) make it imperative that the concepts, methods, and tools used in the economic analysis be understandable to: a) the other specialists involved in feasibility

Steps in a procedure may be abbreviated by reducing the extent of the analysis and amount of data collected where greater accuracy or detail is clearly not justified by the cost of the plan components being analyzed (P&G, 1983, p. 19). The level of effort to determine efficiency (feasibility) of a project should be appropriate to the project scope/ scale (P&R, 2013).

studies, b) management who must make a decision concerning the proposed project, and c) the various stakeholders who are involved in the planning process and who will ultimately be affected by the project.

To meet the statutory requirements of NDCC 61-03-21.4, this document, *Guidance for Economic Analysis of Flood Control and Water Conveyance Projects*, has been developed to:

- Explain the EA concept (Section 2);
- Outline the basic elements of what is included in EA (Sections 3 & 4);
- Provide an overview of why EA is conducted, how it's used, and what is included; and
- Provide a process for conducting EA – from a North Dakota perspective (later referred to as SED) (Sections 4, 5, & 6).

The entire analytical process needs to be understandable in lay terms and implementable by project sponsors or their consultants. This requires simplification of widely available methods for economic analysis, which, in no way, reduces the efficacy of such analysis.

1.3 Federal and State Economic Analysis Guideline

It is critical to understand Federal guidance, as many agencies (Federal and State) rely on Federal principles as a starting point for conducting economic analysis. Federal agencies engaged in water and related land resources development must follow the *Principles & Guidelines* (P&G, 1983). All other federal agencies must follow *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (published by the President's Office of Management and Budget, October 29, 1992). Federal agencies may supplement the P&G with their own guidelines and procedural manuals such as the NRCS Natural Resource Economics Handbook.

The P&G sets forth principles "…intended to ensure proper and consistent planning by federal agencies in the formulation and evaluation of water and related land resources implementation studies," and "…establish standards and procedures for use by federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies." Key elements include more detailed discussions of Federal planning standards (i.e., how to implement the P&G process) as well as specific concepts and procedures for computing benefits that are not typically expressed in monetary units, for example, municipal, industrial, and agricultural water supply; urban and agricultural flood damage; power (hydropower); and transportation (inland and deep draft navigation, recreation, and commercial fishing).

This guidance is for a State Economic Development (SED) model, similar to the NED, but from a state perspective.

Recommended approaches outlined in this document are consistent with the P&G but are focused on preparing economic analysis based on the benefits that contribute to the State of North Dakota's economic development. The P&G identifies four categories of benefits: National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). This guidance is for a State Economic Development (SED) model, similar to the NED, but from a state perspective. It only includes direct, measurable benefits and costs, as specified by the Legislature. It does not include secondary benefits (federal RED), such as jobs created, gross business volumes (obtained using a multiplier), or tax revenues generated; since these are not part of an economic efficiency test.

2. Economic Analysis Methods and Measures

Economic analysis is a logical, systematic approach to finding the optimum use of the State's scarce resources (measured in dollar terms whenever possible), involving comparison of two or more alternatives in achieving a specific objective under the given assumptions and constraints. It explicitly considers the value of resources employed and attempts to measure the private and social costs and benefits of a project to the community or economy. Economic analysis takes a broader perspective, including, in principle, ALL benefits and costs to whomsoever they accrue (in State), whenever they accrue (in State, now or in the future) and wherever they accrue (in State) from the completion of a project.

The level of effort to carry out an EA varies from very little to extreme, depending on the availability of data, hydrologic models, and disciplinary professionals. Using secondary data, assumptions, and expert judgment, an EA can be done with little effort, yet still be defensible (the EA presented in section 5.2 and Appendix B uses this approach). At the other extreme, developing site specific data and refined hydrologic models can lead to a more precise outcome, but it may not be any more accurate, and the level of effort (and cost) could easily be 10x or even 100x more.

Several metrics resulting from economic analysis are useful for decision-making and may be used to help select the best of many projects, or to prioritize several, from the State's perspective.

2.1 Benefit to Cost Ratio (BCR)

The benefit-cost ratio sums the present values of total benefits and costs using a discount rate (see Section 3.2). Benefits and costs are then presented as a ratio with benefits as the numerator and costs as the denominator. A ratio greater than one (>1.0) indicates benefits exceed costs and the project is economically justifiable. SED benefits are estimated using the EA method described below, which is, in essence, a state-level BCR.

$$BCR = \frac{PVB}{PVC}$$

Where: PVB present value of benefits
PVC present value of costs

2.2 Least Cost Alternative (cost effectiveness)

Looking at just the cost side of an economic analysis will show which project has the lowest overall cost, but accomplishes the objective. Cost effectiveness measures need to be done by looking at alternatives that provide identical outcomes, or using a cost/unit output as the metric. (The companion State LCCA guidance is based on cost effectiveness.)

$$\text{Least Cost} = \text{Lowest PVC}$$

2.3 Net Benefits/Net Present Value (NPV)

The net benefits, or Net Present Value (NPV), is the difference between the present values of total benefits and costs of a project. To ensure fair comparisons, all benefits and costs are adjusted to present values using a discount rate. If the NPV is positive, the benefits of the project exceed its expected costs and the alternative is desirable relative to baseline conditions. A project is economically justified if the present value of its benefits exceeds the present value of its costs over the life of the project. One caveat to consider is that NPV shouldn't be used to compare different-sized projects.

$$NPV = PVB - PVC$$

2.4 Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) is the discount rate that results in net benefits equaling the net costs (i.e., the "breakeven" point where BCR = 1.0, and NPV = 0.0). The IRR approach uses the NPV formulation to sum costs and benefits over time. However, the NPV is set equal to zero and the discount rate that equates benefits and costs is determined. The resulting discount rate can then be compared to the Federal discount rate or other rates of return on alternative investments.

$$IRR = \text{The Discount Rate That Makes NPV Zero}$$

2.5 Payback Period

This is the number of years for project benefits to repay initial project costs. Or put another way, the number of years for the project to break even on the initial investment cost is the payback period. Obviously, the shorter the payback period the better. For example, if the BCR = 1.0, it takes the assumed life of the project (50 years) to repay the initial investment cost and reach a breakeven point. Alternatively, if the BCR is <1.0, the project never reaches a breakeven point between benefits and costs during the assumed analysis period of 50 years. When the BCR is >1.0, project costs are repaid in less than the assumed life of the project.

$$\text{Payback Period} = \text{When Cumulative PVB} = \text{Cumulative PVC}$$

3. Principles of Economic Analysis

There is only one widely accepted process for conducting economic analyses—Benefit-Cost Analysis. For all agencies (Federal and State) EA (BCA) guidelines are the same in principle, some are just more pedantic (i.e., detail oriented) than others. The Federal process is not inherently complicated, unless the problem being addressed or the alternatives are complicated. Furthermore, the P&G notes that the Federal EA process can be abbreviated where "greater accuracy or detail is clearly not justified by the cost of the plan components being analyzed." (P&G, 1983, p. 8)

EA is a conceptual framework that quantifies as many of the costs and benefits of a project in monetary terms as possible. Benefits represent the extent to which society and economies impacted by a project are made better-off through lower costs, fewer damages, or enhancements. In principle, any net increase in well-being (as measured by the summation of individual and society well-being changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would pass the efficiency test if the benefits to some are large enough to compensate the losses

Economics may be the dismal science, but it has been carefully developed as a scientific discipline since Adam Smith wrote The Wealth of Nations (1776). As a science, economics is replete with principles, concepts, and notions that may not be familiar to non-economists. Thousands of books and other manuscripts have been written to explain economic theory, so no simple explanation of complex concepts does them justice. Readers are encouraged to refer to other, more in-depth, sources if any of these principles are not clear to them.

of others. Finally, EA is a forward-looking exercise, seeking to anticipate the well-being impacts of a project or proposal over its entire life-cycle. Future well-being changes are weighed against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

3.1 State Economic Development (SED) Perspective

Perspective of value is important to consider since not all perspectives embrace similar values. Value may differ from individual to individual; from local to state to federal perspective; or from a user's to an owner's viewpoint. The SED analysis is concerned with incremental changes in the value of a good or service from the State of North Dakota's perspective and the costs that bring about this change. SED analyses lead to project evaluation metrics such as a benefit-cost ratio or net present value that enable projects to be compared from the perspective of net value to the State. Thus, SED in this guidance is seen from the State's perspective, but is comparable to NED from a Federal viewpoint.

3.2 Discount Rate and Present Value

An inherent problem in any evaluation or decision analysis is the difficulty of making value comparisons among projects that are not measured in common units. For example, dollars spent today are not equal to dollars projected to be spent in 20 years. To account for this, all future costs are converted to present value costs through a process known as discounting, which shows what a dollar received in 20 years, for example, is worth today. Discounting is accomplished using a discount rate selected to represent the time value of money. For the North Dakota EA guidance, the recommended rate is the annual discount rate published in USACE Economic Guidance Memorandum (EGM) Federal Discount Rate, table: Federal Discount Rates for Project Formulation and Evaluation.[1] The EGM is updated annually, and current federal rates should be used. For 2018, the federally approved discount rate is 2.75%.[2] Higher discount rates benefit projects with more costs incurred in the future, while lower discount rates benefit projects with more up-front costs. If the timing of costs is similar between projects, the discount rate has little effect on the economic analysis.

