RTD-254

California Department of Water Resources

# Economic Analysis

# *Guidebook*

A Guide to Assist Program Managers with:

- ✓ Federal and State Economic Analysis Guidance
- ✓ Economic Analysis Methods
- ✓ Ecosystem Valuation Methods
- ✓ Economic Analysis Models
- ✓ Economic Analysis and the Federal Planning Process

January 2008

State of California
The Resources Agency

Department of Water Resources

# Economic Analysis Guidebook

January 2008


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# Executive Summary

Because of its considerable water management partnerships with the federal government, the Department of Water Resources (DWR) has a policy that all economic analyses conducted for its internal use on programs and projects be fundamentally consistent with the federal *Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*), which was adopted by the US Water Resources Council on March 10, 1983. The *P&G* set 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 *guidelines* that "…establish standards and procedures for use by federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies."

It is also DWR policy to adopt, maintain, and periodically update its own *Economics Analysis Guidebook*, which is consistent with the *P&G* but can also incorporate innovative methods and tools when appropriate. This policy is necessary because (a) the *P&G* has not been updated for more than 20 years, (b) federal and State economic analyses sometimes have different regional analysis perspectives, and (c) water management projects and programs have become more complex.

The *Economics Analysis Guidebook* (Guidebook) was developed to assist DWR economists in performing economic analyses and, more importantly, to explain economics concepts, methods, and tools to non-economist staff, program managers, and management within DWR. This Guidebook should be used in conjunction with the federal *P&G* in the preparation of project feasibility and socioeconomic impact analyses. If DWR is partnering with a federal agency during the preparation of a feasibility study, then the *P&G* will have precedence over this Guidebook in determining the federal National Economic Development Plan. However, this Guidebook may help DWR identify a "Locally Preferred Plan" that is preferable from a State or local perspective rather than a National Economic Development Plan, which otherwise might have been implemented with strict adherence to the *P&G*.

Economic analysis is a critical element of the planning process, although it is but one of many important elements. Every agency involved in water resource development has its own planning process, which can sometimes be formally defined. For example, the US Army Corps of Engineers (Corps) and US Bureau of Reclamation (Bureau) follow a six-step planning process based upon the federal *P&G*:

- Specification of Problems and Opportunities
- Inventory and Forecast of Water and Related Land Resource Conditions
- Identification of Alternative Plans
- Comparison of Alternative Plans
- Evaluation of the Effects of Alternative Plans
- Selection of Appropriate Plan

Within the water management planning process, an increasingly important goal is to plan for solutions that promote the sustainable use of all natural resources to ensure their availability for future generations. *California Water Plan Update 2005* (Bulletin 160-05, Volume 1, Chapter 2) identifies "Three E's" that are vehicles to sustainability and help ensure that competing needs are met when implementing integrated resources planning—environment, social equity, and economy. Economic analysis can play an important role in evaluating all three:

- Environmental evaluation: Tradeoffs between the "natural" and "human" environments exist, and these will have to be evaluated for existing and new water uses. For example, water uses that benefit the natural environment must be considered even if they adversely impact agricultural and urban water users.
- Social equity evaluation: Water management proposals can affect different groups within society differently, thus the social equity (or environmental justice) implications of these proposals must be evaluated. For example, third party impacts resulting from water transfers from agriculture to accommodate urban growth can disproportionately impact migrant worker communities.
- Economic and financial evaluation: This requires an evaluation of all economic costs for structural and non-structural alternatives. These costs include capital, operations, maintenance, and mitigation. Non-monetary costs and benefits must also be taken into account. In addition, identifying how the costs and benefits are allocated among stakeholders is an important component of any plan.

The *Economics Analysis Guidebook* discusses the following topics, which are summarized below:

- Federal and State Economic Analysis Guidelines
- Economic Analysis Methods
- Ecosystem Valuation Methods
- Economic Analysis Models
- Economic Analysis and the Federal Planning Process
- Financial Analysis

Federal and State Economic Analysis Guidelines. Because DWR often partners with federal agencies, it is critical that we understand and be in compliance with federal guidance. Federal agencies engaged in water and related land resources development must follow the *Principles & Guidelines (P&G)*.[a] 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.

As its name implies, the *P&G* comprises two parts. The first part of 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." The second part of the *P&G* includes guidelines that "…establish standards and procedures for use by federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies."

[a] Federal agencies required to follow the *P&G* include the Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and Soil Conservation Service (now called the Natural Resource Conservation Service).

Included in the first section is the federal objective of water and related land resources project planning: "… to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statues, applicable executive orders, and other federal planning requirements." The first section identifies four planning accounts which provide a framework for project evaluations.

- The national economic development (NED) account displays changes in the net value of the national output of goods and services expressed in monetary units; display of the NED account is required whereas display of the other accounts is discretionary.
- The environmental quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans.
- The regional economic development (RED) account displays changes in the distribution of regional economic activity (for example, income, and employment).
- The other social effects (OSE) account displays plan effects on social aspects—such as, community impacts, health, and safety, displacement, energy conservation, and other effects.

Key elements of the second section include more detailed discussions of federal planning standards (that is, how to implement the *P&G* process) as well as specific concepts and procedures for computing NED benefits that are typically expressed in monetary units, for example, municipal and industrial and agricultural water supply, urban and agricultural flood damage, power (hydropower), transportation (inland and deep draft navigation, recreation, and commercial fishing). The second section also discusses EQ evaluation concepts and procedures (for example, developing indicators that measure changes in the physical characteristics of plant and animal species but which are not usually assigned monetary values) as well as procedures for the other two accounts.

In addition to federal guidance, DWR relies on its own economics references including the 1968 *Economics Manual* (part of DWR's *Planning Manual Series*) and the 1977 *Draft Economics Practices Manual.* However*,* both of these references are outdated, and the 1977 draft manual was never formally adopted by DWR.

<u>Economic Analysis Methods</u>. Three common economic analysis methods include cost-effectiveness, benefit-cost, and economic impact analyses. The use of one or more of these methods will depend upon the scope and objectives of the analysis as well as the available data.

- Cost-effectiveness is the least comprehensive analysis that identifies the least costly method for achieving specific physical objectives.
- Benefit-cost analysis determines whether the direct social benefits of a proposed project or plan outweigh its social costs over the analysis period. Such a comparison can be displayed as either the quotient of benefits divided by costs (the benefit/cost ratio), the difference between benefits and costs (net benefits), or both. 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.
- Socioeconomic impact analysis is broader in scope because it identifies the direct and indirect (secondary), positive and negative effects of an action or project.

Ecosystem Valuation Methods. Water resource management projects and programs are becoming more multi-objective, and often one of those objectives is ecosystem restoration. For most objectives, monetary benefits can be reasonably estimated (for example, water supply and quality, hydropower, flood damage reduction, recreation). However, for ecosystem restoration, the economic evaluation is much more difficult. How can monetary benefits be assigned to ecosystem resources? Ecosystems perform a multitude of complex and interrelated functions that not only provide basic biological support but also provide valuable goods and services to society (for example, enhanced water supply and quality, flood damage reduction, recreation). If these goods and services can be identified and measured, then it may be possible to place monetary values on them using market or non-market valuation methods. However, if these ecosystem goods and services are monetized, the resulting values should not be interpreted as the total value of the ecosystem but rather of the particular services it provides for humans. Federal guidance does not currently allow for the monetization of ecosystem benefits; instead, ecosystem benefits must be evaluated using cost-effectiveness methods which may be combined with benefit-cost or tradeoff analyses if other monetized benefits (such as, water supply or flood damage reduction) are provided by a project.

Economic Analysis Models. For economic feasibility analyses, models have been developed by different organizations for specific project purposes (water supply reliability, ecosystem restoration, flood damage reduction, and water quality improvement). These models are used to determine the economic justification of a proposed project through benefit-cost or cost-effectiveness analyses. Some of these models are also used to provide critical information for statewide water planning, such as, forecasting urban and agricultural water demands for the California Water Plan Update (Bulletin 160 series).

Economic analyses generally focus on the primary, or direct, effects of proposed plans, which form the basis of project benefit-cost analyses. However, these direct effects can have ripple (indirect) effects throughout an economy. Input/output (I/O) analysis is a quantitative description of the relationship among industries within the economy; it is an excellent tool for providing a comprehensive description of the economy and identifying secondary economic impacts. Thus, I/O models (such as, IMPLAN) are informative for estimating regional impacts that can be included in federal investigations (the “regional account”) as well as project environmental impact reports/statements.

Table ES-1 summarizes various economic analysis models and their analysis.

**Table ES-1 Economic analysis models and analysis objectives**

| Organizations/ models | Economic justification | | | | Socioeconomic impact analysis |
|---|---|---|---|---|---|
| | Water supply reliability | Ecosystem restoration | Flood damage reduction | Water quality improvement | |
| **DWR** | | | | | |
| Least Cost Planning Simulation (LCPSIM) | X | | | | |
| California Agriculture (CALAG) | X | | | | |
| Net Crop Revenue Models (NCRM) | X | | X | | |
| **Corps** | | | | | |
| IWR MAIN | X | | | | |
| IWR PLAN | | X | | | |
| HEC FDA | | | X | | |
| **FEMA** | | | | | |
| HAZUS | | | X | | |
| Riverine B/C | | | X | | |
| **SWRCB** | | | | | |
| Lost Beneficial Use Value Calculator | | | | X | |
| **MWD/Bureau** | | | | | |
| Salinity Impacts Economics Model | | | | X | |
| **IMPLAN I/O Analysis** | | | | | X |

<u>Economic Analysis and the Federal Planning Process.</u> The culmination of the federal planning process is the selection of a plan or the decision to take no action. The Corps has identified the following types of plans:

- NED Plan: Includes single-project purposes (such as, water supply or flood damage reduction) where project outputs can be measured in dollars and project selection is based on maximizing net monetary benefits.
- National Ecosystem Restoration (NER) Plan: Includes single project purpose of ecosystem restoration projects where project outputs (for example, increases in habitat) are measured in non-monetary units and project selection is based on “reasonably” maximizing ecosystem restoration benefits.[b] The analysis is more subjective in that it does not result in the unique identification of a “best” plan, but the Corps does have an accepted methodology to determine the relative performance of these types of projects using cost-effectiveness and incremental-cost analyses.

[b] The US Bureau of Reclamation currently does not have the authority to formulate NER plans.

- Combined NED/NER Plan: Includes projects which have both NED and NER objectives. Recommendations for multipurpose projects will be based on a combination of NED benefit-cost analysis and NER cost-effectiveness and incremental cost analyses and possibly tradeoff analyses between these two outputs.
- Locally Preferred Plan (LLP): Projects may deviate from the NED, NER, or combined NED/NER plans if requested by the non-federal sponsor. For example, if the sponsor prefers a more costly plan and the increased scope of the plan is not sufficient to warrant full federal participation based on the NED analysis, the LLP may be approved as long as the sponsor pays the difference in costs between the NED (or NED/NER) plans and the LPP.

DWR's economists follow economic guidance set forth in the *P&G* because it is relevant to DWR studies. First, if DWR is a partner with a federal agency on a study or project, then federal guidelines must be followed in order to determine the federal interest in the project and, consequently, its eligibility for federal funding. However, because the federal interest is focused primarily upon the NED account, DWR should also broaden the economic analysis to include regional economic development or other social effects (the RED and OSE accounts), which can significantly assist in the decision-making process. The RED account is particularly important if a proposed plan will have significantly different regional effects (for example, Northern California vs. Southern California) that might otherwise be irrelevant to the NED national perspective. The full evaluation of all four accounts for alternative plans may lead DWR to recommend an LLP that is different than the NED Plan.

<u>Financial Analysis.</u> The objective of financial analysis is to determine financial feasibility (that is, whether someone is willing to pay for a project and has the capability to raise the necessary funds). A financial analysis answers questions such as, Who benefits from a project? Who will repay the project costs, and are they able to meet repayment obligations? Will the beneficiaries be financially better off compared to what they will be obligated to pay? Within DWR, the State Water Project Analysis Office performs financial feasibility analyses for proposed SWP facilities.

The test of financial feasibility is passed if (a) beneficiaries are able to pay reimbursable costs for project outputs over the project's repayment period, (b) sufficient capital is authorized and available to finance construction to completion, and (c) estimated revenues are sufficient to cover allocated costs over the repayment period.

Financial costs are the actual expenditures, "out of pocket" costs that are required to construct and operate a project. Financial costs can be grouped into two main categories—capital and OM&R (operation, maintenance, and replacement). Capital costs are nonrecurring costs required to construct a project from the inception of planning to completion of construction. OM&R costs occur continuously or periodically and are incidental to project operations—such as, electric power for pumping, materials, and supplies used in maintenance and repair—and project administration. Cost allocation is the process by which financial costs of a project are distributed among project purposes. There are various cost allocation methods, including Separable Costs-Remaining Benefits (SCRB), Alternative Justifiable Expenditures, and Proportionate Use of Facilities. However, the most commonly used method is the SCRB method, which distributes costs among the project purposes by identifying separate costs and allocating joint costs or joint savings in proportion to each purpose's remaining benefits. The SCRB method is commonly applied to SWP water storage dams and reservoir projects.

# Acronyms

| | |
|---|---|
| AAUH | average annual habitat unit |
| AW | applied water |
| B/C | benefit/cost |
| Bureau | US Bureau of Reclamation |
| CALAG | California Agriculture model |
| CD | compensation demand |
| COP | certificate of participation |
| Corps | US Army Corps of Engineers |
| CVP | Central Valley Project |
| CVPM | Central Valley Production Model |
| DRMS | Delta Risk Management Strategy |
| DWR | California Department of Water Resources |
| EQ | environmental quality |
| ETAW | evapotranspiration of applied water |
| EWMP | efficient water management practices |
| FDA | Flood Damage Assessment |
| FDR | Flood Damage Reduction |
| FEMA | Federal Emergency Management Agency |
| GAMS | General Algebraic Modeling System |
| HEC | Hydrologic Engineering Center |
| I/O | Input/output analysis |
| IRR | internal rate of return |
| IWR | Institute for Water Resources (Corps) |
| LBUVC | Lost Beneficial Use Value Calculator |
| LCCA | Life Cycle Cost Analysis |
| LCPSIM | Least Cost Planning Simulation Model |
| LLP | Locally Preferred Plan |
| MWD | Metropolitan Water District of Southern California |
| NCRM | Net Crop Revenue Model |
| NED | National Economic Development |
| NER | National Ecosystem Restoration |
| OMP&R | operation, maintenance, power, and replacement |
| OPR | Office of Planning and Research |
| OSE | other social effects |
| P&G | *Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* |
| PFP | probable failure point |
| PMP | Positive Mathematical Programming |
| PNP | probable non-failure point |
| RED | regional economic development |
| SCRB | Separable Costs-Remaining Benefits |
| SWP | State Water Project |
| SWRCB | State Water Resource Control Board |
| TDS | total dissolved solids |
| WTA | willingness to accept |
| WTP | willingness to pay |

# Chapter 1

# Introduction

Economic analysis is a critical element of the water resources planning processes 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 the feasibility 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.

Water resource projects are increasingly becoming more complex, requiring more difficult economic analyses. Projects now tend to have multiple purposes and affect many diverse stakeholders. Thus, public involvement and potential sources of funding are also more complex. And if all that isn't tough enough, traditional methods of performing economic analysis often do not provide reliable means for quantifying important categories of benefits that these projects may provide (such as, ecosystem restoration).

In the California Department of Water Resources (DWR), the chief of the Economic Analysis Section of the Division of Planning and Local Assistance is responsible for ensuring that appropriate practices are used for all economic analyses conducted within DWR, either through direct supervision or review of the work managed by others, including consultants. Program managers should brief the chief and staff of the Economic Analysis Section early in the planning process regarding the objectives of their studies and any required economic analyses. The Economic Analysis Section chief or staff will then prepare scopes of work presenting the appropriate methods and tools to be used for the economic analysis and its data and time requirements or review the scopes of work that may have been prepared by others, including consultants, and suggest changes as appropriate. However, the program manager, project manager, or team lead remains ultimately responsible for ensuring that appropriate economics practices are followed.

## Purposes of DWR Economic Analysis Guidebook

The purposes of this Guidebook are to assist DWR staff by:

- making economic analysis more understandable to other specialists, management, and stakeholders;
- identifing emerging methods of performing economic analysis, particularly those involving benefit assessment for project outputs not usually assigned monetary values;
- describing the basic economic analysis concepts, methods and tools used in water resource planning; and
- providing examples of various types of economic analyses.

This Guidebook will not, however, provide step-by-step instructions for performing economic analysis. Numerous other sources are available that provide this level of detail, including the federal *Economic and Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*) and DWR's 1977 *Draft Economics Practices Manual*. These will be referenced in this Guidebook for those wishing greater detail on how to perform actual evaluations (for example, the estimation of urban or agricultural water supply benefits).

The *Economic Analysis Guidebook* is not intended to supplant regulations that may be required by the Office of Administrative Law for specific programs, such as, loan and grant programs administered by DWR. Also, appropriate regulations may have to be developed by program staff for programs that require economic analysis guidance or criteria to be followed by agencies other than DWR. However, it is recommended that newly adopted regulations reference or incorporate this guidebook.

## Economic Analysis and the Planning Process

As mentioned above, economic analysis is a critical element of the planning process, although it is but one of many important elements. Every agency involved in water resource development has its own planning process, which can sometimes be a formal process. For example, the US Army Corps of Engineers (Corps) and US Bureau of Reclamation (Bureau) follow a six-step planning process based upon the federal *P&G*:

- Specification of Problems and Opportunities
- Inventory and Forecast of Water and Related Land Resource Conditions
- Identification of Alternative Plans
- Comparison of Alternative Plans
- Evaluation of the Effects of Alternative Plans
- Selection of Appropriate Plan[1]

An abundance of written guidelines has been promulgated for Corps planners to follow.[2] Within DWR, the planning process is just as important, but has been less formal than the federal process.

However, whether formal or not, there is no such thing as "the planning model." A more comprehensive model of the planning process may include the following steps:

1) Problem diagnosis
2) Goal articulation
3) Prediction and projection
4) Alternative development
5) Feasibility analysis
6) Evaluation and selection of recommended alternative
7) Implementation
8) Performance evaluation

[1] USACE, *Planning Manual*, November 1996, pg. 13.
[2] For example, see USACE, Regulation No. 1105-2-100, *Planning Guidelines Notebook*, April 22, 2000.

Within the water management planning process, an increasingly important goal is to plan for solutions that promote the sustainable use of all natural resources to ensure their availability for future generations. *California Water Plan Update 2005* (Bulletin 160-05, Volume 1, Chapter 2) identifies “Three E’s” that are vehicles to sustainability and help ensure that competing needs are met when implementing integrated regional water management and planning—environment, social equity and economy. Economic analysis can play an important role in evaluating all three:

- Environmental evaluation: Tradeoffs between the “natural” and “human” environments exist, and these will have to be evaluated for existing and new water uses. For example, water uses that benefit the natural environment must be considered even if they adversely impact agricultural and urban water users.
- Social equity evaluation: Water management proposals can affect different groups within society differently, thus the social equity (or environmental justice) implications of these proposals must be evaluated. For example, third party impacts resulting from water transfers from agriculture to accommodate urban growth can disproportionately impact migrant worker communities.
- Economic and financial evaluation: This requires an evaluation of all economic costs for structural and non-structural alternatives. These costs include capital, operations, maintenance, and mitigation. Non-monetary costs and benefits must also be taken into account. In addition, identifying how the costs and benefits are allocated among stakeholders is an important component of any plan.

## Economic Analysis vs. Financial Analysis

A common misconception is that economic and financial analyses are the same. Although both are required to determine overall project feasibility and sometimes use the same data, they are conceptually different types of analyses. Table 1-1 summarizes the differences between economic and financial analyses.

**Table 1-1 Comparison of economic vs. financial analyses**

| | Economic analysis | Financial analysis |
|---|---|---|
| Analysis perspective | Can vary from individuals, communities, state, and/or national; DWR uses statewide perspective | Project beneficiaries |
| Evaluation period | Economic life of project (usually 50 to 100 years) | Bond repayment period (usually 20 years) |
| Adjustment for inflation | Exclude inflationary effects; price changes different from inflation can be included (escalation) | Include inflationary effects |
| Project input valuation | Project inputs valued using their economic opportunity costs[a] | Project inputs valued using their purchase costs |
| Adjustment for benefits and costs over time | Determine present values using economic discount rate | Determine present values using financial discount rate |
| Discount rate | Economic discount rate; real rate of return (excluding inflation) that could be expected if money were invested in another project; DWR currently uses 6% | Financial discount rate; financial rate of return (including inflation) that could be expected if money were invested in another project; DWR uses expected interest rate of bonds sold to finance project |
| Interest paid on borrowed funds during construction | Not included (financial cost) | Included; DWR uses State revolving fund cost |
| Forgone investment value during construction | Included; real rate of return that could be expected if construction funds were invested in another project (opportunity cost) | Not included |
| Financial costs | Not included | Included |

a. Opportunity cost is the productivity forgone by not investing in the next optimal project. The value of the sacrificed productivity is determined by the monetary value placed on the output of the alternative project. For example, assume that a particular input can be used on either Project A or B. If it's used for Project A, it will create a net benefit of $100 and if it's used for Project B, $150. The purchase cost of this input is $50. For an economic analysis, the opportunity cost of using this input for Project A is the net benefit forgone of not using the input on Project B, or $150. However, for a financial analysis of Project A, only the purchase cost ($50) is used. For an economic analysis, it is often difficult to determine what these opportunity values are, so purchase costs usually are used as a "proxy."

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 test of economic feasibility is passed if the total benefits that result from the project exceed those which would accrue without the project by an amount in excess of the project costs. It is important that the comparison be *with* and *without* rather than *before* and *after* because many of the after effects may even occur without the project and can thus not properly be used in project justification. Economic justification is contingent on engineering feasibility because a project incapable of producing the desired output is not going to produce the benefits needed for its justification.[3]

The economic analysis should answer questions such as, Should the project be built at all? Should it be built now?, Should it be built to a different configuration or size? Will the project have a net positive social value for Californians irrespective of to whom the costs and benefits accrue? Three common methods of economic analysis are cost effectiveness, benefit-cost, and socioeconomic impact analyses.

The objective of financial analysis is to determine financial feasibility (that is, whether someone is willing to pay for a project and has the capability to raise the necessary funds). The test of financial feasibility is passed if (a) beneficiaries are able to pay reimbursable costs for project outputs over the project's repayment period, (b) sufficient capital is authorized and available to finance construction to completion, and (c) estimated revenues are sufficient to cover allocated costs over the repayment period. Thus, a financial analysis answers questions, such as, Who benefits from a project? Who will repay the project costs? Are they able to meet repayment obligations? Will the beneficiaries be financially better off compared to what they will be obligated to pay? Within DWR, the State Water Project Analysis Office performs financial feasibility analyses for proposed SWP facilities.

Some significant differences between economic and financial analyses are listed below.

### Economic Analysis

- Although economic analyses can be evaluated from many different perspectives (individuals, communities, etc.), DWR conducts these analyses from a statewide perspective.
- Evaluation period is the economic life of the project (for example, 50 years).
- Project benefits and capital and annual operation costs are estimated in uninflated dollars.
- Benefits and costs are adjusted to show expected differences in their relative economic value over time.[4]
- Economic discount rate is applied to account for time value of project costs and economic benefits (or avoided economic costs) produced by the project.
- Forgone investment cost during construction are included (opportunity cost of investment).[5]
- Project inputs are valued at their economic opportunity cost.
- Financing costs are not included.

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[3] James and Lee (1971) *Economics of Water Resources Planning*, pg. 161.
[4] Prices used in an economic analysis are held constant over time, except for items that are expected to experience changes in prices different from the general inflation rate. A differential price level increase is called escalation
[5] Opportunity cost is the productivity forgone by not investing in the next optimal project. The value of the sacrificed productivity is determined by the monetary value placed on the output of the alternate project.

### Financial Analysis

- Evaluation is from the perspective of parties expected to pay their allocated costs.
- Evaluation period is the bond repayment period (for example, 20 years).
- Project costs are expected monetary outlays to implement and operate the project.
- Project income and capital and annual operation costs are estimated in inflated dollars.
- Income and costs are adjusted to show expected differences in their relative market value over time.
- Expected interest rate of bonds sold to finance the project is used as the time value of project costs.
- Expected financial rate of return on alternative investments is used as the time value of income (or cost savings) produced by the project.
- Interest paid during construction is included (State revolving fund cost).
- Project inputs are valued at their purchase cost.
- Bond sale and service costs are included.

It is possible for projects to be economically feasible but financially infeasible, or vice versa. For example, a project can be shown to have economic benefits that exceed costs at the statewide level, but there may be no sponsors willing or able to finance it. On the other hand, it may not be possible to demonstrate positive net economic benefits for a project, but a sponsor may still be willing to finance and implement the project.

## Application of Economic Analysis within DWR

Economic analysis has many important applications within DWR, including:

- **SWP facilities' feasibility analysis.** DWR is continuously engaged in evaluating improvements to the facilities and programs of the SWP. Economic analysis is used to determine the net benefits of these facilities and programs as well as the socioeconomic impact upon local communities and the service areas receiving additional water supplies. Although historically such economic evaluations have focused upon structural water management facilities, the significant environmental, social, and financial challenges to building large structural projects has increased the emphasis on non-structural solutions—such as, intra- and inter-regional water transfers and facility operational changes.
- **Non-SWP facilities' feasibility analysis.** DWR often partners with the federal government and other government agencies to conduct feasibility studies for projects not necessarily related to the SWP, but which are critical for statewide water management. Recent examples include Shasta Reservoir enlargement studies conducted by the Bureau and flood damage reduction/ecosystem restoration studies conducted by the Corps and the State Reclamation Board. DWR economists assist with the economic analyses required for these feasibility studies.
- **Statewide planning.** Another key mission of DWR is statewide planning, specifically the preparation of the California Water Plan Update (Bulletin 160 series) every five years. A critical element of the water plan update is the forecasting of regional urban and agricultural water demands and evaluation of alternative response strategies, which can be accomplished using a wide variety of economics modeling tools described below.

- **Environmental/socioeconomic impact analysis.** Federal and State legislation (National Environmental Policy Act and California Environmental Quality Act) require the preparation of environmental impact statements/reports that may require the estimation of socioeconomic impacts of proposed projects and programs. Economic modeling tools described in Chapter 5 can be used to estimate socioeconomic impacts of proposed facilities and programs upon local communities as well as the service areas that will be receiving additional water supplies. These impacts include changes in population, employment, income levels, public service requirements, and revenues, etc.
- **Local assistance loan and grant programs.** Beginning with the Davis-Grunsky Act of 1960, DWR has administered numerous programs that provide either low-interest loans or grants to local communities for water conservation, groundwater recharge, or local water supply development purposes.[6] Many of these programs require the local agencies to prepare benefit-cost ratios (verified by DWR economics staff) as a prerequisite for State funding.
- **Review of other agencies' reports and analyses.** DWR economics staff review and comment on economic analyses prepared by other agencies, including the review of urban and agricultural water management plans that incorporate economic analysis of proposed projects and programs.
- **Support for DWR internal management decisions.** Because of the extensive system of SWP facilities (dams and reservoirs; pumping plants; aqueducts, canals, and pipelines; radial gates, maintenance facilities, etc.) throughout most of the state, DWR management is faced with operational decisions that require the use of resources. These decisions can benefit from economic analysis, although the type of analysis would vary upon individual circumstances. For example, in situations where a decision has been made to proceed with a project or program, a more limited cost-effectiveness analysis may be appropriate to help ensure the best use of resources to achieve that objective. In other cases where a wide range of options is being considered, a more intensive benefit-cost analysis may be more effective. In the past, DWR economics staff have prepared analyses of (a) building a centralized maintenance facility for the repair and painting of radial gates along the California Aqueduct vs. repairing and painting them in place; (b) the addition of an afterbay for the A.D. Edmonston Pumping Plant, and (c) moving the Southern Field Division headquarters to a different location.

[6] Besides Davis-Grunsky, these include programs associated with Propositions 25 (1984), 44 (1986), 82 (1988), 13 (1999), and 50 (2002).

# Chapter 2
# Federal and State Economic Analysis Guidance

Both the federal and State governments (including DWR) have developed guidelines and procedures on how the various agencies are expected to perform economic analyses. Although much of the guidelines were developed more than 20 years ago, many of the concepts and methods are still relevant. They are essential to ensure that staffs performing project feasibility studies are following appropriate and consistent procedures. The guidance also helps managers better understand the results of economic analyses. The economic analysis guidelines are summarized below. Because DWR often partners with federal agencies, it is critical that we understand and be in compliance with federal guidelines.