Benefits and costs are converted to present value using the following calculation:

$$PV = \frac{FV}{(1+r)^n}$$

Where: *PV* *present value of the cost or benefit*
FV *the future value of the cost or benefit*
r *the discount rate*
n *the current time period in years*

In an EA framework where benefits and costs occur over the life of the project, total present value costs are obtained by summing the present value of each annual cost (Table 1). For example, consider a project with benefits occurring over 4 years. With a discount rate of 2.75%, the table below shows the calculation of present value in each year. The total present value benefit is $11,421 or the sum of the benefits in the last row.

1 Economic Guidance Memorandum 18-01, Federal Interest Rates for Corps of Engineers Projects https://planning.erdc.dren.mil/toolbox/library/EGMs/EGM18-01.pdf

2 More information on discounting and present value can be found in the CRS Report "Discount Rates in the Economic Evaluation of U.S. Army Corps of Engineers Projects." August 2016. https://www.everycrsreport.com/reports/R44594.html

Table I.

Year	I	2	3	4
Benefits	$5,000	$5,000	$I,000	$I,000
Discount Rate	2.75	2.75	2.75	2.75
Present Value Calculation	$PV = \frac{\$5000}{(1.0275)^1}$	$PV = \frac{\$5000}{(1.0275)^2}$	$PV = \frac{\$1000}{(1.0275)^3}$	$PV = \frac{\$1000}{(1.0275)^4}$
Present Value Cost	$4,866	$4,736	$922	$897

3.3 Separable Costs Remaining Benefits (SCRB)

Any separable component of an alternative that can stand alone without affecting the desired outcomes of the alternative should be analyzed separately. In other words, if a recreational add-on feature is not necessary for the project, the overall project benefits should not be used to economically carry an inefficient component. Each separable component must pass its own EA test.

3.4 Economic Analysis vs. Financial Analysis

Economic and financial analyses are not the same. Although both may be required to determine overall project feasibility and use some of the same data, they are conceptually different types of analyses and serve different purposes. The objective of economic analysis is to determine if a project represents the best use of resources over the analysis period (that is, the project is economically justified). The objective of financial analysis is to determine financial feasibility (that is, whether someone is willing and able to pay for a project). Financial analysis occurs as a separate effort, is a different process, and is outside the scope of this guidance process. The key differences between economic analysis and financial analysis are as follows:

Economic Analysis

- Although economic analyses can be evaluated from many different perspectives (e.g., individuals, communities), the State Water Commission is conducting these analyses from a statewide perspective.
- Evaluation period is the economic life of the project (50 years).
- Project benefits and capital and annual operation costs are estimated in uninflated (real) dollars.
- Benefits and costs are adjusted to show expected differences in their relative economic value over time.
- Economic discount rate is applied to account for time value of project costs and economic benefits (or avoided economic costs) produced by the project.
- Project inputs are valued at their economic opportunity cost – meaning alternatives are valued based on choosing one alternative over another and missing the forgone opportunity.
- Intensity of a project sponsors' desire for an alternative is NOT a factor in economic analysis.

Financial Analysis

- Evaluation is from the perspective of parties expected to pay their share of costs.
- Evaluation period is the time it takes to pay for the project (through special tax revenues or bond repayment – of 20 years, for example).
- Project costs are expected, and time wise monetary outlays are required to implement and operate the project.
- Project income and capital and annual operation costs are estimated in inflated (nominal, current) dollars.
- Expected interest rate of bonds sold to finance the project is used as the time value of project costs.
- Project inputs are valued at their purchase cost.
- Bond sale and service costs are included.

3.5 Avoid Double Counting

Since the value of some benefits can be expressed in more than one way; the model developed for the State (See Appendix) only includes one measure of value for each benefit (or cost) in the analysis. For example, the value of flood damage reduction on an acre of cropland, in principle, is equivalent to the increase in land value. Likewise, including both the reduction in flood insurance premiums and estimated physical damages to structures and contents would be double counting because flood insurance premiums represent a capitalized estimate of flood losses from living in a flood plain.

3.6 Economic Externalities

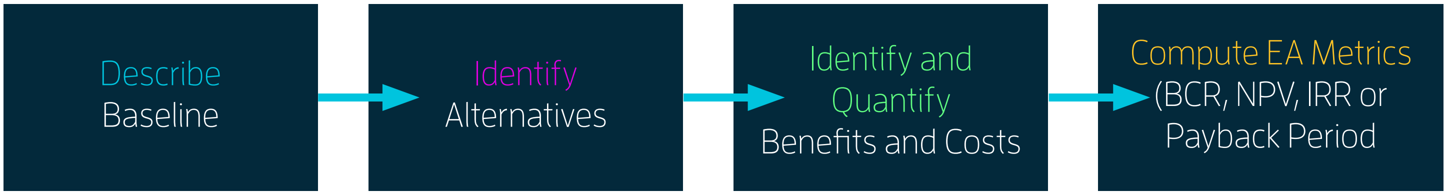
Externalities are the unintended side effects of an alternative on a third party not part of the decision process and can be either positive or negative. Positive externalities of a water impoundment project might be: (1) increased pollinator habitat that helps a neighboring bee farmer, or (2) improved downstream water quality outside of the study area. Negative externalities might be: (1) increased mosquito numbers that require additional control methods by neighbors, or (2) increased waterfowl or blackbird populations that lead to depredation in nearby crops. All of these externalities, as well as any others, should be included in an assessment of the alternative's costs and benefits.

3.7 Sunk Costs and Existing Benefits

Sunk costs are monies spent on an alternative (or a component) prior to a current economic analysis, and are NOT to be included in forward-looking EA. Similarly, existing benefits are also NOT to be included in forward-looking EA. Only those added, future benefits that can be tied directly to implementation of an alternative are to be included.

4. Economic Analysis Process

There are four general steps in development of an Economic Analysis (Figure 1). Each of these steps is described in more detail below.



4.1 Describe Baseline

In order to determine incremental impacts of a project alternative, it must be compared with a baseline, or the without project condition. Functionally, the without project scenario is existing reality prior to any investment into project alternatives. A clear definition of the baseline helps describe the issues and therefore how the proposed alternative may address the issues. The baseline begins by describing the current situation, but then continues to describe how future conditions will affect key parameters over the planning period.

The without project condition (i.e., baseline) is what would be expected to happen if a state-supported water management project were not to happen. It does not assume the status quo, but considers what locals would do about water management in the future without a state-assisted project.

Regarding adaptive management, we can assume someone attempting to produce crops on flood-prone land will cease their attempts if it is likely that the average of future attempts will result in negative returns. Likewise, we can assume that township officials will either abandon or drastically improve a culvert that washes out frequently. In other words, "without project" is not the same as maintaining the status quo.

The baseline should be consistent among multiple alternatives. The impacts of an alternative are based on changes from the baseline. Therefore, as long as multiple project alternatives are compared to the same baseline, the resulting impacts across alternatives will be consistently calculated and should allow for comparisons of EA measures (identified in Section 2).

4.2 Identify Alternatives

Project alternatives should be identified that are potential solutions to the flood control or water conveyance needs. For example, alternatives for urban flood damage reduction may include upstream impoundments, dikes and levees, buyouts, or watershed land management. Alternatives for rural flood damage reduction could be enhanced soil-water management, water conveyance projects, taking frequently flooded lands out of crop production, or impoundments to store floodwaters.

Alternatives should be specific, significantly different approaches to accomplishing the objectives. Merely scaling up, or down, one alternative does not create a separate alternative. Each alternative should be developed at its optimal scale/size by project sponsors and planners.

Alternative flood control and water conveyance projects are constructed to provide service to current and future generations. To account for this in an economic analysis framework, benefits and costs are evaluated over an expected operational life of the project. The period of analysis is the length of time over which a project's consequences are included in a study. Typical analysis periods for flood control and water conveyance projects are 50 to 100 years. For the Economic Analysis Worksheets (See Appendix), the period of analysis of each alternative has been set at 50 years for all projects.

Within the analysis period, a base year must be identified which generally is when project construction/implementation occurs, and project benefits occur after the base year. The base year is usually called year 0 and subsequent years are numbered 1 through the end of the analysis period.

4.3 Identify and Quantify Benefits and Costs

The next step of economic analysis is to explicitly identify direct costs and direct benefits for each alternative.

- Direct benefits are a result of project implementation and are generally realized by a community or individual landowners.
- Direct costs are out-of-pocket costs to build and operate the alternatives.
- Secondary benefits are changes in jobs, additional gross business volumes (as measured by multipliers), and changes in tax revenue. These are not applicable to efficiency analysis and are not included in North Dakota's EA guidelines, as directed by State Statute.

Benefits and costs are first described in technical terms (e.g., acre, ton, day, ppm, sandbags) and then quantified in monetary terms. Benefits and costs that are qualitatively described are not included in EA calculations, but can be provided as narrative. Keep in mind that procedures used to estimate damages or potential enhancements need to be transparent, defensible, reasonable, and replicable. Another analyst following essentially the same steps, using the same or similar information, should reach approximately the same outcome. Also, when assumptions are necessary, they should be ballasted with strong supporting arguments. Assumptions should also be explicitly stated so they can be revised to fit others' valid opinions; with new results based on different, but plausible assumptions.

4.3.1 Flood Damage Reduction Benefits

A primary objective in flood damage reduction studies is to determine the Expected Annual Damage (EAD) along a river, stream or lake; taking into account all possible flood scenarios and to compare changes in the damage resulting from various alternative plans over the study period. EAD is approximately equivalent to an average annual damage estimate, taking into account all possible storm events that might occur, from very frequent to very infrequent. The determination of EAD in a flood management study must take into account interrelated hydrologic, hydraulic, geotechnical, and economic information. Specifically, EAD is determined by combining depth of flooding, percent of damage to structures and contents determined using depth-damage functions, elevation data for structures, and values for structures and contents.