## Federal Economic Analysis Guidelines

Economic analyses performed by federal agencies engaged in water and related land resources development must follow the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*) adopted by the US Water Resources Council on March 10, 1983. All other federal agencies must follow *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, which was published by the President's Office of Management and Budget (October 29, 1992).

### Principles and Guidelines

As its name implies, the *P&G* comprises two parts.[7] The first part sets forth *principles* that are "…intended to ensure proper and consistent planning by federal agencies in the formulation and evaluation of water and related land resources implementation studies." The second part includes guidelines that "…establish standards and procedures for use by federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies." Thus, the first part essentially establishes project planning policies, and the second part discusses the "how to" procedures.

Included in the first section is the federal objective of water and related land resources project planning: "… to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statues, applicable executive orders, and other federal planning requirements." This section identifies the four federal planning accounts that provide a framework for the evaluation and display of effects of alternative plans.

- The **National Economic Development (NED) account** displays changes in the economic value of the national output of goods and services expressed in monetary units.
- The **Environmental Quality (EQ) account** displays non-monetary effects on significant natural and cultural resources.

[7] Federal agencies required to follow the *P&G* include the Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and Soil Conservation Service (now called the Natural Resource Conservation Service). Copies of the *P&G* (plus related Corps planning guidelines) can be found at: http://www.usace.army.mil/cw/cecw-cp/library/planlib.html

- The **Regional Economic Development (RED) account** shows changes in the distribution of regional economic activity that result from each alternative plan using nationally consistent projections of income, employment, output, and population.
- The **Other Social Effects (OSE) account** shows plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts (such as, urban and community impacts, life, health and safety factors, displacement, long-term productivity, and energy requirements and conservation).

The NED account is required. Other information that is required by law or that will have a material bearing on the decision-making should be included in the other accounts, or in some other appropriate format used to organize information on effects. A plan recommending federal action is the alternative plan with the greatest net economic benefit consistent with protecting the nation's environment (the NED plan), unless the Secretary of a department or head of an independent agency grants an exception to this rule.

Key elements of the second section include more detailed discussions of federal planning standards (that is, how to follow the *P&G* process) as well as specific concepts and procedures for computing NED benefits (municipal and industrial and agricultural water supply, urban and agricultural flood damage, power [hydropower], transportation [inland and deep draft navigation, recreation and commercial fishing]), which are typically expressed in monetary units. This section also discusses EQ evaluation concepts and procedures (for example, developing indicators that measure changes in the physical characteristics of plant and animal species but which are not usually assigned monetary values) as well as procedures for the other two accounts.

Federal agencies may supplement the *P&G* with their own guidelines and procedural manuals. The Corps is an excellent example. Its *Planning Guidelines Notebook* (plus an abundance of guidelines letters, engineering regulations, engineering circulars, and engineering manuals) contain specific policies and detailed procedures for conducting Corps planning studies that are in compliance with the *P&G*. The Corps' planning process is discussed in more detail in Chapter 6.

Although the *P&G* represented the state-of-the art when adopted in 1983, it has come under increasing criticism because of its focus upon the NED account and what is often perceived as inadequate attention to the environmental and other accounts.[8] In 1999, the National Research Council recommended "...that the federal *Principles & Guidelines* be thoroughly reviewed and modified to incorporate contemporary analytical techniques and changes in public values and federal agency programs."[9] This criticism is particularly relevant given the multi-objective nature of water resources projects today and the need to incorporate—and thus better evaluate—environmental and other types of benefits. These issues are discussed in Chapter 6.

[8] In comparison, the *P&G's* predecessor (the 1971 *Principles & Standards for Planning Water and Related Land Resources)* gave equal weight to all four accounts.
[9] National Research Council, *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*, pg. 19.

### Circular A-94

The President's Office of Management and Budget published *Circular A-94*[10] to "…promote efficient resource allocation through well-informed decision-making by the Federal Government. It provides general guidelines for conducting benefit-cost and cost-effectiveness analyses." *Circular A-94* applies to all federal agencies except those following the *P&G*. As with the *P&G*, *Circular A-94* sets forth general principles (for example, when to use benefit-cost analysis vs. cost-effectiveness analysis) and more specific guidelines (for example, identification and measurement of benefits, treatment of inflation, discount rates, etc.) for economic analyses. In addition, *Circular A-94* provides special guidelines for public investment, regulatory impact analysis, and lease-purchase analyses. *Circular A-94* Appendices A and B provide definitions and additional guidelines for discounting. Appendix B provides updated Treasury interest rates.

## State Economics Analysis Guidance

There is no economics guideline publication for State agencies that is comparable to the federal *P&G*, although some agencies have adopted their own. For example, DWR, the State Water Resource Control Board (SWRCB), and the Office of Planning and Research (OPR) have published economic guidelines for use within their own departments or for use by other State and regional agencies.

### California Department of Water Resources

DWR economists follow economic guidelines set forth in the *P&G*. However, DWR has published its own economics guidelines dating back to 1968 when an *Economics Manual* was included as part of DWR's *Planning Manual Series*.[11] This economics manual was to serve "…as a source of reference not only for economic aspects of planning, but also for all economic studies undertaken by DWR." Key elements of this first manual included framework and standards for economic analysis, concepts, and important factors of benefit analyses, economic justification policies, economic analysis methods, definitions, benefit measurement techniques, types of water project benefits, financial feasibility analyses.

In January 1977, DWR released a revision to the *Economics Manual*—the draft *Economics Practices Manual*. Although never finalized, it serves as a useful reference manual. This revision incorporated much of the information from the first manual, but added several new topics reflecting broader planning concerns such as, "…the display of monetary and non-monetary benefits and costs associated with environmental considerations and the inclusion of secondary impacts involving regional analysis, inter-industry relationships, community and social-personal impacts, and so on." Additional sections were added concerning values in water planning, forecasting techniques, demand and price elasticity, selection of alternatives, water quality assessments, and uncertainty management. More detail was also included concerning "how to" estimate water project-related benefits, compared to the primarily conceptual discussions of benefit evaluation in the first economics manual. This draft manual was published when the 1971 *Principles and Standards* was still in effect, and it recommended procedures similar to those federal guidelines. Hard copies of the 1968 and 1977 manuals can be found in the Economic Analysis Section of the Division of Planning and Local Assistance.

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[10] Copies of OMB Circular A-94 can be obtained at http://www.whitehouse.gov/omb/circulars/index.html.

[11] DWR, *Planning Manual: Economics*, August 1968. Other manuals included *Design and Cost Data*, *Fish and Wildlife*, *Geology*, *Ground Water Hydrology*, *Land Utilization*, *Recreation*, *Reports*, *Sedimentation*, *Surface Water Hydrology*, *Water Quality* and *Water Utilization*.

### State Water Resources Control Board

The SWRCB's Office of Water Recycling published the *Interim Guidelines for Economic and Financial Analyses of Water Reclamation Project* in February 1979. These guidelines were developed to (1) elaborate on the US Environmental Protection Agency regulations and to make them specific to reclamation projects and (2) assist engineers and financial advisors in performing appropriate economic and financial evaluations, especially those applying for grants. These guidelines are well written and include example formats for setting up analyses as well as numerical examples. However, the guidelines have not been updated.

### Governor's Office of Planning and Research

OPR published *Economics Practices Manual: a Handbook for Preparing an Economic Impact Assessment* in 1978 with a revised edition published in April 1984. The purpose of this manual is to assist local officials in assessing the socioeconomic impacts of land use decisions. These impacts include changes in population, employment, income, housing, land use, and fiscal effects (public service costs and revenues). This manual contains very specific "how to" instructions as well as detailed example calculations. Socioeconomic impacts are not usually included in benefit-cost analyses (which focus upon primary project benefits and costs), but they are critical to regional analyses, particularly growth-inducing impacts of (a) water project construction in a local community and (b) water deliveries to water-deficient service areas. This manual has not been updated.

Hard copies of the SWRCB and OPR manuals can be found in the Economic Analysis Section of DWR's Division of Planning and Local Assistance.

# Chapter 3
# Economic Analysis Methods

Three common economic analysis methods are cost-effectiveness, benefit-cost, and socioeconomic impact analysis. A cost-effectiveness analysis identifies the least costly method for achieving specific physical objectives. A benefit-and-cost analysis determines whether the social benefits of a proposed project or plan outweigh its social costs over the analysis period. Such a comparison can be displayed as either the quotient of benefits divided by costs (the benefit-cost ratio), the difference between benefits and costs (net benefits), or both. 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. Socioeconomic impact analysis is broader in scope because it identifies the direct and indirect (secondary) positive and negative effects of an action or project. The use of one or more of these methods will depend upon the scope and objectives of the analysis as well as available data.

## Cost-Effectiveness Analysis

As the name implies, cost-effectiveness analysis focuses upon costs of achieving or exceeding an objective that can be expressed in specific, non-monetary terms (acre-feet, milligrams per liter, habitat units, etc.). For example, if the objective of the project is to deliver *x* acre-feet of water to a service area per year, then a cost-effectiveness analysis would compare the costs of alternative plans that meet or exceed that objective. Other things being equal, the plan that delivers the specified water quantities at the least cost would be the preferred plan. Although benefit-cost analysis is the primary method used to economically justify a project (as described below), cost-effectiveness analysis can often provide additional information that can serve as a "reality check" for the benefit-cost analysis (for example, Does it make sense?) and has implications for the financial analysis (for example, Can the community really afford the project?).

Cost-effectiveness analysis is particularly important when the objective cannot be expressed in monetary terms and therefore cannot be included in a traditional benefit-cost analysis. A good example of this in water resources planning is ecosystem restoration; many projects now include ecosystem restoration either as their primary purpose or as part of a multi-objective project. Although there are techniques to place monetary values on the outputs of ecosystem restoration projects (described in Chapter 4), traditionally these types of projects are evaluated by computing the cost-per-restored-habitat-acre or some other physical measure (such as, habitat units), and comparing these costs (as well as the incremental changes in costs and outputs among proposed alternatives). Because ecosystem restoration is now a recognized project purpose for the Corps (either by itself or combined with other purposes), the Corps' Institute for Water Resources has developed software to perform this type of analysis—IWR PLAN.[12]

The costs usually included in a cost-effectiveness analysis are capital and annual operation, maintenance, and replacement. Capital costs refer to the construction or "first costs" of the project, whereas the other costs are annual costs incurred to keep the project operational. If there are other costs imposed upon others as a result of project operations (externalities), then these should be included as well if they can be monetized. As shown in the discounting analysis example in Appendix A, all costs should be discounted

[12] This software is available at the IWR Web site: http://www.water-resources.us/index.cfm

back to a base year using the appropriate discount rate.[13] Similarly, when capital costs are expended over a number of years prior to project operation, the costs must be brought forward to the base year using the inverse of the discount rate.

## Benefit-Cost Analysis

Benefit-cost analysis is the procedure where the different benefits and costs of proposed projects are identified and measured (usually in monetary terms) and then compared with each other to determine if the benefits of the project exceed its costs. Benefit-cost analysis is the primary method used to determine if a project is economically justified. A project is justified when:[14]

- estimated total benefits exceed total estimated economic costs;
- each separable purpose (for example, water supply, hydropower, flood damage reduction, ecosystem restoration, etc.) provides benefits at least equal to its costs;
- the scale of development provides maximum net benefits (in other words, there are no smaller or larger projects which provide greater net benefits); and
- there are no more-economical means of accomplishing the same purpose.

### Decision Criteria

Economic comparisons of projects are most commonly made on the basis of net benefits, the benefit-cost ratio, or the internal rate of return.

- Net benefits: the optimum scale of development for a given project occurs at the point where its net benefits are at a maximum. Net benefits are at a maximum when the benefits added by the last increment of a project are equal to the cost of adding that increment. In other words, marginal benefits equal marginal costs. Net benefits are determined by estimating discounted benefits and costs over the study period, and then subtracting the discounted costs from the discounted benefits to obtain discounted net benefits. The net benefit criterion does not take into account the absolute level of costs involved in realizing the net benefits, thus it should be used only when the projects being compared are of similar objectives and size.
- Benefit/cost (B/C) ratio: Benefits and costs can be expressed as a ratio by dividing discounted benefits by discounted costs. A project is economically justified if its B/C ratio is greater than 1.00. The B/C ratio is a measure of relative rather than absolute merit, thus it can be used to select from projects of different scales and objectives. However, the most economic use of a given resource rarely occurs at that scale of development where the B/C ratio is at a maximum. Thus, B/C ratios can be used to select a project from several alternatives, but once an alternative is chosen, a net benefit analysis may be warranted to determine the most economic-efficient scale of the selected alternative. In other words, can increasing the size of the selected alternative increase its net benefits?
- Internal rate of return (IRR): This criterion computes the rate of return, or discount rate, which just equates discounted benefits with discounted costs. If the computed rate of return is greater than a specified discount rate, then the project is determined to be economically justified. For example, DWR is currently using a 6% discount rate (see below). If the IRR of a proposed project is determined to be 4%, then the project would be rejected. In contrast, if the IRR is estimated to

[13] The base year is the year prior to operations (year zero). See Appendix A for an example of discounting.
[14] DWR Draft *Planning Manual: Economics*, 1968.

be 7%, then the project would be economically acceptable. Although the IRR criterion usually produces the same results as the net benefits or B/C criteria, it is possible for the IRR to compute more than one solution depending upon the time stream of benefits and costs.[15]

### Discount Rate

The discount rate is used to adjust dollars received or spent at different times to dollars of a common value, usually present day dollars ("present worth" or "present value"). Although there are different methods for determining discount rates, generally the value to use for this rate is the real (that is, excluding inflation) rate of return that could be expected if the money were instead invested in another project. In other words, the discount rate is a measure of forgone investment opportunity (that is, "opportunity cost") if the money allocated to the project were invested elsewhere.

The selection of a discount rate is critical for the analysis because the larger the discount rate, the greater the reduction in future monetary values. This tends to affect benefits more than costs because the majority of costs are incurred early in the analysis period (for example, construction costs); whereas, benefits typically occur later in the analysis period. DWR is currently using a 6% discount rate, which approximates the marginal pretax rate-of-return on an average investment in the private sector in recent years. This rate will be periodically reviewed and revised as necessary. The US Treasury Department annually sets the discount rate used by the Corps and the Bureau.[16] The discount rate is very much different from the bond repayment interest rate that is used in the financial analysis.