4.3.1.1 Depth-Damage Functions (urban)

Depth-damage functions form the link between the engineering data inputs, and structure and contents values and elevations to determine the monetary value of flood damages. These functions identify the percentage of damage to the structure and contents for each stage of flooding. Functions for damages to residential property structures and contents were obtained from the *Corps Economic Guidance Memorandum EGM 0401.1*. Within the model explained in Appendix A, an aggregate depth-damage function for commercial and industrial properties in the study area was used based on curves obtained from the USACE Chicago District.

4.3.1.2 Cropland Inundation-Timing Crop Loss Function (rural)

Similar to depth-damage functions for structure damages, crop-loss functions are an important part of estimating damages to crop production from flooding. Crop loss functions estimate potential maximum crop loss according to crop growth stage, seasonality, and inundation duration. Crop loss functions are described in more detail in the *National Economic Development Procedures Manual – Agricultural Flood Damage*. A detailed procedure for cropland flooding EA is available at Leitch and Fritz (2018).

For example, inundation damages on cropland depend on the type of crop (e.g., corn, wheat, beans), inundation timing (e.g., pre-planting, growing season, harvest), and inundation duration (i.e., how many days the crop is under water). For example,

- A spring snowmelt flood will likely have no effect on the year's crop.
- A pre-planting flood may delay planting, resulting in some crop loss.
- A post-planting early emergence flood of 1 day may result in 13% to 15% loss of wheat, corn, and beets.
- A 3-day flood in the peak of the growing season may result in over 50% loss of crop revenue.
- A 6-day flood during the peak growing season will result in total crop loss for all crop types, except mature corn.

Tables are available for estimating these types of crop loss functions and are included in the Economic Analysis Worksheet (Appendix B), but they are generalized estimates of reality, especially at very site specific locations.

For flood control and water conveyance projects, benefits can include a broad spectrum of impacts - both direct and indirect. A selection of the typical and often monetized effects of these types of projects is shown in the table below. An important note is that these benefits, as they pertain to the State of North Dakota, are divided between urban and rural benefits categories. While, for example, structure damages would occur under both (flood mitigation benefits and rural structure damages), scale (number of structures) and the level of detail required for the analysis can be quite different. Urban flood mitigation benefits might encompass hundreds or thousands of structures, whereas a rural water conveyance project might include only a few structures. In addition, the detail available to conduct such an analysis for a rural project, e.g. information about flooding, including depths, duration, and frequency, may be more limited. Thus, the resulting level of detail in the analysis may be more limited than the urban flood damage assessment. In either case, the analysis should make best use of available data to monetize impacts to the extent possible.

Projects may protect existing development from flood damage and make flood-prone land more suitable for appropriate development. Typical benefit measurement techniques include reduction in costs (damages) associated with flooding. Commonly monetized flood mitigation benefits include, but are not limited to those outlined in Figure 2.

Figure 2. Categories of Flood Damages/Costs (Potential Benefits)

Benefits Area	Potential Benefits Categories
Urban	Flood Preparation Flood Fighting Flood Recovery Income losses Transportation Impacts
Rural	Structures and Infrastructure Cropland Damage Pasture Damage Enhancements (Recreation, Water Quality) Grade/Bank Stabilization

4.3.2 Enhancement Benefits

Flood damage reduction projects may result in benefits that are not merely reducing damages, but that are increases in natural resource-related outputs, such as increased recreational opportunities and water quality improvements.

4.3.2.1 Recreation & Other Benefits

Alternatives may improve all forms of outdoor recreation and other activities created or protected by a water resource project. Typical benefit measurement techniques include values ($/user day) for recreation day activities and travel cost or contingent valuation methods. Specific information concerning how to estimate recreation benefits is found in the P&G (section 2.8). The analyst simply needs to estimate the net number of user days the project will produce.

Consumptive Recreation

Consumptive recreation is that where the person recreating converts a natural resource to private use, such as harvesting a game bird or a fish, making it unavailable to other users. Considerable data are available on the values of various types of recreation. A meta-analysis for North Dakota-specific values indicates that a $113/user day is appropriate for water resources projects. [3]

Additional days of recreation at a project site are not project benefits if they are merely shifted away from nearby sites and do not add to the overall availability of recreation days. Only those recreation days that are net increases at the state level are legitimate project benefits.

Non-Consumptive Recreation

Non-consumptive recreation is that where the person recreating does not alter the amount of resources available to other participants, such as bird-watching, hiking, boating, or sightseeing. The value of a user day of non-consumptive recreation was found to be $153 in North Dakota.[3]

4.3.2.2 Water Quality Benefits

Flood control or water conveyance projects may be designed so as to improve water quality in a watercourse. The benefit would be improved quality for in-stream uses (e.g., aquatic species) and lower treatment costs for downstream water users. A secondary source has reported the benefit of reduced water pollution from some projects could be approximately $0.73/acre-foot of water impounded during flood events. [3]

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[3] Leitch and Fritz. (2018)

4.3.3 Flood Damage Reduction Costs

Implementation of alternatives to reduce flood damages requires expenditures, both up-front and on-going. These costs are identified in the worksheets in Appendix A and B, but examples include construction; real estate; and planning, engineering, and design; as well as annual operations and maintenance (O&M) costs.

4.4 Compute EA Metrics

The next step is to develop a system to compute the desired EA metrics (BCR, NPV, etc.). The analyst is provided with a step-by-step model in Appendix A and B.

5. EA/SED in Practice

In practice, the North Dakota EA/SED process must be easy to implement, straightforward, and transparent. The State Water Commission receives funding requests for multiple types of projects. However, the only projects subject to the North Dakota EA/SED are: (1) urban and rural flood damage reduction, and (2) water conveyance projects – with a cost of one million or greater. For reasons that should become apparent below, these are treated as two separate (but comparable) procedures.

5.1 Urban Flood Damage Reduction

In practice, urban flood damage reduction projects are designed to eliminate flood damages up to, and including, a 100-year flood. Most urban areas have, over time, managed their flood plains to eliminate flood damages from 5-year, 10-year, 25-year, and 50-year floods. While there may be some natural resource enhancements from urban flood damage projects, they are a small part of the overall benefits.

5.1.2 Specific Benefits and Costs

The specific benefits for input into the EA Urban (U) model are reductions in costs associated with urban flood damage. These costs include physical damages to properties and infrastructure; reductions in temporary relocations (displacement costs) of families; and post flood cleanup costs. The EA (U) model also includes benefits associated with avoided flood fighting costs and increased travel time for the traveling public seeking alternative routes due to road closures. Finally, the framework also includes a value to society associated with mental well-being from reducing the risk of flooding to homeowners (peace of mind associated with knowing the home is at a lower risk of flooding).

The costs of each alternative (e.g., construction, O&M) are estimated by project planners, engineers, or cost estimators. Construction costs should include all up-front costs, including, but not limited to, design, right-of-way (ROW), actual construction, management and engineering during construction, and contingencies. O&M costs should include all anticipated future annual operation and maintenance costs. All of the aforementioned costs are worksheet inputs as seen in Appendix A.

5.2 Rural Flood Damage Reduction and Conveyance

Economic analysis for project planning purposes in small, rural watersheds also includes the four steps shown on page 11 (Describe Baseline, Identify Alternatives, Identify and Quantify Benefits and Costs, and Compute EA Metrics (BCR, NPV, IRR & Payback Period)). Anyone following these steps should adhere to the policies and principles in all applicable guidance documents. However, an experienced analyst can develop a defensible estimate without using all the detailed procedures and sophisticated modeling suggested in more rigorous guidance documents. An estimate is often done without the benefit of refined hydrologic models, which are rarely available for small projects in rural areas.

Rural flood damage reduction is primarily implemented to protect cropland from frequent flooding, such as 5-year, 10-year or greater flood event. Rural flood damage protection for structures is typically at the 100-year recurrence level. Natural resource enhancements may be a substantial part of the benefits of rural flood damage reduction projects.

Typical projects in rural areas might be constructing legal drains, diverting or storing floodwaters, ring dikes and levees, and flood proofing infrastructure and utilities.

5.2.1 Specific Benefits and Costs

The costs of each alternative (e.g., construction, and O&M) are estimated by project planners. Construction costs should include all up-front costs, including, but not limited to, design, ROW, and actual construction. O&M costs should include all anticipated future annual operation and maintenance costs. If snagging and clearing or sediment removal are parts of O&M, their costs should be specified in the year(s) they will be conducted (e.g., years 12, 24, and 36). Costs are worksheet inputs as seen in Appendix B.

Benefits are a bit more complicated to estimate. For example, some project benefits occur only when floods occur (e.g., structure or infrastructure damage, and cropland losses), but others, such as enhancement benefits, occur every year once the project is complete. Three categories of benefits are included as worksheet inputs (Appendix B): (1) cropland and pasture, (2) structures and infrastructure, and (3) enhancements. Worksheets are provided that lead to estimates for input to the EA Rural (R) model.

6. Presentation and Comparison of Results

The worksheets in Appendix A and B will produce five EA measures demonstrated in the table below. The measures in Table 2 below are made up, but show that Alternative 1 is clearly the most efficient alternative. Alternative 3 is not efficient, since the total benefits are less than the total costs.

Table 1.

	BCR/EA/SED	*PVC (Least Cost)	NPV	IRR	Payback Period
Alternative 1	2.3	$3,340,000	$1,340,000	6.0	23 years
Alternative 2	1.5	$3,149,000	$1,050,000	3.9	35 years
Alternative 3	0.9	$2,962,000	Negative	2.4	65 years

Each of these economic analysis measures can be used to judge the feasibility of an alternative. The economic analysis requirement per NDCC 61-03-21.4 can be met by presenting any of the above results metrics.

Analysts are encouraged to use the set model values to maintain comparability across projects. However, set values may be changed to better fit local conditions, but adequate justification must be provided. Certain set values (e.g., discount rate, average annual cropland flood damages, recreation day values) will be adjusted by the SWC as better data become available or conditions change.

Epilogue

Given the current state of data and model availability with respect to North Dakota flood control and conveyance projects, numerous assumptions and generalizations were made in the model parameters. Over time, as these models are used by project sponsors, refinements may be suggested and data may improve, at which time the models can be upgraded. However, what is important with EA models is that they are used consistently across the state. If they are used consistently as they are provided, it will provide a valid and useful way to prioritize projects seeking state-level funding.

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NORTH DAKOTA
STATE WATER COMMISSION

Appendix A: Introduction to EA (Urban) Worksheet

This Appendix will take the user through the EA (Urban) model step by step, explaining where user inputs are required to estimate flood control benefits and where the model does internal calculations. The model itself is available for download at www.swc.nd.gov, then click on the "Project Development" tab.

Project sponsors, or more likely their consultants are encouraged to use the model. The steps outlined in Appendix A provide a detailed process of how to conduct EA for flood damage reduction projects in urban settings.

NOTE: User inputs are shown as ***bold-italics***.

STEP 1: Name the project and describe the alternative(s)

If using the fillable model/worksheets, proceed to the "**1 – Project Overview**" worksheet to begin information entry (Figure A1).

- ***Provide Contact Information***
- ***Name The Project*** (e.g., Bismarck Flood Control Project)
- ***Describe The Project, Problem, and Need Being Addressed***
- ***Identify The County or City Where the Project Is Located*** (This is necessary for basic informational purposes, and because the model makes some calculations based on county. If the project is located in more than one county, identify the county containing most of the study area.)
- ***Provide Population Served***

STEP 2: Identify and quantify costs

- ***Define Project Area***

If using the fillable model/worksheets, continue entering information in the "**1 – Project Overview**" worksheet (Figure A1).

- ***Provide Construction Cost Estimate Information*** (This should include all upfront costs, including construction, real estate, planning, engineering, design, construction management, and contingencies.)
- ***Provide Operation and Maintenance Cost Estimates*** (This is an annual cost estimate.)
- ***Provide An Estimate of Persons Per Household*** (Within the study area.)

Please note, the model can evaluate one alternative at a time. If more than one viable alternative is being considered, a separate model should be created for each alternative and then a comparison should be done of the project metrics outside of the model. However, it may be most common at this phase (external funding request), to have one alternative developed into a project to move forward.

Figure A1 : Project Overview Data Entry ("1 – Project Overview" Worksheet)

Cell for User Input	
Locked Cell for Calculations	

Contact Information

Analysis Prepared by:	
Ph.:	
Email:	
Date	

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1 - Project Overview

This is the first data entry worksheet. Users provide information about the applicant, including a point of contact, a description of the project, project area, construction costs, and annual O&M costs.

Name of the Project

Describe the Project **(Please describe the project, the problem, and the need being addressed in the space below.)**

Reviewing system inputs and results

Study Area:

Project Sponsor	
County:	
City:	
Population Served:	80,000
Project Area:	

Project Construction Cost Estimate

Construction	$600,000
Real Estate	$150,000
Planning, Engineering, and Design	$120,000
Construction Management	$36,000
Contingency	$112,500
Total Cost	$1,018,500

Annual Operations and Maintenance

O&M Cost	$5,000

Study Area Data

Average Hourly Wage	$26
Hours Per Person	34.4
Persons Per household	2.44
Persons Per Business	37.67
Roadway Repair Costs Per Mile	$528,000

STEP 3: Describe the baseline

If using the fillable model/worksheets, proceed to the "2 – Inputs" worksheet to continue information entry.

In this step, users will describe the baseline (see section 4.1 of the guidance manual), which includes explanations related to the extent of existing flood and flood-related damages in the study area, and whether the proposed project will ameliorate them all or not. At this stage, the baseline contains several categories of DAMAGES, part of which will become BENEFITS in Step 4 below.

Flood-related damages include:

a. Physical damages to structures and contents;
b. Flood relocation costs;
c. Flood fighting (emergency) costs;
d. Transportation delays due to roadway inundation;
e. Social value of flood risk; and
f. Other damages due to flooding not included in a-e

Data entry begins by specifying project parameters in the worksheet (Figure A2).

- ***Identify The Base Year*** (This is the beginning of the analysis period.)
- ***Identify The Years of Construction*** (This is the number of years required to construct the project.)

Figure A2 : Initial Project Parameters Entry ("2 – Inputs" Worksheet)

2 - Inputs

This is the second data entry worksheet where users provide specific data necessary to estimate project benefits.

Locked Cell for Calculations

Cell for User Input

Category	Sub Category	Input	Units	Input Value	Definition of Term	Reference
Key Inputs	Base Year		Year	2018	Beginning year of analysis period	
	End Year		Year	2073	Ending year of analysis period	
	Project Life		Years	50	From construction start to end of analysis. Must be	
	Discount Factor		%	3%	Discount factor used for present value calculations	Discounting is the process of determining the
	Years of Construction		Years	5		

A major issue with estimating flood damage is the need for hydrologic and hydraulic models to develop flood damage curves. To estimate damages, flood depths or water surface profiles are needed for a range of recurrence intervals in order to compute an expected annual damage. If this data is not available or there are only a few structures being impacted, proceed to Appendix B, the EA(Rural) or EA(R) worksheet, and follow instructions to estimate damages for structures and infrastructure. Otherwise, data entry continues (Figure A3).

- ***Specify Four Recurrence Intervals*** (These will be used to evaluate damages.)
- ***Specify The Level of Protection Provided By The Project***

Figure A3 : Entry of Recurrence Intervals and the Level of Protection ("2 – Inputs" Worksheet)

2 - Inputs

This is the second data entry worksheet where users provide specific data necessary to estimate project benefits.

Locked Cell for Calculations
Cell for User Input

Category	Sub Category	Input	Units	Input Value	Definition of Term	Reference
Key Inputs	Base Year		Year	2018	Beginning year of analysis period	
	End Year		Year	2073	Ending year of analysis period	
	Project Life		Years	50	From construction start to end of analysis. Must be 55 years	
	Discount Factor		%	2.750%	Discount factor used for present value calculations	Discounting is the process of determining the present value of
	Years of Construction		Years	5		
Capital Investment	Project Costs		$	1,018,500.00		
	Annual Operations and Maintenance		$	5,000.00		
Flood Return Periods	Recurrence level	Interval 1	Years	10		
		Interval 2	Years	20		
		Interval 3	Years	50		
		Interval 4	Years	100		
		Level of Protection	Years	50		
Base Data	Residential Value Per SQFT		$/SQFT	93.62	Depreciated replacement value	Marshall and Swift, 2018, estimated for Bismarck ND

Figure A4 : Entry of Lodging Costs ("2 – Inputs" Worksheet)

Other and Recreation	Consumptive Use	Users	#				
		Days	#				
		Value	$	113.00	Applied to User-Days Justification-Source Required		
	Non-Consumptive Use	Users	#	60			Parks and pathways and golf for this example
		Days	#	30.00			
		Value	$	35.00	Appied to User-Days Justification-Source Required		Trust for Public Lands - 2009 Measuring the value of a City Park System
Travel Delays	Vehicles Per Day		#/Day	600.00			
	Normal Drive Time		Minutes	10			
	Detour Drive Time		Minutes	20			
	Duration of Roadway Closure		Interval	Without	With		
			10	6	0	Days	
			20	8	0	Days	
			50	12	2	Days	
			100	14	6	Days	

Transportation Delays Due to Roadway Inundation

Key inputs to estimate the impact of transportation delays due to flooding are ***average daily one way trips*** (vehicles per day or average annual daily traffic), ***normal drive time*** and ***drive time of the detour route, and expected duration of road closure*** for each return period.

Vehicles per day and drive times for the preferred and detour routes are entered into the "**2 - Inputs**" worksheet.

- ***Estimate Transportation-related information, including Vehicles per Day, Normal Drive Times, Detour Drive Times, and Duration of Road Closure.*** These data can be sourced from a State DOT, transportation model, or other equivalent sources. Vehicles per day or average annual daily traffic can be obtained from traffic counters, state DOT, or other sources. Drive time can be estimated using the length of the route (normal and alternative) and the approximate vehicle speed. Finally the duration of the road closure should be estimated using either hydrologic information for timing of flood or some other method.

Figure A5 : Transportation Delay Data Entry ("2 – Inputs" Worksheet)

Other and Recreation	Consumptive Use	Users	#				
		Days	#				
		Value	$	113.00	Applied to User-Days Justification-Source Required		
	Non-Consumptive Use	Users	#	60			Parks and pathways and golf for this example
		Days	#	30.00			
		Value	$	35.00	Appied to User-Days Justification-Source Required		Trust for Public Lands - 2009 Measuring the value of a City Park System
Travel Delays	Vehicles Per Day		#/Day	600.00			
	Normal Drive Time		Minutes	10			
	Detour Drive Time		Minutes	20			
	Duration of Roadway Closure		Interval	Without	With		
			10	6	0	Days	
			20	8	0	Days	
			50	12	2	Days	
			100	14	6	Days	

Duration of road closures are entered into the orange cells on the "**2 – Inputs**" worksheet. The model automatically computes transportation delay costs based on the route travel times, the value of time (l/2 the state wage rate) and average annual daily traffic.