### Types of Benefits

Benefits are the values of goods and services produced by the project and by activities stemming from or induced by the project. Benefits play a critical role in determining the economic justification of a project and in allocating costs among different project purposes and sponsors. There are many different types of benefits, some more easily measured than others, that can complicate a benefit-cost analysis.

- Primary vs. secondary. *Primary benefits* are the increased values of goods and services attributable to a project; that is, increases in products or services and/or reductions in costs, damage, or losses to those directly affected by the project (primary beneficiaries). Examples of a water project's products and services include increased water supply and improved water quality; an example of reduced damage is flood damage reduction. Primary beneficiaries are those parties that directly use the project's outputs (for example, the farmers who receive water supplies to grow crops or the homeowner whose home is protected by a project levee*). Secondary (indirect) benefits* are the values that accrue to persons other than primary beneficiaries as a result of economic activity induced by or stemming from a project. An example of an "induced by" activity is the increased sales of farm equipment and supplies to growers who receive project water. In contrast, an example of a "stemming from" activity is the additional processing required of many agricultural products. Secondary beneficiaries are persons other than primary beneficiaries to whom net values accrue indirectly as a result of economic activity induced by or stemming from a project. In the above examples, the secondary beneficiaries would include the owners of the farm supplies store and the agricultural products processing plant. Sometimes

[15] Anderson and Settle (1977) *Benefit-Cost Analysis: A Practical Guide*, Chapter 3.
[16] The Corps discount rates are included in their Economic Guidance Memorandum found on their General Planning Guidelines website: http://www.usace.army.mil/cw/cecw-cp/library/planlib.html

secondary beneficiaries may be affected negatively by a project. For example, proposals to transfer water supplies from farmers often encounter resistance because of the potential negative effects upon local businesses that supply goods and services used for farm production. Even though the farmers may be compensated for the loss of the water supply (and the resultant loss of crop net income), local business owners may not be compensated for lost sales revenue ("third party" impacts). Only primary benefits are included in benefit-costs analyses because they generally assume full employment; thus, if there were secondary benefits attributable to a project, these benefits could only be achieved if there were offsetting reductions in output in other sectors of the economy.[17]

- Tangible vs. Intangible. *Tangible benefits*, either primary or secondary, can be expressed in monetary terms. Examples include the value of agricultural or urban water supplies or the reduction in flood damage to structures and their contents. *Intangible benefits*, either primary or secondary, cannot be expressed easily in monetary terms, although there are some techniques that can be used (such as, contingent valuation discussed in Chapter 4). Examples include the values enjoyed by individuals as they visit parks and other natural areas or the benefits they derive knowing that these areas are protected even if they have no plans for visiting them ("existence" value), that these areas are protected for their possible future uses ("option" value), or they are protected for future generations to enjoy ("bequest" value).
- Private vs. public. *Private benefits* are obtained from goods and services purchased by individual producers and consumers through "markets". Private goods are those goods where one person's consumption of a good is dependent upon their paying its price, while another person, who does not pay, is excluded from the benefits of using that good. Exchange cannot occur without property rights. Examples include most items exchanged in a market place: food, clothing, automobiles, houses, etc. *Public benefits* are obtained from providing goods and services that are consumed by society as a whole (national defense, police protection, highways, parks, etc.). Public goods usually are not exchanged in a market place, and consumption of these goods by one individual does not preclude consumption by other individuals.

Finally, other benefit distinctions include whether they are short- or long term and their geographic scope (local, regional, statewide, or national).[18]

### Primary Benefit Measurement Methods

Primary benefits are the increased values of goods and services attributable to a project; that is, increases in products or services and/or reductions in costs, damage, or losses to those directly affected by the project (primary beneficiaries). The economic value of a good or service to a person who is a buyer is measured by the maximum amount of other things that he or she is willing to give up in order to acquire that good or service. In a barter society, this trade-off is obvious. An example is when a person gives up three units of good A in order to obtain one unit of good B. However, in market economies, dollars (or other forms of currency) are the accepted indicator of economic value because the amount of dollars a person is willing to pay for an item indicates how much of other goods and services he or she is willing to

[17] For a more detailed discussion of why secondary benefits are not included in B/C analyses, see Shidong Zhang, Washington State Department of Ecology, "An Evaluation of Probable Benefits and Costs for the Proposed Rule to Establish the Columbia River Water Resources Management Program," December 2004.
[18] See the discussion of planning time horizons and analysis perspectives in Appendix A.

give up for that particular item. In short, the economic value of a good to a buyer is equal to his or her "willingness to pay."[19]

Because projects proposed by DWR (water supply, flood damage reduction, hydropower, restored habitat, etc.) can provide both private and public benefits, a number of market and non-market methods for estimating the public's "willingness to pay" for the outputs of these projects can be used, including: revealed willingness to pay (based upon market price indicators); imputed willingness to pay (based upon avoided costs); expressed willingness to pay (utilizing surveys); and benefit transfers. The application of these methods depends primarily upon the type of benefit that is being evaluated and the data that is available which can be used to quantify and value the resource. Each of these methods has its own data requirements, advantages, and disadvantages.

### *Revealed Willingness to Pay*

Most goods and services are traded in markets; thus, their values can be estimated using market prices. Methods that rely on some form of market prices include market price, productivity, hedonic pricing and travel cost methods.

- Market Price Method. The market price method uses prevailing prices for goods and services traded in markets. For these goods and services, the standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using market price and quantity data. The total net economic benefit, or economic surplus, is the sum of consumer and producer surplus.[20]
- Productivity Method. The productivity method is used to estimate the economic value of resources that are directly used in the production of commercially marketed goods. If a natural resource can be used as a factor of production, then changes in the quantity or quality of the resource will result in changes in production costs and/or increased production, both of which would affect producer surplus. This method is also called the "factor income" method. For example, improved water quality may lead to greater agricultural productivity—more crops may be grown or greater yields can be obtained from the same amount of irrigated land, both of which would increase income to the grower.
- Hedonic Pricing Method. The hedonic pricing method is used to estimate the value of amenities that affect prices of marketed goods. The method is based on the assumption that the prices people pay for goods are influenced by the set of characteristics that people consider important when purchasing the good. The hedonic pricing method is often used to evaluate housing prices based upon characteristics of the house and property, the neighborhood and community, and environmental characteristics.
- Travel Cost Method. The travel cost method is used to estimate the value of recreational benefits. The basic premise of the travel cost method is that the time and travel cost expenses that people

[19] A comparable concept is called "willingness to accept" or "willingness to receive," which measures how much an individual who is a seller would accept or receive as payment if he or she could be induced to forgo a good or service. The amount of payment can then be equated to the economic value of the good or service. In short, the economic value to a seller is equal to his or her "willingness to accept." Willingness to pay/accept are discussed further in Appendix A.

[20] See Appendix A for a more detailed explanation of these concepts.

- incur to visit a site represent the "price" of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that people make at different travel costs.

### *Imputed Willingness to Pay*

Project benefits can be estimated based on the related concepts of (1) reduction of costs or (2) alternative costs. These methods do not provide strict measures of economic values based on peoples' willingness to pay for a product or service. Instead, they assume that the value of damage avoided by a project or the ability to avoid more costly alternatives can provide "imputed" estimates of how beneficiaries might benefit from proposed projects.

- Reduction of cost. A beneficiary's avoidance of direct monetary costs. For example, a flood damage reduction project—such as, a levee—will reduce damage and costs to property owners it protects; this reduction in costs is a benefit.
- Alternative cost. If a project enables a primary beneficiary to avoid implementing a more costly project, then the avoided costs of that alternative project can be used as the upper limit on benefits. This alternative must be the least costly alternative that the beneficiaries would actually implement if the proposed project is not built. For example, the development of a ground water recharge project by a community may allow it to forgo constructing a more expensive surface water importation project that would have been implemented if the recharge project were not constructed.

### *Expressed Willingness to Pay*

Many resources (including water) are not traded in markets and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for them through their market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario (contingent valuation) or what they would be willing to accept in compensation if an amenity were to be taken away. Alternatively, people can be asked to make trade-offs among different alternatives, from which their willingness to pay can be estimated (contingent choice).

- Contingent Valuation Method. The contingent valuation method is used to estimate economic values for many resources, particularly those with non-use values. With this method, people are surveyed as to how much they would be willing to spend for specific resource. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific resources. It is called "contingent" valuation because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the resource.
- Contingent Choice Method. The contingent choice method is similar to contingent valuation, in that it can be used to estimate economic values for virtually any resource, and can be used to estimate non-use as well as use values. Like contingent valuation, it is a hypothetical method—it asks people to make choices based on a hypothetical scenario. However, it differs from contingent valuation because it does not directly ask people to state their values in dollars. Instead, the contingent choice method asks the respondent to state a preference between one group of resources or characteristics (at a given price or cost to the individual) and another group of resource characteristics (with a different cost).

### *Benefit Transfers*

The benefit transfer method does not specifically measure benefits of proposed projects. Instead, this method is used to transfer values developed by other studies for similar projects to the project currently being evaluated. For example, values for recreational fishing at a particular site may be estimated by applying measures of recreational fishing values from a study conducted at another site. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. The benefit transfer method is most reliable when the original site and the current study site are similar in terms of factors such as, quality, location, and population characteristics; when the environmental change is very similar for the two sites; and when the original valuation study was carefully conducted and used sound valuation techniques.

## Benefits Related to Water Resource Projects

Water resource projects may provide one or several types of benefits, including:

- Water supply. Making water available for all uses (urban, agricultural, and environmental) through either structural (dams, reservoirs, aqueducts, etc.) or non-structural (conservation) methods. For urban water supply projects, typical techniques for measuring primary benefits include avoided alternative costs and water market prices where appropriate price data is available. In comparison, for agricultural water supplies (where a direct relationship between water supply and agricultural production can be established), the productivity and avoided alternative costs are the most used methods. Other techniques can be used to estimate environmental water benefits (see Chapter 4). Specific information concerning how to estimate urban and agricultural water supply benefits is found in the *P&G* (sections 2.2.and 2.3) and in the DWR Draft *Economics Practices Manual* (pg. 192 and 196).
- Water quality. Improving the quality of water available for all uses (urban, agricultural, and environmental) through either structural (treatment plants) or non-structural (pollution control) methods. For water quality projects, typical techniques for measuring primary benefits include reduction of costs, avoided alternative costs and productivity methods. Specific information concerning how to estimate water quality benefits is found in the *P&G* (sections 2.2.and 2.3) and in the DWR Draft *Economics Practices Manual* (pg. 196).
- Hydropower. Generating electrical energy using flowing water. For hydroelectric power projects, typical techniques for measuring primary benefits include avoided alternative costs and market price data. Specific information concerning how to estimate hydropower benefits is found in the *P&G* (section 2.5) and in the DWR Draft *Economics Practices Manual* (pg. 213).
- Flood damage reduction (flood control). Protecting existing development from flood damage and making flood-prone land more suitable for appropriate development. Typical benefit measurement techniques include reduction in costs and value added (for intensified land uses). Specific information concerning how to estimate flood damage reduction benefits is found in the *P&G* (sections 2.3 and 2.4) and in the DWR Draft *Economics Practices Manual* (pg. 216).
- Navigation. Improving the transportation of freight and passengers on inland waterways. Typical benefit measurement techniques include avoided alternative costs and productivity. Specific information concerning how to estimate navigation benefits (both inland waterways and deep-

draft navigation) is found in the *P&G*, sections 2.6 and 2.7, and in the DWR Draft *Economics Practices Manual*, pg. 222.

- Recreation. Improving all forms of outdoor leisure activities associated with a water resource project. Typical benefit measurement techniques include unit day values and travel cost or contingent valuation methods. Specific information concerning how to estimate recreation benefits is found in the *P&G* (section 2.8) and in the DWR Draft *Economics Practices Manual* (pg. 224) using unit day values. Other valuation techniques that can be used for recreation benefits—such as, travel cost and contingent valuation—are discussed in Chapter 4.
- Ecosystem restoration. The National Research Council defines ecosystem restoration as the "… return of an ecosystem to a close approximation of its condition prior to disturbance."[21] Typically, monetary benefits are not assigned to environmental benefits. Instead, environmental benefits are usually measured in physical units (acres, habitat units, etc.) that can then be used in a cost-effectiveness and/or trade-off analysis. However, non-market evaluation methods are available that can be used to measure at least some aspects of environmental benefits (discussed in Chapter 4). Environmental quality benefits are discussed in the *P&G* (section 3.0).

Table 3-1 summarizes the benefit measurement methods that are *typically* used for different water management project purposes.

[21] More specifically, the National Research Council defines ecosystem restoration as "…ecological damage to the resource is repaired. Both the structure and functions of the resource are recreated…The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs." This differs from *preservation* which involves the management of an existing resource to maintain its good quality natural functions and characteristics; *creation* which brings into being a new ecosystem that previously did not exist on the site.; *enhancement* which is any improvement of a structural or functional attribute; *rehabilitation* which includes improvements of a visual nature to a natural resource or putting it back in "good condition or working order", and *mitigation* which is any action taken to avoid, reduce, or compensate for the effects of environmental damage. (National Research Council, *Restoration of Aquatic Ecosystems*, Glossary.)

### Water Demand and Water Use

**Water Demand.** The relationship—over a range of water prices—between those prices and quantities of water that would be purchased by willing buyers. Usually an inverse relationship: As price goes up the quantity purchased goes down. This relationship depends upon the marginal value of water to buyers either through final use (e.g., residential use) or as an input to production (e.g., crop irrigation).

**Change in Water Demand.** A change in the relationship between prices and quantities caused by a change in the marginal value of water to buyers. This can be caused by a shift in water use technology like moving to high-efficiency irrigation systems, for example.

**Water Demand Curve.** The mathematical or graphical representation of the Water Demand relationship. A Change in Water Demand can be represented as a change in the location (that is, intercept) and/or slope of the curve.

**Water Quantity Demanded.** The quantity of water that would be purchased by willing buyers at a specified price; represented by a point on the Water Demand Curve.

**Change in Water Quantity Demanded.** Change resulting from movement along the Water Demand Curve caused by a change in price or resulting from a shift in the Water Demand Curve caused by a change in the marginal value of water to buyers, or both.