Proceed to the "**4 – EA Urban Flood Damages**" worksheet to continue information entry related to structures in the project area.

Physical Damages to Structures and Contents

The worksheet computes flood control benefits at each structure from the difference between without and with project damages for each of four return periods. These individual structure flood control benefits are then aggregated to a comprehensive flood control benefit.

Estimating physical losses to structures and contents requires data from engineering and economics including:

- Engineering models – depth of flooding or water surface elevations and;
- Structure economic data – building square feet, occupancy category (e.g. l story with basement), value per square foot, and foundation height (above ground).

The EA (Urban) worksheet contains standardized values for value per square foot and foundation height. The user will need to select the appropriate Occupancy Category for each structure. Data is entered on the "**4 – EA Urban Flood Damages**" Worksheet (Figure A6).

- ***Select Occupancy Categories*** (for each structure).
- ***Input Structural Values*** (If structure values are unknown, enter the square footage. This will value the structure at $93.62 per square foot. This value was determined using the Marshall and Swift Estimator for residential structures.)

Figure A6 : Entry of Structure Data ("4 – EA Urban Flood Damages" Worksheet)

4 - EA Urban Flood Damages

This is the final data entry worksheet. This worksheet is used to estimate urban flood damage reduction benefits. In this worksheet users provide information regarding individual structures to estimate urban flood damages. Necessary inputs include: structure type, square footage, building value, and depth of flooding.

Locked Cell for Calculations
Cell for user Input

Structure ID	Occupancy Category	Area (sqft)	Structure Value If Known	Structure Value ($1K)	Column Index	Existing - Pre Mitigation Flood Depth Feet: 10 yr	20 yr	50 yr	100 yr	Mitigation (EX: 0.50, 2.00, 3.5, 5.00) Fill each cell where no damage occurs with -9.: 10 yr	20 yr	50 yr	100 yr	10 yr - Without: Index Values for Damage Curves: 10 yr - Without - Flood Depth	10 yr - Without - DD Upper Index Range	10 yr - Without - DD Index Midpoint	Damage: 10 yr - Without - Prop Damage	Contents: 10 yr - Without - Contents	10 yr - Without - Contents CSVR	Displace: 10 yr - Without - Displacement Days	10 yr - With: Index Values for Damage Curves: 10 yr - With - Flood Depth	10 yr - With - DD Upper Index Range	10 yr - With - DD Index Midpoint	Damage: 10 yr - With - Prop Damage	Contents: 10 yr - With - Contents	10 yr - With - Contents CSVR	Displace: 10 yr - With - Displacement Days
1	2+ Story, with Basement	3000	$350,000	$350.00	4	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-2.00	-1.00	0.00%	10.20%	0.00%	100.00%	0.00	-11.50	-10.00	-50.00%			100.00%	
2	1 Story, with Basement	4500		$421.29	3	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-1.00	0.00	0.00%	19.40%	1.00%	100.00%	0.00	-10.50	-9.00	-50.00%			100.00%	
3	Apartment	4500	$750,000	$750.00	7	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.50%	9.64%	38.00%	22.50	-9.00	-8.00	0.00%			38.00%	
4	Public	10000	$1,500,000	$1,500.00	5	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.00	1.00	0.00%	0.00%	0.36%	66.00%	0.00	-9.50	-8.00	-50.00%			66.00%	
5	2+ Story, with Basement	2500	$245,000	$245.00	4	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-2.00	-1.00	0.00%	10.20%	0.00%	100.00%	0.00	-11.50	-10.00	-50.00%			100.00%	
6	Public	27500	$4,500,000	$4,500.00	5	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.00	1.00	0.00%	0.00%	0.36%	66.00%	0.00	-9.50	-8.00	-50.00%			66.00%	
7	Apartment	45000		$4,212.90	7	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.50%	9.64%	38.00%	22.50	-9.00	-8.00	0.00%			38.00%	
8	Commercial	32300	$7,500,000	$7,500.00	6	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	6.58%	11.57%	52.00%	22.50	-9.00	-8.00	0.00%			52.00%	
9	Industrial	75000	$6,800,000	$6,800.00	8	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.21%	14.86%	36.00%	22.50	-9.00	-8.00	0.00%			36.00%	

- ***Flood Depths (depth of flood water in relation to the ground level)*** at each structure should be entered (Figure A7).

Figure A7: Entry of Flood Depths ("4 – EA Urban Flood Damages" Worksheet)

This is the final data entry worksheet. This worksheet is used to estimate urban flood damage reduction benefits. In this worksheet users provide information regarding individual structures to estimate urban flood damages. Necessary inputs include: structure type, square footage, building value, and depth of flooding.

Locked Cell for Calculations
Cell for user Input

Structure ID	Occupancy Category	Area (sqft)	Structure Value If Known	Structure Value ($1K)	Column Index	Existing - Pre Mitigation Flood Depth Feet: 10 yr	20 yr	50 yr	100 yr	Mitigation (EX: 0.50, 2.00, 3.5, 5.00) Fill each cell where no damage occurs with -9.: 10 yr	20 yr	50 yr	100 yr	10 yr - Without: Index Values for Damage Curves: 10 yr - Without - Flood Depth	10 yr - Without - DD Upper Index Range	10 yr - Without - DD Index Midpoint	Damage: 10 yr - Without - Prop Damage	Contents: 10 yr - Without - Contents	10 yr - Without - Contents CSVR	Displace: 10 yr - Without - Displacement Days	10 yr - With: Index Values for Damage Curves: 10 yr - With - Flood Depth	10 yr - With - DD Upper Index Range	10 yr - With - DD Index Midpoint	Damage: 10 yr - With - Prop Damage	Contents: 10 yr - With - Contents	10 yr - With - Contents CSVR	Displace: 10 yr - With - Displacement Days
1	2+ Story, with Basement	3000	$350,000	$350.00	4	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-2.00	-1.00	0.00%	10.20%	0.00%	100.00%	0.00	-11.50	-10.00	-50.00%			100.00%	
2	1 Story, with Basement	4500		$421.29	3	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-1.00	0.00	0.00%	19.40%	1.00%	100.00%	0.00	-10.50	-9.00	-50.00%			100.00%	
3	Apartment	4500	$750,000	$750.00	7	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.50%	9.64%	38.00%	22.50	-9.00	-8.00	0.00%			38.00%	
4	Public	10000	$1,500,000	$1,500.00	5	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.00	1.00	0.00%	0.00%	0.36%	66.00%	0.00	-9.50	-8.00	-50.00%			66.00%	
5	2+ Story, with Basement	2500	$245,000	$245.00	4	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	-2.00	-1.00	0.00%	10.20%	0.00%	100.00%	0.00	-11.50	-10.00	-50.00%			100.00%	
6	Public	27500	$4,500,000	$4,500.00	5	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.00	1.00	0.00%	0.00%	0.36%	66.00%	0.00	-9.50	-8.00	-50.00%			66.00%	
7	Apartment	45000		$4,212.90	7	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.50%	9.64%	38.00%	22.50	-9.00	-8.00	0.00%			38.00%	
8	Commercial	32300	$7,500,000	$7,500.00	6	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	6.58%	11.57%	52.00%	22.50	-9.00	-8.00	0.00%			52.00%	
9	Industrial	75000	$6,800,000	$6,800.00	8	0.50	2.00	3.00	4.00	-9.00	-9.00	-9.00	4.00	0.50	1.00	50.00%	5.21%	14.86%	36.00%	22.50	-9.00	-8.00	0.00%			36.00%	

Flood depths can be obtained from a variety of sources including:

- Comparing FIRM mapping with topographical mapping, or
- Overlay of flood depth grids with structure locations.

NOTE: If a structure is not flooded at any recurrence interval, a value of -9 should be used.

Once this information is entered, the model will automatically compute baseline physical damages to structures by comparing flood inundation depths, with structure information, and depth-damage functions (see section 4.3.1.1 of the guidance manual).

Flood Relocation Costs

Regional studies from the US Army Corps of Engineers (USACE) have used flood relocation costs estimated at 7% of expected annual damages in lieu of specific FEMA relocation costs.[4] This percentage is applied here to estimate the costs of disaster relief. Flood relocation costs are automatically computed based on total physical damages initially computed in the worksheet.

Flood Fighting (Emergency) Costs

To estimate typical emergency costs, a survey of planning reports submitted to Head Quarters USACE (HQUSACE) by Corps Districts across the nation in recent years is applied in the model. This analysis found that emergency costs (flood fighting and volunteer costs, and EMS response impacts) claimed in approved Corps reports averaged about 9% of total EAD.[5] This value was used for this study's emergency cost valuation. Emergency costs are calculated on the total physical damages initially computed in the worksheet.

Social Value of Flood Risk

Finally, the framework also includes a value to society associated with mental well-being from reducing the risk of flooding to homeowners (peace of mind associated with knowing the home is at a lower risk of flooding). A value per household of $2.44 from FEMA's BCA Toolkit is used along with the number of residential structures damaged.[6] This benefit is automatically computed for each recurrence interval and the EAD is estimated in the worksheet.