**Water Use.** The quantity of water that is used. Use may be less than Water Quantity Demanded due to lack of availability (e.g., rationing during a drought). If Water Use is less than Water Quantity Demanded, the marginal value of water to buyers is greater than its price.

**Table 3-1 Water management benefit measurement methods**

| Benefit measurement methods | Water management purposes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Water supply | Water quality | Hydropower | Flood damage reduction | Navigation | Recreation | Ecosystem restoration | Fisheries |
| *Revealed Willingness to Pay* | | | | | | | | |
| Market Prices | X | | X | | | | | X |
| Productivity | X | X | X | | X | | | X |
| Hedonic Pricing | | | | | | | X | |
| Travel Cost | | | | | | X | X | X |
| *Imputed Willingness to Pay* | | | | | | | | |
| Reduction in Costs | X | X | | X | X | X | X | X |
| Alternative Costs | X | X | X | X | X | X | X | X |
| *Expressed Willingness to Pay* | | | | | | | | |
| Contingent Valuation | X | | | | | X | X | X |
| Contingent Choice | X | | | | | X | X | X |
| *Benefit Transfers* | X | X | X | X | X | X | X | X |

### Types of Costs

Project costs generally can be classified as either capital or annual operating costs. All costs necessary to obtain project benefits over the period of analysis must be included in the cost analysis. For many water supply projects, these can include water storage, conveyance, and treatment costs. Conceptually, all costs in the economic analysis should reflect the opportunity costs of using resources to construct and operate the project. In other words, using the resources for the proposed project means that there is a loss of value elsewhere in the economy. In practical terms, however, the cost information used in the analysis is often limited to the actual purchase expenditures:

- Capital. Capital costs are all expenditures necessary to complete the project so operations can commence. Capital costs (for example, construction, “fixed” or “first” costs) include expenditures for land, structures, materials, equipment, and labor, as well as allowances for contingencies. Financial costs (such as, interest during construction and long-term debt service interest) are not included, although they are important in a financial analysis.
- Operation, maintenance, and replacement. These include the project’s annual administrative, maintenance, energy and replacement costs and they are often called “variable costs” because they vary with different levels of project output. For example, an aqueduct’s energy pumping costs will vary with the amount of water being delivered through the aqueduct.
- Externalities. Often the activities of producers or consumers have effects upon others that impose costs (or sometimes benefits) for which no compensation is received. For example, a new levee in community A may increase river stages downstream in community B, which subsequently results in more flood damage in community B. The benefit-cost analysis, which is performed to justify the new levee in community A, should also take into account the cost increases for community B. Unfortunately, many externalities are difficult to identify, quantify, and ultimately, assign monetary values.

### Trade-off Analysis

Benefit-cost analysis requires that benefits and costs be monetized. However, some types of benefits (such as, ecosystem restoration) are not easily expressed in monetary terms. Although there are techniques for monetizing some ecosystem benefits (described in Chapter 4) such that they can be directly incorporated into the benefit-cost analysis, another approach for project evaluation is to use trade-off analysis. Trade-off analysis displays all monetary and non-monetary effects of the project, and the “gains and losses” among different plans can be identified. The Corps’ Institute for Water Resources has developed some very sophisticated mathematical methods of trade-off analysis for projects involving ecosystem restoration and more traditional national economic development benefits (for example, water supply and flood damage reduction).[22] Appendix B contains a summary of economic analysis conducted for a proposed Corps and State Reclamation Board flood damage reduction and ecosystem restoration project at Hamilton City, including a trade-off analysis using the “proportion of maximum value” method to normalize monetary and non-monetary benefits (see Table 3-2).

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[22] See USACE (IWR) publication *Trade–off Analysis Planning and Procedures Guidebook* IWR 02-R-2 (April 2002) at: http://www.iwr.usace.army.mil/inside/products/pub/iwrpub.cfm

**Table 3-2 Hamilton City trade-off analysis proportion of maximum value method**

| Alternative | Ecosystem restoration | Flood damage reduction benefits | Total annual cost | Sum of weighted products | Ranking |
|---|---|---|---|---|---|
| 1 | [783]<br>0.8356 | [$576,000]<br>0.9983 | [$2,606,000]<br>-0.8550 | 0.1386 | 3 |
| 4 | [642]<br>0.6852 | [$536,000]<br>0.9289 | [$2,541,000]<br>-0.8337 | 0.0668 | 4 |
| 5 | [937]<br>1.0000 | [$568,000]<br>0.9844 | [$3,048,000]<br>-1.0000 | 0.1588 | 2 |
| 6 | [888]<br>0.9477 | [$577,000]<br>1.0000 | [$2,687,000]<br>-0.8816 | 0.1836 | 1 |
| Weighting factor | 0.50 | 0.08 | 0.42 | ----- | ----- |

Source: USACE ,Hamilton City Flood Damage Reduction and Ecosystem Restoration Study, see Appendix C.
Notes: Actual amounts shown in [ ].
Alt 6 Example = 0.1836 = (0.9477 x 0.5) + (1.0000 X 0.08) + (-0.8816 X 0.42)

### Distribution Effects

Benefit-cost analysis develops information concerning the economic justification of a project; however, it does not address the distribution of benefits and costs among different groups in society. In other words, are some groups more likely to benefit from a project when compared with others? Does the project result in an *equitable* distribution of benefits and costs? Although it is much more difficult to incorporate distributional effects into benefit-cost analyses, there are techniques for doing so, such as, assigning weights to benefits and/or costs.[23] Equity issues can be an important consideration for stakeholders and decision-makers, and they are included in environmental documentation (environmental impact reports/environmental impact statements) as "environmental justice."

## Socioeconomic Impact Analysis

Whereas benefit-cost analyses measure changes in resource costs and benefits to primary beneficiaries, socioeconomic impact analyses focus upon changes in regional population and economic activity as well as fiscal impacts upon local governments (changes in public services and revenues). Socioeconomic impact analyses are particularly relevant in evaluating the effects upon local communities where water resource projects are constructed and operated as well as within the service areas where project supplies are delivered. The results of socioeconomic impact analyses are typically displayed either in the Regional Economic or Other Social Effects accounts (see Chapter 2, Federal and State Economic Analysis Guidelines) and may be incorporated into environmental documentation (such as, environmental impact statements/reports).

A good reference for conducting socioeconomic impact assessment is the Office of Planning and Research's *Economics Practices Manual* described in Chapter 2. This manual provides step-by-step instructions for estimating population, employment, income, housing, land use/environmental, and fiscal impacts. As discussed in Chapter 5, input/output models can also be used to estimate secondary economic effects such as, income and employment.

[23] See Richard Musgrave, *Public Finance in Theory and Practice*, 1980.

An excellent example of a recent DWR analysis of regional impacts is the *Draft Report on Economic Analyses* (January 2004) prepared for the proposed CALFED In-Delta Surface Storage project. This analysis included the effects of the project upon local employment, income levels, and sales taxes. This report is available at the program's Web site: http://calwater.ca.gov/Programs/Storage/InDeltaStorageReports_2003/InDeltaFeasibilityStudies_Jan2004.shtml

## Risk and Uncertainty

Risk and uncertainty are intrinsic in water resources planning and design and are defined by the National Research Council as follows:

> "*Risk*" is generally understood to describe the probability that some undesirable event occurs, and is sometimes used to describe the combination of that probability and the corresponding consequence of the event. The Corps measures risk by the probability that a levee fails or that an ecosystem restoration project fails to meet a standard. The complement of risk is *reliability*; the probability that a system operates without failing. The term "*uncertainty"* should be used to describe situations without sureness, whether or not described by a probability distribution.[24]

All measured or estimated values in project planning and design are to various degrees inaccurate due to sampling, measurement, estimation, forecasting, and modeling errors. Invariably the "true" values are different from any single point values currently used in many planning studies. The federal *Economics and Environmental Principles and Guideline for Water and Related Land Resources Implementation Studies* requires that planners characterize, to the extent possible, the different degrees of risk and uncertainty inherent in water resources planning and to describe them clearly so decisions can be based on the best available information. The Corps is a leading proponent of "risk-based analysis," which attempts to analytically incorporate considerations of risk and uncertainty.

For more information concerning risk and uncertainty, see Appendix A.

[24] National Research Council. *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*, Chapter 3.

# Chapter 4
# Ecosystem Valuation Methods

For most objectives associated with water management projects, monetary benefits can be assigned that can be directly incorporated into a benefit-cost analysis (for example, water supply and quality, hydropower, flood damage reduction, recreation, etc.). However, for ecosystem restoration, the economic evaluation is much more difficult. How can one possibly place a dollar value on ecosystem resources?

Many economists have been reluctant to assign dollar values to ecosystem resources. This reluctance has been further institutionalized by the US Army Corps of Engineers, which requires a cost-effectiveness/ incremental-cost approach (that is, changes in cost per acre or habitat unit attributable to different sized plans) in evaluating ecosystem outputs. This approach is required because of the inherent difficulties in assigning monetary benefits to ecosystem outputs. However, this reliance upon only cost-effectiveness has its limitations as well, especially when analyzing multi-objective projects that may affect different types of ecosystems or involve trade-offs among different objectives.

## Ecosystem Services

Ecosystems perform many complex and interrelated functions which not only provide basic biological support, but also provide valuable goods and services to society. If these societal goods and services can be identified and measured, then it may be possible to value them using one or more of the methods discussed below.

Ecosystems provide both *biocentric* and *anthropocentric* types of services.[25] Biocentric (or biological) services are those that benefit the plants and animals inhabiting the ecosystem. Anthropocentric services are those that directly benefit humans—such as, the maintenance of water supply quantity and quality, soil and air quality, floodwater storage, recreation, etc. Other human services include the maintenance of genetic information over time (for example, preserving genetic material over time which might lead to new drugs or other products) as well as values that we associate with ecosystems based upon our individual preferences, knowledge, emotions, etc. This latter group of human services is considerably more difficult to quantify and value compared to the first group. The valuation methods discussed below can best be applied to the first group of human-related services, although some methods (such as, contingent valuation) may be applicable for the second group of human services. None of these valuation methods can be applied to an ecosystem's biological services, although tools are available that attempt to measure the physical outputs of ecosystems (such as, habitat evaluation procedures).

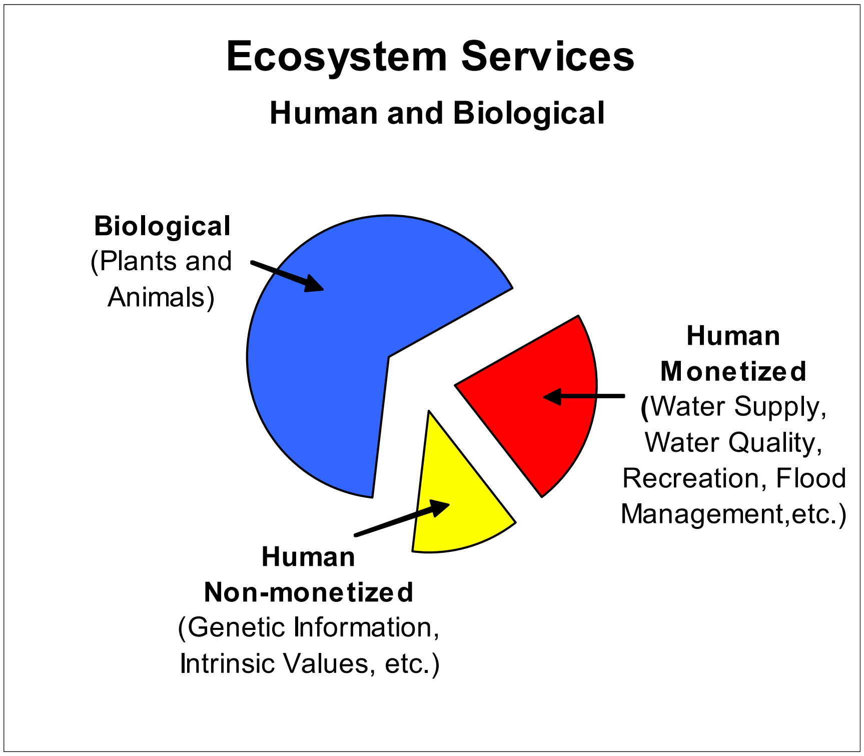
Commonly cited examples of floodplain and wetland services include flood conveyance and storage, erosion control, pollution prevention and control, fish and shellfish production, water supply, recreation, food production, education and research, historical, archaeological values, open space and aesthetic values, timber production, and habitat for waterfowl and other wildlife, including game species. However, even for these services that are easier to assign monetary values, it still may be very difficult to establish relationships among ecosystem structures, functions, and, ultimately, human services. These difficulties arise because of the incomplete scientific understanding of ecological functions and the complex

[25] Cole, R.A., J.B. Loomis, T.D. Feather, and D.F. Capan. *Linkages Between Environmental Outputs and Human Services*. USACE IWR Report 96-R-6 (Evaluation of Environmental Investments Program), February 1996.

production relationships linking them to human uses. Even when there is at least a partial understanding of these relationships, obtaining the necessary data (such as, changes in water quality and availability, soil quality, recreation, etc.) can be time-consuming and expensive. Other human services are very difficult, if not impossible, to measure their service outputs (such as, the continuation of genetic information or the intrinsic values humans place upon healthy ecosystems).

Figure 4-1 hypothesizes what the relationship of these types of services may look like since nobody really knows what the total value of any ecosystem is or the relative size of its biological or human services. This figure indicates that whatever values are derived for ecosystem-related human services, these should not be considered as the "total" value of that ecosystem's services.

**Figure 4-1 Ecosystem services**



# Monetizing Ecosystem Benefits

If the ecosystem services discussed above can be expressed in monetary terms, then it is possible that they can be directly incorporated into B/C analyses. Some of the services provided by ecosystems are priced in competitive markets and therefore the price paid for that service at least partially reflects the value of that ecosystem service. However, many ecosystem services are not traded in markets because individuals do not own the resources—these are public goods rather than individual goods. The absence of markets does not mean that there is no economic value to the resource. Rather, it means that traditional market measures of value are inappropriate. In these cases, non-market valuation techniques can be used to estimate economic values. Following is a discussion of different methods of valuing ecosystem benefits grouped by the "willingness to pay" categories discussed in Chapter 3: revealed willingness to pay, imputed willingness to pay, expressed willingness to pay, and benefit transfers. The application of these methods for ecosystem benefit valuation is discussed below and summarized in Table 4-1, which follows.[26]

### Revealed Willingness to Pay

Some ecosystem products—such as, fish, wood, or berries—are traded in markets; thus, their values can be estimated using market prices (market price method). Other ecosystem services—such as, clean water—are used as inputs in production, and their value may be measured by their contribution to the value obtained from the final goods (productivity method). However, some ecosystem or environmental services, like aesthetic views or many recreational experiences, may not be directly bought and sold in markets. Even though these services are not bought and sold in traditional markets, it may be possible to estimate their values from prices people are willing to pay in markets for related goods. For example, people often pay a higher price for a home with a view of the ocean (hedonic pricing method), or will take the time and incur expenses to travel to a special spot for fishing or bird watching (travel cost method).