STEP 4: Identify and input project benefits (changes in baseline) for each alternative

Project benefits are somewhat more complicated to estimate than project costs, since they require predicting an unknown future over the life of the project, a future that will likely change with or without a project. However, users already know the baseline level of damages from Step 2 above, which is the upper limit of flood damages that can be eliminated with a project. With each of the benefits categories from Step 3, the with project flood depths and durations should also be entered. The worksheets will automatically compute flood control benefits associated with those projects.

Flood control projects may have other benefits other than those described in the EA (Urban) portions of the worksheets. For example, if a flood control project contains a dam or reservoir, the project may in fact provide agricultural benefits or habitat enhancements downstream of the urban project extents. As noted in the guidance document, every effort should be made to monetize as many benefits of the project as possible. For additional non-urban benefits please refer to the EA (Rural) benefits analysis covered under Appendix B.

4 Based on information provided by USACE Omaha District and used in USACE Section 205 Studies, September 2017.

5 Based on recommended values from USACE Omaha District for flood risk management studies, September 2017.

6 BCA Reference Guide, Federal Emergency Management Agency, June 2009. https://www.fema.gov/medialibrary-data/201-30726-1736-25045-7076/bca-reference-guide.pdf

STEP I: Name the project and describe the alternative(s)

When users have completed Steps I through 4, the model will have available a number of results in an output table. The results are found in "**5 - Results Summary**" and "**6 – EA Detail**". In "**5 - Results Summary**" users are presented with a breakdown of the total present value and average annual benefits and costs of the project. The estimated benefits and costs are combined into four project performance metrics: Benefit-to-Cost Ratios, Net Benefits, Internal Rate of Return (IRR), and Payback Year. The use of these metrics is described in more detail in the main guidance document.

In "**6 – EA Detail**", users are able to see the annual calculations for costs and benefits. The costs and benefits are shown in both undiscounted (real monetary terms) and converted to present value (discounted). The sheet also provides the total present value sum of the costs and benefits.

Figure A8 : Results Summary ("5 – Results Summary" Worksheet)

5 - Results Summary

This worksheet serves as the summary for all outputs created in the model. For the given inputs, the Results Summary provides an overview of present value and average annual benefits and costs. The Results Summary also presents project performance metrics including: Benefit-to-Cost Ratios, Net Benefits, Internal Rate of Return, and Payback Year.

Scenario Analysis - Benefit Summary

Urban Flood Control Benefits	Present Value ($1K)	Average Annual ($1K)
Flood Mitigation Benefits	$199	$8
Flood Relocation	$14	$1
Travel Time Delays	$44	$2
Flood Fighting	$18	$1
Social Benefits	$2	$0
Subtotal	$276	$10
Other Benefits		
Other Benefits	$1,466	$56
Consumptive	$0	$0
Non-Consumptive	$1,466	$56
Rural Flood Conveyance and Other Benefits		
Rural Flooding Benefit	$0	$0
Bank Erosion Benefit	$0	$0
Cleanup Cost Benefit	$0	$0
Sediment Removal Benefit	$0	$0
Stored Water Benefit	$0	$0
Detour Benefit	$0	$0
Total Rural Mitigation Benefits	$0	$0
Subtotal	$1,466	$56
Grand Total	$1,743	$66

Project Costs	Present Value ($1K)	Average Annual ($1K)
Capital Costs	$963	$37
Annual O&M	$116	$4
Total	$1,080	$41
Project Performance Metrics	**Present Value ($1K)**	**Average Annual ($1K)**
Benefit-to-Cost Ratio	1.614	
Net Benefits	$663	$25
Internal Rate of Return	226%	
Payback Year	5	

Appendix B: Introduction to EA (Rural) Worksheet

This Appendix will take the user through the EA (Rural) model step by step, explaining where user inputs are required and where the model does internal calculations. The model itself is available for download at www.swc.nd.gov, then click on the "Project Development" tab.

Project sponsors, or more likely their consultants are encouraged to use the model. The steps outlined in Appendix B provide a detailed process of how to conduct EA for flood damage reduction or water conveyance projects in rural settings.

NOTE: User inputs are shown as ***bold-italics***.

STEP I: Name the project and describe the alternative(s)

If using the fillable model/worksheets, proceed to the "**I – Project Overview**" worksheet to begin information entry (Figure BI).

- ***Provide Contact Information***
- ***Name The Project*** (e.g., Cass County Drain #23)
- ***Describe The Project, Problem, and Need Being Addressed***
- ***Identify The County or City Where the Project Is Located*** (This is necessary for basic informational purposes, and because the model makes some calculations based on county. If the project is located in more than one county, identify the county containing most of the study area.)
- ***Population Served***
- ***Project Area***

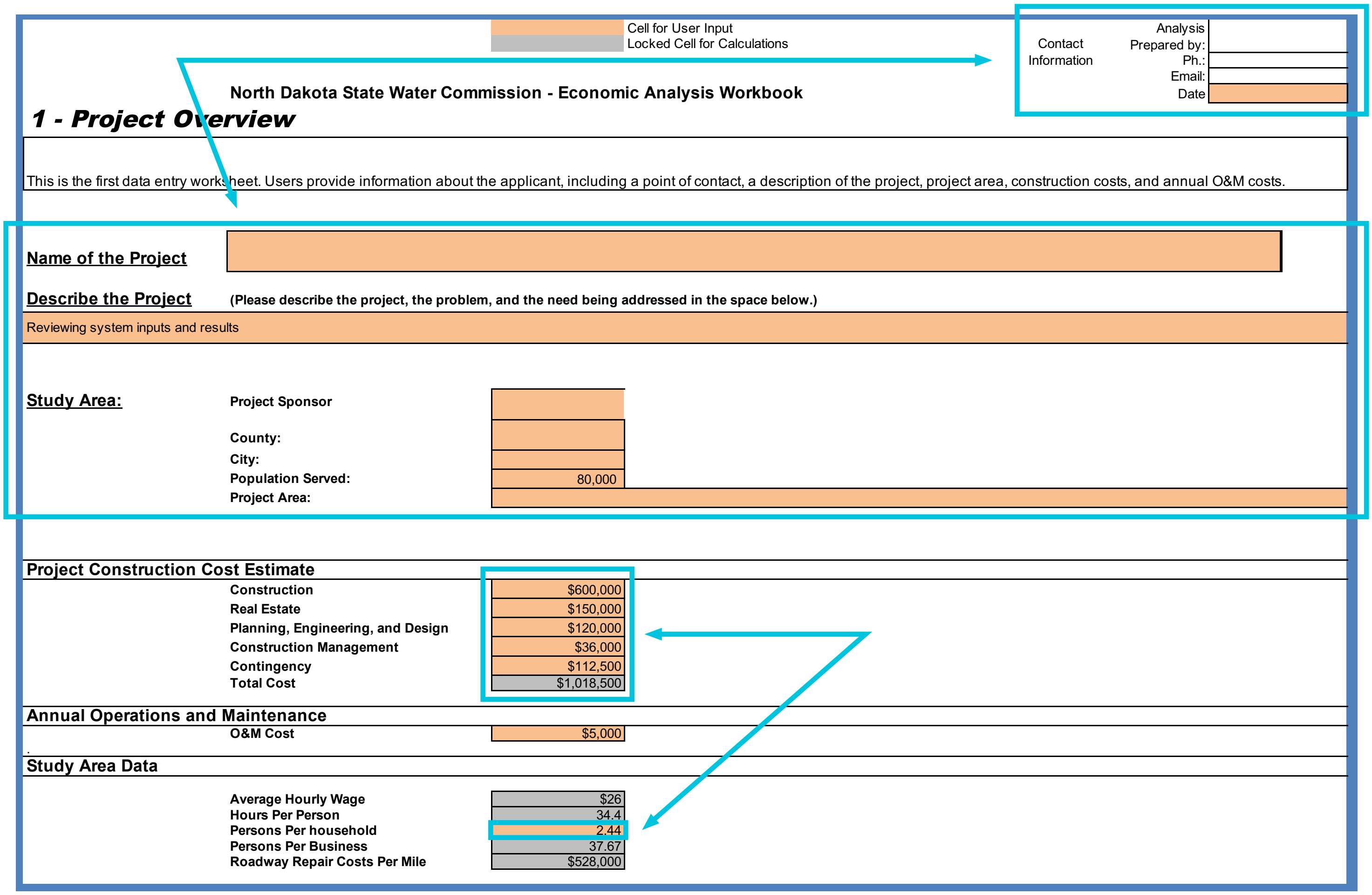
STEP 2: Identify and quantify costs

If using the fillable model/worksheets, continue entering information in the "**I – Project Overview**" worksheet (Figure BI).

- ***Provide Construction Cost Estimate Information*** (This should include all upfront costs, including construction, real estate, planning, engineering, design, construction management, and contingencies.)
- ***Provide Operation and Maintenance Cost Estimates*** (This is an annual cost estimate.)
- ***Provide An Estimate of Persons Per Household*** (Within the study area.)

Please note, the model can evaluate one alternative at a time. If more than one viable alternative is being considered, a separate model should be created for each alternative and then a comparison should be done of the project metrics outside of the model. However, it may be most common at this phase (external funding request), to have one alternative developed into a project to move forward.

Figure B1 : Project Overview Data Entry ("1 – Project Overview" Worksheet)



Cell for User Input
Locked Cell for Calculations

Contact Information	Analysis Prepared by:	
	Ph.:	
	Email:	
	Date	

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1 - Project Overview

This is the first data entry worksheet. Users provide information about the applicant, including a point of contact, a description of the project, project area, construction costs, and annual O&M costs.

Name of the Project

Describe the Project (Please describe the project, the problem, and the need being addressed in the space below.)

Reviewing system inputs and results

Study Area:	
Project Sponsor	
County:	
City:	
Population Served:	80,000
Project Area:	

Project Construction Cost Estimate	
Construction	$600,000
Real Estate	$150,000
Planning, Engineering, and Design	$120,000
Construction Management	$36,000
Contingency	$112,500
Total Cost	$1,018,500

Annual Operations and Maintenance	
O&M Cost	$5,000

Study Area Data	
Average Hourly Wage	$26
Hours Per Person	34.4
Persons Per household	2.44
Persons Per Business	37.67
Roadway Repair Costs Per Mile	$528,000

STEP 3: Describe the baseline

If using the fillable model/worksheets, proceed to the "**2 – Inputs**" worksheet to continue information entry.

In this step, users will describe the baseline (see section 4.1 of the guidance manual) which includes explanations related to the extent of existing flood and flood-related damages in the study area, and whether the proposed project will ameliorate them all or not. At this stage, the baseline contains several categories of DAMAGES, part of which will become BENEFITS in Step 4 below.

Rural flood-related damages include:

a) Losses to production agriculture on flooded cropland and pasture;

b) Damages to inundated structures, infrastructure

c) Damages to water management infrastructure (i.e., ditches); and

d) Other damages due to flooding not included in a-c.

Data entry begins by specifying project parameters in the worksheet (Figure B2).

- ***Identify The Base Year*** (This is the beginning of the analysis period.)
- ***Identify The Years of Construction*** (This is the number of years required to construct the project.)

Figure B2 : Initial Project Parameters Entry ("2 – Inputs" Worksheet)

2 - Inputs

This is the second data entry worksheet where users provide specific data necessary to estimate project benefits.

Locked Cell for Calculations
Cell for User Input

Category	Sub Category	Input	Units	Input Value	Definition of Term	Reference
Key Inputs	**Base Year**		Year	2018	Beginning year of analysis period	
	End Year		Year	2073	Ending year of analysis period	
	Project Life		Years	50	From construction start to end of analysis. Must be 55 years	
	Discount Factor		%	2.750%	Discount factor used for present value calculations	Discounting is the process of determining the present value of
	Years of Construction		Years	5		

Losses to Production Agriculture on Flooded Cropland

To enter information related to losses to production agriculture on flooded cropland, proceed to the "**3 – EA Rural Flood Damages**" worksheet.

A major issue with estimating flood damage in rural areas is an almost complete absence of appropriate small-scale hydrologic models to develop crop-inundation damage curves. As such, this guidance will use an average-annual-flooded-acre damage estimate taken from secondary sources (Leitch and Fritz, 2018). The damage to each acre of cropland flooded is $100 for every flood event after spring snowmelt (in east central North Dakota). This value was developed for use in Norman County, Minnesota, which is adjacent to Traill and Cass counties in east central North Dakota. The model generates county-specific dollar damage/cropland acre estimates.

In the absence of stage-damage curves, users must estimate the total acres flooded under each flood frequency (Figure B3). The model will compute the average annual acres flooded and subsequent damages.

- ***Estimate and Enter Total Acres Flooded Under Each Flood Event*** (without the project).

The area flooded will likely contain non-cropped areas, wetlands, roads, and farmsteads.

Users enter their best estimates of cropland and pasture acres, within the total area flooded, that are flooded under each flood event. For example, it is possible that no cropland is located within the 2-year floodplain.

Figure B3 : Total cropland and pasture acres flooded at different flood frequencies without the project(s) ("3 – EA Rural Flood Damages" Worksheet)

Total Pasture and Cropland Damages For Existing or Without Project										
Flood Event/ Probability		Total Acres Flooded	Cropland Acres Flooded	Pasture Acres Flooded	Cropland Flood Frequency	Pasture Flood Frequency	Average Annual Acres Flooded	Average Annual Cropland Damages	Average Annual Pasture Damages	Average Annual Damages
2-year/0.5	0.5				0	0	0	-	-	$0.00
5-year/0.2	0.2				0	0	0	-	-	$0.00
10-year/0.1	0.1				0	0	0	-	-	$0.00
25-year/0.04	0.04				0	0	0	-	-	$0.00
50-year/0.02	0.02				0	0	0	-	-	$0.00
100-year/0.01	0.01				0	0	0	-	-	$0.00
Without Project Total										$0.00

With the above information completed and input into the worksheet by the user, the model multiplies the flood frequency probability by the acres flooded and sums across frequencies to get average-annual-acres-flooded for both cropland and pasture. These sums are then internally multiplied by the county-specific annual values for flooded cropland and pasture (each adjusted for county) which is the baseline total annual value of cropland and pasture flood damage. The annual value is then internally multiplied by the present value multiplier for 50 years to get the present value of the baseline damages over the project period.

Damages to Inundated Structures, Infrastructure, and Detours

To enter information related to damages to inundated structures, infrastructure, and detours, continue data input in the "3 - EA Rural Flood Damages" worksheet.

- **Enter The Number of Farmsteads Flooded** (without the project).

In the absence of stage-damage information, baseline farmstead (houses, outbuildings, and grain bins) flood damage is based on the number of farmsteads flooded at each flood-frequency. It is unlikely there would be any structures or infrastructure flooded at high frequency events (i.e., 2-year, 5-year), but the user determines if there are any.

The number of farmsteads entered by the user is internally multiplied by $1,250 to arrive at the average annual farmstead damage. The $1,250 comes from a rural watershed flooding study in Norman County (Leitch and Fritz, 2018). The model-generated average-annual number is then converted to present value within the model.

Figure B4 . Baseline Farmsteads Without the Project(s) ("3 - EA Rural Flood Damages" Worksheet)

Flood Event/ Probability		Farmsteads Flooded	
		Number of Farmsteads Flooded	Annual Farmstead Damages
2-year/0.5	0.5		$0.00
5-year/0.2	0.2		$0.00
10-year/0.1	0.1		$0.00
25-year/0.04	0.04		$0.00
50-year/0.02	0.02		$0.00
100-year/0.01	0.01		$0.00
			$0.00

Baseline infrastructure damages are based on TOTAL flooded acres (which has already been entered). For every 1,000 acres flooded, there is an average annual infrastructure damage of $500 (Leitch and Fritz, 2018). That annual average is multiplied by the present value multiplier to get the 0-year total. If site specific conditions indicate there is more, or less, infrastructure damage, the user will enter that number in place of $500, but justification is required to make that change.

Baseline detour costs are calculated in the model by multiplying miles x vehicles x days of detour x Federal mileage rate, plus total miles/30 x local labor rate for detour time.

Damages to Water Management Infrastructure (i.e., ditches)

"Without project" flooding can lead to ditch bank sloughing and erosion. The expected length of bank erosion during each flood event is entered into Figure B5 and the input worksheet. The model computes an average annual bank erosion factor, assigns a value of $40/foot for repair, and computes the present value over the 50-year project life. The value of $40/foot is from recent bank repair projects in North Dakota.

- **Enter Feet of Bank Erosion** (without the project).
- **Enter Feet of Snagging and Clearing** (without the project).
- **Enter Linear Feet of Sediment Removal** (without the project).

Figure B5 . Irregular Project Cost Data Entry ("3 - EA Rural" Worksheet)

Flood Event/ Probability		Bank Erosion		Cleanup		Sediment Removal	
		Feet of Bank Erosion	Annual Erosion Damage	Length Snagging & Clearing	Annual Clearing Costs	Sediment Removal	Annual Sediment Removal Costs
2-year/0.5	0.5		$0.00		$0.00		$0.00
5-year/0.2	0.2		$0.00		$0.00		$0.00
10-year/0.1	0.1		$0.00		$0.00		$0.00
25-year/0.04	0.04		$0.00		$0.00		$0.00
50-year/0.02	0.02		$0.00		$0.00		$0.00
100-year/0.01	0.01		$0.00		$0.00		$0.00
			$0.00		**$0.00**		**$0.00**

Summary of Step 3

After completing Step 3, the model will provide an estimate of the present value of baseline flood damages if they occurred over the project life (50 years). Both total and category-specific PV estimates will be included.

STEP 4: Identify and input project benefits (changes in baseline) for each alternative

Project benefits are somewhat more complicated to estimate than project costs, since they require predicting an unknown future over the life of the project, a future that will likely change with or without a project. However, users already know the baseline level of damages from Step 3, which is the upper limit of flood damages that can be eliminated with a project.

Another nuance about benefits, is that some benefits occur only when floods occur (e.g., reduced structure or infrastructure damage, reduced cropland losses), but others, such as enhancement benefits, occur every year once the project is complete. Three categories of benefits are included as worksheet inputs: (1) cropland and pasture, (2) structures and infrastructure, and (3) enhancements. Worksheets are provided that lead to estimates for input to the EA(R) model (Figure B6).

Referring again to the four categories of Baseline damages:

a) Losses to production agriculture on flooded cropland and pasture;

b) Damages to inundated structures, infrastructure, and associated transportation costs;

c) Damages to water management infrastructure (i.e., ditches); and

d) Other damages due to flooding not included in a-d.

These are the four areas where a project can reduce damages from the baseline.

Benefits to Production Agriculture on Flooded Cropland and Pasture

To enter information related to benefits pertaining to production agriculture, continue data input in the "3 - EA Rural Flood Damages" worksheet.