### Imputed Willingness to Pay

The value of some ecosystem services can be estimated based on the (1) damage to adjacent or downstream properties that would occur if a wetland were lost to development or (2) the costs of replacing ecosystem services with other alternatives that provide similar services. These methods do not provide strict measures of economic values, which are based on peoples' willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. If people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. For example, if an existing wetland is to be lost because of development, then its flood protection benefits may be estimated by either (1) the damage that would occur to adjacent or downstream properties if the wetland were to be lost to development, (2) the cost of acquiring or restoring another wetland that will provide the same flood protection services, or (3) the cost of structural infrastructure that would be required in the wetlands absence—such as, a retaining wall, levee, or flood detention basin, whichever is less.

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[26] Much of the information in this chapter is adapted from the website http:/www.ecosystemvaluation.org. This Web site, which was developed by Dr. Dennis King, University of Maryland, and Dr. Marissa Mazotta, University of Rhode Island. with funding from the NRCS and NOAA, provides good descriptions of the various valuation methods, including step-by-step instructions and examples. This Web site is written to be understandable for non-economists.

### Expressed Willingness to Pay

Many ecosystem services are not traded in markets and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for them through their market purchases or actions, nor is there any circumstantial evidence to infer what they might be willing to pay. In these cases, surveys can be used to ask people directly what they are willing to pay based on a hypothetical scenario (contingent valuation) or what they would be willing to accept in compensation if an amenity were to be taken away. Alternatively, people can be asked to make trade-offs among different alternatives, from which their willingness to pay can be estimated (contingent choice). An example might be surveys to determine the willingness of state residents whether they would be willing to fund restoration efforts for Hetch Hetchy Reservoir.

### Benefit Transfers

The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location or context. For example, values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. The benefit transfer method is most reliable when the original site and the current study site are similar in terms of factors such as, quality, location, and population characteristics; when the environmental change is very similar for the two sites; and when the original valuation study was carefully conducted and used sound valuation techniques. Although original studies are preferable to benefit transfer, researchers agree that, in the absence of funding and resources needed for conduct of such studies, benefit transfer can provide a reasonable valuation of non-market values provided that the above factors are met.

Appendix C contains references of studies and reports which further discuss and provide examples of the valuation of ecosystem services.

**Table 4-1 Summary of ecosystem valuation methods**

| Valuation type | Methods | Advantages | Disadvantages |
| --- | --- | --- | --- |
| Revealed Willingness To Pay | Market Price | Price, quantity and cost data are relatively easy to obtain<br><br>Uses observed data of actual consumer preferences and behavior<br><br>Uses standard, accepted, economic techniques | Not applicable to many ecosystem services because of lack of markets<br><br>True economic value may not be reflected in prices due to seasonal variations and other effects<br><br>Prices may not reflect costs of other resources used to bring ecosystem products to markets |
| | Productivity | Required cost and production data may be readily available<br><br>Uses standard, accepted, economic techniques | Limited to those resources that can be used as production inputs<br><br>Requires information concerning the physical relationship of the resource in the production process<br><br>If changes in the availability and use of the resource in the production process result in significant changes in the final prices of the final goods, this method becomes more difficult to apply |
| | Hedonic Pricing | Uses observed data of actual consumer preferences and behavior<br><br>Property markets are good indicators of values<br><br>Data on property sales and characteristics are readily available | Limited to environmental benefits that can be related to primarily housing prices<br><br>Will only capture people's willingness to pay for perceived differences in environmental characteristics<br><br>Relatively complex to implement and interpret<br><br>Requires high degree of statistical expertise |
| | Travel Cost | Uses observed data of actual consumer preferences and behavior<br><br>On-site surveys may benefit from large sample sizes<br><br>Results are relatively easy to interpret and explain | Complications arise if consumers visit more than one site<br><br>Assigning the "opportunity costs" of time traveling is difficult<br><br>Availability of substitute sites will affect values<br><br>Surveying techniques can introduce biases<br><br>Requires high degree of statistical expertise |

*Table 4-1 continues on next page*

**Table 4-1 Summary of ecosystem valuation methods (continued)**

| Valuation Type | Methods | Advantages | Disadvantages |
|---|---|---|---|
| Imputed Willingness To Pay | Damage Costs Avoided<br>Replacement Cost<br>Substitute Cost | These methods provide rough indicator of economic value, subject to data constraints or substitutability of related goods and services.<br><br>It is often easier to measure the costs of producing benefits than measuring the values of the benefits themselves.<br><br>These approaches are less data- and resource-intensive.<br><br>Data or resource limitations may rule out other valuation methods. | These methods assume that expenditures to repair or to replace ecosystem services are valid measures of the benefits provided, which may not be true.<br><br>These methods require information on the substitution between replacement services and the natural ecosystem.<br><br>Substitute goods are unlikely to provide the same types of benefits as the natural resource.<br><br>The goods or services being replaced probably only represent a portion of the total value of the natural resource, thus estimated benefits may be underestimated.<br><br>These approaches are only valid if there is evidence that the public would demand the alternative replacement or substitute project. |

*Table 4-1 continued on next page*

**Table 4-1 Summary of ecosystem valuation methods (continued)**

| Valuation Type | Methods | Advantages | Disadvantages |
|---|---|---|---|
| Expressed Willingness To Pay | Contingent Valuation<br>Contingent Choice | Can be used to estimate the economic value of most goods and services whether they are marketed or not.<br><br>Commonly used method for measuring the value of non-use goods and services.<br><br>Most appropriate to use when goods and services can be easily understood by the public and are consumed in discrete units (such as, user days of recreation). | There is much debate whether these methods adequately measures peoples' willingness to pay for improvements to environmental quality.<br><br>These methods perhaps incorrectly assume that people understand the good or service in question and will reveal their preferences in a "contingent" market just as in a real market.<br><br>There may be fundamental differences in the way that people make hypothetical decisions relative to the way they make actual decisions (for example, people may not take questions seriously since they will not actually have to pay the stated amounts).<br><br>The payment question can be phrased as a "willingness to pay" question or as a "willingness to accept compensation" question in cases where an environmental amenity may be given up. In theory the answers to these questions should be the same but often they are not. |

*Table 4-1 continued on next page*

**Table 4-1 Summary of ecosystem valuation methods (continued)**

| Valuation Type | Advantages | Disadvantages |
|---|---|---|
| Benefit Transfers | Typically less costly and time consuming than conducting an original valuation study<br><br>Method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted | Method may not be accurate, unless the original site and site its being compared with have similar location and physical characteristics.<br><br>Existing studies may be difficult to find<br><br>It is difficult to assess the adequacy of existing studies.<br><br>Reporting of existing studies may be inadequate in order to make needed adjustments.<br><br>Unit use values may be out-of-date. |

## Cost-Effectiveness Analysis

Many project planners are reluctant to place monetary values upon ecosystem benefits. The US Army Corps of Engineers, in particular, does not monetize ecosystem benefits but instead relies upon a cost-effectiveness and incremental-cost analysis to formulate and evaluate projects with ecosystem benefits. Cost-effectiveness and incremental cost analysis is a valid tool for evaluating projects with ecosystem benefits, although this type of analysis makes it difficult to evaluate multi-purpose projects that have more traditional monetary benefits (such as, water supply and flood damage reduction) combined with ecosystem restoration benefits.

Cost-effectiveness and incremental-cost analyses examine changes in cost and output that result from decisions to implement alternative plans and plan components. Cost-effectiveness analysis ($/unit) can be used to identify the least-cost plan for producing every attainable level of environmental output (acres, habitat units, etc.), as well as for identifying those plans where more output could be produced for the same or less cost. Incremental cost analysis can assist in determining the appropriate scale of restoration by revealing variations in cost across alternatives. Once these costs are computed, decision makers can explicitly ask, Is this incremental change in output "worth it?" The Corps Institute for Water Resources has developed the IWR-PLAN software specifically to perform cost-effectiveness and incremental-cost analyses.[27]

**Economic Evaluation of Ecosystem Resources—Two Example Analyses**

Appendix B presents two federal/State/local studies (2004) that incorporate both National Economic Development (NED) and National Ecosystem Restoration (NER) benefits—the Hamilton City Flood Damage Reduction and Ecosystem Restoration Study and the Colusa Basin Integrated Watershed Management Study. The Hamilton City study was conducted by the US Army Corps of Engineers and the State Reclamation Board. It focuses upon improving flood protection for the Glenn County community of Hamilton City (and surrounding agricultural land) and restoring riparian habitat along the Sacramento River. The Colusa Basin Integrated Watershed Management Plan was conducted by the Colusa Basin Drainage District to evaluate alternative plans for improving flood protection for the City of Willows in western Glenn County along Interstate 5. Willows is subject to frequent flooding from three streams that flow east from the nearby coastal range mountains. This study also evaluated various ecosystem restoration and watershed management measures. An interesting distinction between both of these studies is how the economic analysis is being conducted for the ecosystem measures. Corps guidance does not allow for monetary values to be placed on ecosystem benefits, thus it relied upon a cost-effectiveness/incremental cost analysis of proposed ecosystem measures in order to formulate combined NED/NER plans. In contrast, the Colusa Basin Study directly places monetary values on ecosystem restoration measures and incorporates these values into the net benefits analysis

[27] IWR PLAN is available at: http://www.pmcl.com/iwrplan/. A more detailed discussion of the cost-effectiveness and incremental cost analysis can be found in the Corps Institute for Water Resources' report Evaluation of Environmental Investments Procedures Manual, Interim, Cost Effectiveness and Incremental Cost Analysis, May 1995.

# Chapter 5
# Economic Analysis Models

Numerous economic analysis computer software packages and other analytical tools can be used to assist in water resource economic justification and socioeconomic impact analyses

## Economic Justification

For economic analyses, models have been developed by different organizations for specific project purposes (water supply reliability, ecosystem restoration, flood damage reduction, and water quality improvement). These models are used to determine the economic justification of a proposed project through benefit-cost or cost-effectiveness analyses. Some of these models are also used to provide critical information for statewide planning purposes, such as, forecasting urban and agricultural water demands for the California Water Plan Update (Bulletin 160 series).

### Water Supply Reliability

DWR and the US Army Corps of Engineers (Corps) have developed several models for assessing water supply reliability. These include the following:

- DWR Least Cost Planning Simulation Model. The Least-Cost Planning Simulation Model is a PC-based simulation/optimization model that assesses the economic benefits and costs of increasing urban water service reliability at the regional level. The primary objective of LCPSIM is to develop a regional water management plan based on the principle of least-cost planning. Under this principle, the cost to be minimized is the sum of two costs: (1) the cost of the water supply reliability enhancement via a response package and (2) the cost of unreliability, recognizing that the latter is inversely related to the former. Because this principle incorporates economic benefits (that is, reducing the cost of unreliability), it is fundamentally different than cost effectiveness, which is based on minimizing the cost of meeting a physical objective (for example, a quantity of water delivered over a specified drought period.) Any incremental change from managing at the least-cost point will, by definition, result in greater economic costs than gains (that is, a loss of economic efficiency). LCPSIM can be used in the California Water Plan Update process to help determine an economically efficient regional urban water management strategy. It can also be used to specify demand reduction response options and optimize supply augmentation response options (or vice versa) as well as estimate the cost in lost economic efficiency of study plans. Key modeling inputs into LCPSIM include Central Valley Project and State Water Project (SWP) water deliveries estimated by CALSIM (a project operations model) and average water use coefficients from the Corps' Institute for Water Resources (IWR-MAIN, described below). LCPSIM is described in more detail under *Models* at the Web site www.economics.water.ca.gov/.
- DWR California Agriculture. CALAG is a regional, PC-based model of irrigated agricultural production and economics that simulates the decisions of agricultural producers (farmers) in California. The model, which is still being developed in 2006, assumes that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets, and no single farmer can affect or control the price of any commodity. To obtain a market solution, the model's objective function maximizes the sum of producers' surplus (net

income) and consumers' surplus (net value of the agricultural products to consumers) subject to various technical, market, and institutional constraints. The model can be used to estimate changes in agricultural benefits of alternative water management plans. CALAG is described in more detail under *Models* at the Web site www.economics.water.ca.gov/. The Central Valley Production Model (CVPM) preceded and is now a part of CALAG.

- DWR Net Crop Revenue Models. NCRMs are spreadsheet models that estimate average net crop revenues for important crops for recent years in 27 California counties and regions. These models combine data on acres and average yields and prices from more than 100 annual county crop reports with cost information from about 300 University of California Cooperative Extension crop budgets. The spreadsheets price-level adjust cost and gross revenue data to a common year, update interest rates, taxes, and water costs, and then calculate weighted-average estimates of a typical grower's annual net crop revenue (profit or loss) for a 5- or 7-year period. The models include estimates of government support payments for some crops and take into account both cash and non-cash, and fixed and variable costs, for all crops. The spreadsheets also calculate other measures of grower returns, such as, contributions to fixed costs and ability to pay for water. NCRMs were developed for use in DWR Delta Planning Programs and the California Water Plan Update process. Modified versions of these models have also been used to help value the Kern Fan Element of the Kern Water Bank, to help estimate the economic impacts of land retirement programs in the San Joaquin Valley and the Delta, to help value a flood control program, and to help evaluate the economic impacts of a water transfers program. NCRMs could be used in developing information for environmental impact reports and statements and to estimate the economic impact on agriculture of future droughts. Modified versions of NCRMs could be used for financial feasibility analysis—calculating the abilities of farmers and irrigation districts to pay for water from new water projects. The goal of the NCRM program is to develop and maintain up-to-date models covering all the significant agricultural areas in the state. NCRMs are described in more detail under *Models* at the Web site www.economics.water.ca.gov/.
- Corps' IWR-MAIN. IWR-MAIN was developed by the Corps' Hydrologic Engineering Center, but it is maintained and is distributed by Camp, Dresser and McKee. IWR-MAIN has been designed for
    - projecting municipal and industrial water demands,
    - analyzing the potential water savings from water demand management (water conservation) programs and incorporating these savings into projections of water demands, and
    - analyzing the potential monetary benefits and costs of water conservation alternatives.

  IWR-MAIN can also facilitate decision-making in the following areas:

    - Water demand forecasting
    - Drought planning
    - Master planning
    - Rate analysis
    - Watershed planning
    - Capital improvement planning
    - Integrated resources management
    - Conservation planning and evaluation

IWR-MAIN is available at: http://www.iwrmain.com/

### Ecosystem Restoration

The Corps has developed a model for estimating the cost-effectiveness of ecosystem restoration plans:

- Corps IWR PLAN. The Corps' Institute for Water Resources (IWR) has developed this software to assist with the formulation and comparison of alternative ecosystem restoration plans, although the program can be useful in planning studies addressing a wide variety of problems. IWR-PLAN takes user-defined solutions to planning problems and externally generated estimates of each solution's effects and can formulate all possible combinations of those solutions, considering user-defined relationships between solutions. IWR-PLAN will then identify which combinations are the best financial investments through cost effectiveness and incremental cost analyses. IWR plan is available at: http://www.pmcl.com/iwrplan/.

### Flood Damage Reduction

The Corps and the Federal Emergency Management Agency (FEMA) have developed models that specifically evaluate flood damage reduction benefits of alternative plans. These include the following:

- HEC-FDA. Developed by the Corps' Hydrologic Engineering Center (HEC) in Davis, CA, Flood Damage Analysis (FDA) is the Corps' primary flood damage reduction model which integrates hydrologic, hydraulic, and geotechnical engineering and economic data for the formulation and evaluation of flood damage reduction plans. The program incorporates risk-based analysis by quantifying uncertainties in the hydraulics, geotechnical, and economics data using Monte Carlo simulation. The two primary outputs from HEC-FDA include expected annual damage estimates and project performance statistics. Expected annual flood damage is the average of all possible damage values, taking into account all expected flood events and associated hydrologic, hydraulic, geotechnical, and economic uncertainties. Project performance statistics provide information concerning the risk within an area of annual (or long-term) flooding and the ability to survive flood events of given magnitudes. HEC-FDA is available at: http://www.hec.usace.army.mil/software/hec-fda/hecfda-hecfda.html
- FEMA HAZUS. FEMA has developed GIS-based multi-hazard assessment software which contains a Flood Loss Estimation Model that includes flood hazard analysis and flood loss estimation modules. The hazard analysis module uses characteristics—such as, frequency, discharge, and ground elevation—to estimate flood depth, flood elevation, and flow velocity. The loss estimation module calculates physical damage and economic loss using the results of the flood hazard analysis and structural inventories. In addition to the Flood Loss Model, HAZUS also contains earthquake and hurricane wind damage assessment models. HAZUS information is available at http://www.fema.gov/plan/prevent/hazus/index.shtm
- FEMA HMGP Riverine Benefit-cost Software. FEMA has three spreadsheet modules for doing benefit-cost analysis for proposed riverine flood hazard mitigation grant projects: Very Limited Data, Limited Data, and Full Data. The use of a specific module depends upon the quantity and quality of engineering and structural inventory data available. These models are available at bchelpline@dhs.gov

### Water Quality Improvement

The maintenance of good water quality is an important project objective. The State Water Resources Control Board (SWRCB) and the Metropolitan Water District of Southern California (MWD) in cooperation with the US Bureau of Reclamation (Bureau) and other agencies have developed economic models to assess the impacts of changes in water quality.

- SWRCB Lost Beneficial Use Value Calculator. The SWRCB has developed the Lost Beneficial Use Value Calculator (LBUVC) to estimate lost benefits caused by diminished water quality levels. This model is based on the idea that there are upper and lower thresholds of water quality for which beneficial use value is fully unimpaired or fully impaired. For intermediate values of water quality, beneficial use value is proportional to the water quality level relative to these thresholds. Activities that generate beneficial use values are identified, and economic per-unit values for these activities can be selected from a database of beneficial values built into the LBUVC. Pollution discharges that change water quality induce a proportional change in beneficial use value, provided the range of quality change is within impairment thresholds. Lost beneficial use value from multiple pollutants can be assessed in two ways: by assuming that (1) a single pollutant is the limiting pollutant that determines all of the beneficial use value change or (2) that each pollutant contributes proportionately to the change in beneficial use value. More information on this model can be found in the draft report by Daniel Lew, PhD, and others to the SWRCB, *Assessing Economic Impacts of Water Pollution on Beneficial Uses in California Water Bodies: The Lost Beneficial Use Value Calculator* (December 2003).
- MWD Salinity Economics Impacts Model. The MWD in cooperation with the Bureau, DWR, and other agencies has developed a Salinity Economics Impacts Model to estimate regional economic impacts (costs to customers and agencies) of changes in salinity of water sold by MWD. The model is designed to assess regional economic impacts based upon average annual data, such as, water deliveries, total dissolved solids, and costs for a typical household, crop, etc. It uses mathematical functions which define the relationship between total dissolved solids (TDS) and the economic impact for various items affected by salinity, such as, the useful life of appliances, specific crops' yields, additional costs to industries and commercial businesses, etc. The model estimates the "incremental" economic benefits or impacts of TDS changes in SWP and Colorado River Aqueduct water compared to baseline conditions. More information about this model can be found in the report by MWD and the Bureau, *Salinity Management Study, Final Report, Technical Appendices*, June 1999.

## Socioeconomic Impact Analysis

Economic feasibility analyses generally focus upon the primary, or direct, effects of proposed plans, which form the basis of project benefit-cost analyses. However, these direct effects can have ripple (indirect) effects throughout an economy. Input/output analysis is essentially a quantitative description of the relationship among industries within an economy. It shows the interdependence among various sectors of the economy as they combine to meet a given final demand for goods and services. I/O analysis is an excellent tool for providing a comprehensive description of the economy and tracing secondary economic impacts. Thus, I/O models are invaluable for estimating regional impacts which can be included in federal investigations (the "regional account") as well as project environmental impact reports/statements.

IMPLAN® is a PC-based economic analysis system developed by Minnesota IMPLAN Group, Inc. It contains the software and the data files required to create regional models. Using IMPLAN, local I/O models can be developed to estimate the economic impact of various activities. For water resources planning, the model can be used to estimate the income and employment effects upon local communities resulting from water project construction and to estimate the regional effects of water transfers. More information on IMPLAN can be found at www.implan.com/library/documents/implan_io_system_description.pdf#search='IMPLAN.

Table 5-1 summarizes the relationships of these models to the various program objectives they address.

**Table 5-1 Economic analysis models and analysis objectives**

| | Economic justification | | | | |
|---|---|---|---|---|---|
| Organization/ models | Water supply reliability | Ecosystem restoration | Flood damage reduction | Water quality improvement | Socioeconomic impact analysis |
| DWR | | | | | |
| LCPSIM | X | | | | |
| CALAG | X | | | | |
| NCRM | X | | X | | |
| Corps | | | | | |
| IWR MAIN | X | | | | |
| IWR PLAN | | X | | | |
| HEC FDA | | | X | | |
| FEMA | | | | | |
| HAZUS | | | X | | |
| Riverine B/C | | | X | | |
| SWRCB | | | | | |
| LBUVC | | | | X | |
| MWD/Bureau | | | | | |
| Salinity Model | | | | X | |
| IMPLAN | | | | | X |

# Chapter 6
# Economic Analysis and the Federal Planning Process

For federal agencies that are involved with land and water use planning (for example, the US Army Corps of Engineers, the US Bureau of Reclamation and the Natural Resources Conservation Service), the *Economic and Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies* (*P&G*) set forth the overall planning process that is to be used for project formulation, including the economic analysis. However, federal agencies can adopt even more specific guidelines. For example, the Corps in particular has developed extensive guidelines (engineering circulars, engineering regulations, engineering manuals, policy guidelines letters, economics guidelines memoranda, etc.).[28]

DWR economics staff follows economic guidance set forth in the *P&G* because it can be very relevant to DWR studies. First, if DWR is a partner with a federal agency on a study or project, federal guidelines must be followed in order to determine the federal interest in the project and consequently its eligibility for federal funding. However, because the federal interest is focused primarily upon the national economic development (NED) account or the Corps' national ecosystem restoration (NER) account, DWR should also broaden the economic analysis to include regional economic development (RED) or other social effects (OSE) accounts, which can significantly assist in the decision-making process. The RED account is particularly important if a proposed plan will have significantly different effects upon regions that might otherwise be irrelevant to the NED national perspective.

For example, the importance of the RED and OSE accounts was vividly illustrated with the economic and social disruption along the Gulf Coast caused by Hurricane Katrina in 2005. It is estimated that within a year after the storm (2006), total New Orleans employment will only be about half of pre-storm forecasts. It is anticipated that the value of such a devastating loss of jobs and the forgone wages, along with lost business revenue, lost taxes/fees, and the values of disrupted social services could at least equal the more tangible damage to buildings and infrastructure.[29] Although tangible physical losses are typically included in NED flood damage reduction studies, many of these other costs are excluded, not only because of their complexity but also NED guidelines. For example, the loss of income can only be included in a NED flood damage reduction analysis if it can be shown that this loss is not recovered by another firm at a different location or time. Thus, even if the tremendous loss of jobs and income could have been foreseen by Corps' planners in New Orleans, they might not have been able to include them in a proposed project's NED analysis if it could be shown that these jobs would move elsewhere after a damaging storm event. In other words, one region's loss could be another region's gain, which "nets out" in a NED analysis.

Second, the procedures presented in the *P&G* for estimating NED benefits (such as, water supply, flood damage reduction, recreation, etc.) are appropriate for most DWR analyses, although there may be other differences that need to be taken into account. For example, because of the national perspective of the NED analysis, the evaluation of a plan's effect upon agriculture is limited to basic crops. Basic crops (rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture) are crops grown throughout the country such that no water resources project would affect the price and thus cause transfers from one

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[28] Corps planning and economics guidelines may be found at: http://www.usace.army.mil/cw/cecw-cp/library/planlib.html

[29] Sacramento Bee, "Flood's Indirect Impact is Deep," December 30, 2005.

region to another. The production of basic crops is primarily limited by the availability of land. In contrast, on a national basis, production of crops other than basic crops is seldom limited by the availability of land. Thus, production from increased acreage of non-basic crops in the project area could be offset by a decrease elsewhere in the country. DWR analyses may not need to distinguish between basic and non-basic crops.

Third, many of the procedures used by federal and DWR analyses to compute net benefits or basic crop ratios are similar. However, some of the parameters used in the analysis may be different, particularly the discount rate used to discount future benefits and costs. Any differences between discount rates can be accounted for in an analysis by using a sensitivity analysis to determine the effect of different federal and DWR discount rates.

Finally, because many water resource development projects are now multi-purpose, and one of those purposes is often ecosystem restoration, DWR can learn from methods adopted by federal agencies in evaluating ecosystem benefits in combination with more traditional benefits, such as, water supply and flood damage reduction. The fundamental question is, Are ecosystem benefits to be monetized or not? The answer depends upon the data available concerning the ecosystem component of the project, the valuation tools which the analysts is most comfortable with, and, if a federal agency is cooperating with the study, does that agency accept monetized ecosystem values? The Hamilton City and Colusa Basin studies illustrate different methods for monetizing vs. not monetizing ecosystem benefits. These economic analyses are summarized in Appendix B.

## Federal Decision Criteria

The *P&G* identifies four broad decision criteria for the evaluation of all plans: *completeness, effectiveness, efficiency,* and *acceptability*. Completeness is the extent to which a given plan has all the necessary investments and other actions to ensure the realization of the planned effects. Effectiveness is the extent to which an alternative plan accomplishes its planning objectives. Efficiency is the extent to which an alternative plan is the most cost-effective means of accomplishing its planning objectives and is the criteria which is addressed by the economic analysis. Acceptability is the workability and viability of the alternative plans with respect to acceptance by state and local entities and the public as well as compatibility with existing laws, regulations, and public policies. Project *justification* is determined by how well a proposed project meets all four criteria.

## Federal Planning Accounts

The *P&G* states that the federal objective of water and related land resources planning is to contribute to NED consistent with protecting the nation's environment, in accordance with national environmental statues, applicable executive orders, and other federal planning requirements. Contributions to NED (NED outputs) are increases in the net value of the national output of goods and services, expressed in monetary units. They are the direct net benefits that accrue in the planning area and the rest of the nation. Besides the national economic development account there are three other accounts. The environmental quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans (discussed below). The RED account displays changes in the distribution of regional economic activity (for example, income and employment). Finally, the OSE account displays plan effects on social aspects, such as, community impacts, health and safety, displacement, and energy conservation. Display of the NED and EQ accounts is required whereas display of the other two accounts is discretionary.