Benefits (damages prevented) to production agriculture are estimated similarly to damages under the baseline condition.

- **Enter Estimates of Total, Cropland, and Pasture Acres Flooded With The Project** (under each flooding scenario, or for each alternative).

It is expected that a rural flood damage control project will eliminate most, if not all, of the high frequency flood damages. Typically the goal for production agriculture is to eliminate all damages up to and including the 10-year event, which may reduce some of the lower frequency events. However, there may be projects where more protection is desired and the model allows for that. Those protection alternatives are reflected in the numbers users put in Figure B6.

Figure B6 . WITH PROJECT Total, cropland, and pasture acres flooded at different flood frequencies ("3- EA Rural Flood Damages" Worksheet)

Total Pasture and Cropland Damages With Project										
Flood Event/ Probability		Total acres Flooded	Cropland Acres Flooded	Pasture Acres Flooded	Cropland Flood Frequency	Pasture Flood Frequency	Average Annual Acres Flooded	Average Annual Cropland Damages	Average Annual Pasture Damages	Average Annual Damages
2-year/0.5	0.5				0	0	0			$0.00
5-year/0.2	0.2				0	0	0			$0.00
10-year/0.1	0.1				0	0	0			$0.00
25-year/0.04	0.04				0	0	0			$0.00
50-year/0.02	0.02				0	0	0			$0.00
100-year/0.01	0.01				0	0	0			$0.00
With Project Total										$0.00
Total Rural Mitigation Benefits										$0.00

The EA(R) model will internally calculate residual damages with the project and subtract those from the baseline condition, leaving an estimate of project benefits for production agriculture.

Structure, Infrastructure, and Avoided Detour Benefits

Projects that change the extent of land flooded will reduce baseline flood damages to structures and infrastructure. Reduced flooding will also reduce, or eliminate, flood-related detours. Users estimate data to complete the following information, by project or alternative, and enter that data into the worksheet.

- **Enter the Number of Farmsteads Flooded** (with the project).
- **Enter Feet of Bank Erosion** (with the project).

Figure B7 . WITH PROJECT Farmsteads Protected and Bank Erosion Prevented ("3 – EA Rural Flood Damages" Worksheet)

Flood Event/ Probability		Farmsteads Flooded		Bank Erosion	
		Number of Farmsteads Flooded	Annual Farmstead Damages	Feet of Bank Erosion	Annual Erosion Damage
2-year/0.5	0.5		$0.00		$0.00
5-year/0.2	0.2		$0.00		$0.00
10-year/0.1	0.1		$0.00		$0.00
25-year/0.04	0.04		$0.00		$0.00
50-year/0.02	0.02		$0.00		$0.00
100-year/0.01	0.01		$0.00		$0.00
			$0.00		**$0.00**

- **Enter Feet of Snagging and Clearing** (with the project).
- **Enter Feet of Sediment Removal** (with the project).

Figure B8 : WITH PROJECT Length of Snagging and Clearing and Sediment Removal ("3 – EA Rural Flood Damages" Worksheet)

Flood Event/ Probability		Cleanup		Sediment Removal	
		Length Snagging & Clearing	Annual Clearing Costs	Sediment Removal	Annual Sediment Removal Costs
2-year/0.5	0.5		$0.00		$0.00
5-year/0.2	0.2		$0.00		$0.00
10-year/0.1	0.1		$0.00		$0.00
25-year/0.04	0.04		$0.00		$0.00
50-year/0.02	0.02		$0.00		$0.00
100-year/0.01	0.01		$0.00		$0.00
			$0.00		**$0.00**

The EA(R) model will calculate the present value of bank erosion prevented, farmsteads protected, and detours avoided by comparing to the baseline.

With project detour costs are calculated in the model by multiplying miles x vehicles x days of detour x Federal mileage rate, plus total miles/30 x local labor rate for detour time.

- ***Enter the Length of Detour in Miles*** (with the project).
- ***Enter the Number of Vehicles Detoured*** (with the project).
- ***Enter the Number of Days of Detour*** (with the project).

Figure B9 : WITH PROJECT Detour Costs ("3 – EA Rural Flood Damages" Worksheet)

Flood Event/ Probability		Detour Costs			
		Miles	Vehicles	Days	Detour Costs
2-year/0.5	0.5				$0.00
5-year/0.2	0.2				$0.00
10-year/0.1	0.1				$0.00
25-year/0.04	0.04				$0.00
50-year/0.02	0.02				$0.00
100-year/0.01	0.01				$0.00
					$0.00

Enhancement Benefits WITH Project

Rural flood control projects may produce natural resources and environmental (NRE) enhancements, such as habitat and improved water quality. Project planners will identify the extent of NRE enhancements shown in Figure B9 in the "2 - Inputs" worksheet and input those estimates. Enhancements are assumed to be in addition to baseline conditions, so it isn't necessary to estimate a baseline.

- ***Enter the Number of Users and Days Used for Both Consumptive and Non-Consumptive Usage***

Figure B10 : WITH PROJECT Natural Resources Enhancements - Recreation ("2 – Inputs" Worksheet)

Other and Recreation	**Consumptive Use**	**Users**	#	8			
		Days	#	5			
		Value	$	113.00	Applied to User-Days Justification-Source Required		Hunting waterfowl
	Non-Consumptive Use	**Users**	#	0			Parks and pathways and golf for this example
		Days	#	0.00			
		Value	$	35.00	Appied to User-Days Justification-Source Required		Trust for Public Lands - 2009 Measuring the value of a City Park System
Travel Delays	**Vehicles Per Day**		#/Day	600.00			
	Normal Drive Time		Minutes	10			
	Detour Drive Time		Minutes	20			
	Duration of Roadway Closure		Interval	Without	With		
			10	6	0	Days	
			20	8	0	Days	
			50	12	2	Days	
			100	14	6	Days	

Consumptive and non-consumptive recreation days will be available annually from a project, not just when it floods. The model will value each type of day and generate the present value of those benefits over the life of the project. Including benefits for both "habitat" and "recreation days" is double counting. Users are encouraged to include other justifiable benefits as an "other" input in the worksheets, but justification must be included.

Water quality improvement is expected to occur only when impoundments are a project component. Flood waters are stored upstream and released slowly later. As such, water quality benefits only occur when floods occur. Users will enter acre-feet stored during each flood frequency event and the model will annualize that number, assign a value, and calculate its present value over the life of the project.

- **Enter Acre-feet Stored**

Water quality improvements are valued at $0.73/acre-feet of stored water, for keeping nitrogen, phosphorus, and TSS out of the waterway (Taff, 2017).

Figure B11 : WITH PROJECT Stored Water Benefits ("3 – EA Rural Flood Damages" Worksheet)

Flood Event/ Probability		Stored Water Benefits	
		Acre Feet of Stored Water	Annual Stored Water Benefits
2-year/0.5	0.5		$0.00
5-year/0.2	0.2		$0.00
10-year/0.1	0.1		$0.00
25-year/0.04	0.04		$0.00
50-year/0.02	0.02		$0.00
100-year/0.01	0.01		$0.00
			$0.00

STEP 5: Presentation and comparison of results

When users have completed Steps 1 through 4, the model will report a number of results in an output table.

The results are found in "**5 - Results Summary**" and "**6 – EA Detail**". In "**5 – Results Summary**" users are presented with a breakdown of the total present value and average annual benefits and costs of the project. The estimated benefits and costs are combined into four project performance metrics: Benefit-to-Cost Ratios, Net Benefits, Internal Rate of Return (IRR), and Payback Year (Figure B12). The use of these metrics is described in more detail in the main guidance document.

In "**6 – Detail**", users are able to see the annual calculations for costs and benefits. The costs and benefits are shown in both undiscounted (real monetary terms) and converted to present value (discounted). The sheet also provides the total present value sum of the costs and benefits.

Figure BI2 : Results Summary ("5 – Results Summary" Worksheet)

5 - Results Summary

This worksheet serves as the summary for all outputs created in the model. For the given inputs, the Results Summary provides an overview of present value and average annual benefits and costs. The Results Summary also presents project performance metrics including: Benefit-to-Cost Ratios, Net Benefits, Internal Rate of Return, and Payback Year.

Scenario Analysis - Benefit Summary

Urban Flood Control Benefits	Present Value ($1K)	Average Annual ($1K)
Flood Mitigation Benefits	$0	$0
Flood Relocation	$0	$0
Travel Time Delays	$44	$2
Flood Fighting	$0	$0
Social Benefits	$0	$0
Subtotal	$44	$2
Other Benefits		
Other Benefits	$105	$4
Consumptive	$105	$4
Non-Consumptive	$0	$0
Rural Flood Conveyance and Other Benefits		
Rural Flooding Benefit	$40	$2
Bank Erosion Benefit	$369	$14
Cleanup Cost Benefit	$8	$0
Sediment Removal Benefit	$28	$1
Stored Water Benefit	$1	$0
Detour Benefit	$69	$3
Total Rural Mitigation Benefits	$1,062	$40
Subtotal	$1,682	$64
Grand Total	$1,726	$65

Project Costs	Present Value ($1K)	Average Annual ($1K)
Capital Costs	$963	$37
Annual O&M	$116	$4
Total	$1,080	$41

Project Performance Metrics	Present Value ($1K)	Average Annual ($1K)
Benefit-to-Cost Ratio	1.599	
Net Benefits	$646	$25
Internal Rate of Return	225%	
Payback Year	5	

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