Although the *P&G* state that the national objective is NED, the Corps has recognized that water management planning must fully incorporate information from all four accounts.[30] This more comprehensive approach was made even more apparent following the devastation of Hurricane Katrina in 2005 along the Gulf Coast. Unfortunately, analyzing information in some of these other accounts is difficult (for example, Other Social Effects), but efforts are underway by the Corps and others to describe the theoretical bases of these accounts and identify appropriate analytical methods. [31]

## Plan Formulation

The federal planning process consists of six steps: (1) specification of water and related land resources problems and opportunities; (2) inventory, forecast, and analysis of water related land resources within the study area; (3) identification of alternative plans; (4) evaluation of the effects of alternative plans; (5) comparison of the alternative plans; and (6) selection of the recommended plan based upon the comparison of the alternative plans. Plan formulation consists of the third, fourth, and fifth planning steps. It is a highly iterative process that involves cycling through the formulation, evaluation, and comparison steps many times to develop a reasonable range of alternative plans and then narrow those plans down to a final array of feasible plans from which a single plan can be identified for implementation. The Corps has identified the following types of plans:

- NED Plan. For single project purposes—such as, Flood Damage Reduction (FDR) where project outputs can be measured in dollars—project selection is based on maximizing net monetary benefits. The methodology for an NED Plan is relatively straightforward. The first task is to estimate without project conditions (for example, without project flood damage). Next, the net annual benefits for all of the alternatives being evaluated must be determined. Net annual benefits are the annual benefits (for example, the reduction in without project flood damage attributable to each alternative) minus the annual costs for each alternative. Alternatives with positive net benefits are economically feasible. The most efficient of these feasible plans is the one that reasonably maximizes net benefits, and this is referred to as the NED Plan

- NER Plan. The Corps incorporated ecosystem restoration as a project purpose in response to the increasing national emphasis on environmental restoration and preservation. The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more neutral condition. For the single project purpose of ecosystem restoration where project outputs (for example, increases in habitat) are measured in non-monetary units, the analysis is more subjective in that it does not result in the unique identification of a "best" plan. But the Corps does have an accepted methodology to determine the relative performance of these types of projects.[32] Cost-effectiveness and incremental-cost analyses are used to help make the

[30] See USACE Engineering Circular EC 1105-2-409 "Planning in a Collaborative Environment", May 31, 2005.
[31] For example, see C. Mark Dunning and Susan Durden (USACE), "Theoretical Underpinnings of the Other Social Effects Account," September 2007.
[32] Interestingly, the US Bureau of Reclamation does not currently have the authority to formulate NER plans.

subjective decision that incremental units of output are subjectively valued at least equal to the incremental costs and that no alternative can provide the same level of output at a lower cost. Other criteria (such as, significance and relative scarcity of the resources/ecosystem to be restored) are critical for demonstrating the incremental justification of the potential ecosystem restoration plans. The Corps does not place monetary values on ecosystem benefits.

- Combined NED/NER Plan. Corps' projects that produce both NED and NER benefits will result in a "best" recommended plan so that no alternative plan has a higher excess of NED monetary benefits plus NER non-monetary benefits over project costs. This plan shall attempt to maximize the sum of net NED and NER benefits and to offer the best balance between two federal objectives. Plan formulation for projects involving NED (for example, water supply and flood damage reduction) and NER objectives presents a challenge because alternative plans produce both monetary and non-monetary benefits. Comparison of the trade-offs among alternative plans is difficult because monetary and non-monetary benefits cannot be directly compared. To facilitate the plan formulation process, the methodology outlined in the Corps' recent *Engineering Circular 1105-2-4-4*, "Planning Civil Works Projects under the Environmental Operating Principles," (May 1, 2003) was used. [33] The steps in this methodology include:
  - Formulate and screen management measures to achieve planning objectives and avoid planning constraints. Measures are the building blocks of alternative plans.
  - Identify a primary project purpose (NED or NER).
  - Formulate, evaluate, and compare an array of alternative plans (which are comprised of all or some of the above measures) to achieve the primary purpose and identify a feasible plan that reasonably maximizes net benefits.
  - Formulate and screen combined plans that achieve both NED and NER objectives.
  - Evaluate and compare trade-offs among the combined plans and rank them. The highest ranked combined plan is the plan that reasonably maximizes total net NED and NER outputs.
  - Determine whether the highest ranked combined plan is justified; that is, whether the benefits of the plan exceed the costs. If the highest ranked combined plan is not justified, move to the next ranked plan. Continue to move down through the ranked plans until a justified combined plan is identified. The highest ranked and justified combined plan is the NED/NER plan or the combined plan. If no combined plan is justified, then the single-purpose NED or NER plan shall be recommended for implementation.
- Locally Preferred Plan. Projects may deviate from the NED, NER, or combined NED/NER plan if requested by the non-federal sponsor. For example, if the sponsor prefers a more costly plan and the increased scope of the plan is not sufficient to warrant full federal participation, the LPP may be approved as long as the sponsor pays the difference in costs between the federally recommended plan and the LPP.

Table 6-1 summarizes the Corps' project evaluation and selection criteria for the various types of plans.

[33] EC 1105-2-404 : www.usace.army.mil/inet/usace-docs/eng-circulars/ec1105-2-404/toc.htm

**Table 6-1 Summary of US Army Corps of Engineers project evaluation and selection criteria**

| Type of projects | Plan benefits measures | Plan evaluation procedures | Plan selection rules[a] |
|---|---|---|---|
| Single purpose NED projects | Contributions to national economic development (NED outputs) are increases in the net value of goods and services expressed in monetary units. | Benefit-cost analysis: monetary NED benefits and monetary NED costs | "For all project purposes except ecosystem restoration, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment, the NED plan, shall be selected." |
| Single purpose NER projects | Single purpose ecosystem restoration plans shall be formulated and evaluated in terms of their net contributions to increases in ecosystem value (NER outputs) expressed in non-monetary units. | Cost-effectiveness and incremental cost analysis based on non-monetary NER benefits NER benefits and costs to implement plans. | "For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. This selected plan must be shown to be cost-effective and justified to achieve the desired level of output. This plan shall be identified as the NER plan." |
| Multiple purpose NED/NER projects | Multipurpose plans must be evaluated in terms of both (monetary) NED outputs and (non-monetary) NER outputs. | Combination of NED benefit-cost analysis and NER benefits analysis, including cost-effectiveness and incremental cost analysis. | "Projects which produce both NED benefits and NER benefits will result in a best recommended plan so that no alternative plan or scale has a higher excess of NED benefits plus NER benefits over total project costs. This plan shall attempt to maximize the sum of NED and NER benefits, and to offer the best balance between the two objectives." |

a. Source: US Army Corps of Engineers guidelines ER 1105-2-100

# Multi-Objective Projects

In recent years, increasing emphasis has been placed upon developing water and land resource projects that have multiple objectives. Often one of these objectives is ecosystem restoration, which can increase the project's benefits and the number of stakeholders supporting the proposed project, but which can also make it very difficult to perform an economic analysis because of the inherent difficulties in placing monetary values on ecosystem benefits and incorporating them into benefit-cost analysis. Two flood management example analyses are presented in Appendix B and illustrate different ways of evaluating ecosystem benefits in an economic analysis. The Hamilton City study follows Corps planning practices by utilizing cost-effectiveness/ incremental cost analysis to evaluate ecosystem benefits—basically, determining which ecosystem alternative gives the "most bang for the buck" and combining this information (through a trade-off analysis) with flood damage reduction benefits of the proposed project. In contrast, the Colusa Basin study places monetary values on ecosystem benefits, which are then directly incorporated into a benefit-cost analysis along with flood damage reduction benefits.

DWR is involved in other multi-objective programs as well, including the following:

- California Bay-Delta Surface Storage Program: The CALFED Bay-Delta Record of Decision (ROD), completed in August 2000, directed DWR and the Bureau to evaluate five surface storage proposals (Shasta Enlargement, North of Delta Off-Stream Storage, In-Delta Storage, Los Vaqueros Enlargement, and Millerton Enlargement (or equivalent). A feasibility study has been completed for the In-Delta proposal, which would provide capacity to store approximately 217,000 acre-feet of water in the south Delta. Monetary benefits were estimated for project urban and agricultural water supplies as well as recreation, avoided levee maintenance costs, and reduced flood risk. A qualitative benefit assessment was conducted for ecosystem restoration, water quality and operational flexibility benefits. The In-Delta Draft Economics Report can be found on the program's Web site: calwater.ca.gov/Programs/Storage/InDeltaStorageReports_2003/InDeltaFeasibilityStudies_Jan2004.shtml

- California Bay-Delta Authority/DWR/Bureau "Common Assumptions" process. These three agencies are working cooperatively to develop a common set of evaluation approaches and assumptions for studying potential surface storage facilities listed above. A Common Assumptions economics workgroup has been tasked with identifying economic measures and models to be used in the economic analysis for all projects that are being evaluated. The workgroup is developing (a) a common reporting metrics for agricultural economics, municipal and industrial water supply and water quality, flood damage, recreation, ecosystem, hydropower, regional economics, and cost estimation, (b) providing a list of economic tools that could be used within these metrics, (c) investigating cost estimation methods being used by the Bureau and DWR to determine which methods and data are the same as well as different for both agencies, and providing information for project teams on the appropriate guidelines and methods for cost estimation consistent with Bureau and DWR standards. The recommendations of this workgroup should be available in summer of 2006.

- Proposition 50 Integrated Regional Water Management Grant Program. Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, was passed by California voters in 2002 to "…encourage integrated regional strategies for management of water resources and to provide funding, through competitive grants, for projects that protect communities from drought, protect and improve water quality, and improve local water security by reducing dependence on imported water." This legislation authorized $500 million in competitive grants to be administered by DWR and the State Water Resources Control Board. As part of the grant process, applicants are required to provide an economic analysis showing that the project is economically feasible. Benefits to be evaluated include water supply and quality, ecosystem restoration, flood control, recreation, and energy use. Physical benefits (project outputs) are quantified if possible. If physical benefits cannot be quantified, they must be qualitatively described. Monetary benefits are quantified wherever possible. The economic guidelines for this grant program should be available in summer of 2006.

- Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616). The intent of this act was to promote the implementation of voluntary, efficient water management practices (EWMPs) among agricultural water suppliers. It led to the creation of the Agricultural Water Management Council and the signing of a memorandum of understanding among agricultural water supplies, environmental groups, and other interested parties. As part of the EWMP evaluation process, a Net Benefits Analysis was developed that quantitatively and qualitatively evaluates technical, environmental, socioeconomic, financial, and third party impacts related to each EWMP. The Net Benefits Analysis can be found on the Council's Web site: www.agwatercouncil.org/

# Chapter 7
# Financial Analysis

Financial analysis compares project financial costs to project revenues and takes into account the availability of funds. Project financial costs are those incurred in constructing, operating, and maintaining project facilities. As discussed in Chapter 1, there are significant differences between economic and financial analyses, both in their objectives and data requirements. Although an economic analysis determines whether a project is an efficient use of resources, it does not determine if someone is willing to pay for the project and has the capability to raise the necessary funds. A financial analysis answers questions such as, Who should repay the project costs? Are they able to meet repayment obligations? Will the beneficiaries be financially better off compared to what they will be obligated to pay?

## Decision Criteria

The test of financial feasibility is passed if (a) beneficiaries are willing and able to pay their allocated costs for project outputs over the life of the project, (b) sufficient capital is authorized and available to finance construction to completion, and (c) estimated revenues are sufficient to cover costs over the repayment period. Furthermore, DWR does not propose construction of a project unless

- expected revenues or other operating income are sufficient to cover the reimbursable portion of the State's capital investment within the specified time period of repayment and at the project interest rate,
- the project's financial performance or feasibility does not depend on the subsequent construction and operation of any other project, except for those included in the "Delta Operating System," or
- each reimbursable purpose of a multi-purpose project meets the test of financial feasibility.

## Financial Costs

Financial costs are the actual expenditures, "out of pocket," costs that are required to construct and operate a project. Financial costs can be grouped into two main categories—capital costs and operation, maintenance, and replacement costs.

### Capital Costs

Capital costs are nonrecurring costs required to construct a project from the inception of planning to completion of construction. These costs include the following:

- Planning and design
- Labor, materials, supplies, utilities, and services during construction
- Land, easements, rights-of-way, and water rights
- Relocation of facilities
- Clearing and preparation of project land
- Compensation for damage
- Construction contingencies
- Administrative, supervisory, and interim maintenance during construction

- Special works and services
- Regulatory
- Interest during construction

For small projects, capital costs may be incurred over one year or less. However, for large projects, capital costs may be incurred over many years, and the economic analysis should take this into account (see discussion of "Forgone Investment Value" in Appendix A).

### Operation, Maintenance, and Replacement Costs

Operation and maintenance (O&M) costs occur continuously or periodically, and they are incident to project operations—such as, electric power for pumping, materials and supplies used in maintenance and repair, and project administration. For State Water Project (SWP) repayment purposes, a further distinction is made between fixed and variable O&M costs: Fixed O&M costs are common to a project as a whole and do not vary based upon water deliveries (or other project outputs), whereas variable O&M costs are recurring costs that do vary depending upon project outputs (such as, pumping energy requirements). Replacement costs are recurring costs of replacing facilities or major items of equipment (such as, pumps) with an economic life shorter than the period of project repayment and which, therefore, must be replaced one or more times within the repayment period.

## State Water Project Financing

The SWP depends on a complex system of dams, reservoirs, power plants, canals, and aqueducts to deliver water. SWP project facilities have been constructed with four general types of financing: (1) general obligation bonds—under the Burns-Porter Act approved by voters in 1960, (2) tideland oil revenues, (3) revenue bonds, and (4) capital resources. Repayment of these funds and the operations, maintenance and replacement costs associated with water supply deliveries are paid by the 29 agencies/districts that have long-term SWP contracts. The contracts initially provided for a combined maximum annual Table A delivery of 4.23 million acre-feet of water supply, later adjusted to 4,217,786 acre-feet due to contract amendments in the 1980s. The contracts are in effect until 2035.

Charges to SWP contractors include the costs of facilities for the conservation and development of a water supply and the conveyance of such supply to SWP contractor service areas. The Delta Water Charge is a unit charge applied to each acre-foot of SWP water in accordance with the contracts. The unit charge, if applied to each acre-foot of all such water for the remainder of the project repayment period, is calculated to result in repayment of all outstanding reimbursable costs of the SWP's conservations facilities (such as, Lake Oroville). The Delta Water Charge consists of a capital cost and a minimum Operation, Maintenance, Power, and Replacement (OMP&R) component. The Transportation Charge recovers costs of facilities required to transport SWP supplies from the Delta to the contractor's service area. Generally, the annual charge represents each contractor's proportionate share of the reimbursable capital costs and operating costs of the SWP transportation facilities (such as, the California Aqueduct). The Transportation Charge consists of a capital cost component as well as a minimum OMP&R and variable OMP&R component.

## Cost Allocation

Cost allocation is the process by which financial costs of a project are distributed among project purposes. Separable costs that can be identified with particular purposes are allocated directly to those purposes. Use of one structure for more than one project purpose allows the purposes to be included at less cost than the total cost of separate structures for each purpose. The incremental cost of including each purpose as an addition to other purposes of the combined structure should be less than the cost of the most economical single-purpose alternative means of producing similar benefits for that purpose.

A basic principle of cost allocation is that savings, if any, resulting from multiple purpose projects should be equitably distributed among the project's purposes. No purpose should be assigned costs in excess of its benefits or should be supported by benefits attributable to another purpose, and no purpose should be assigned costs greater than the cost of an alternative single-purpose project.

Cost allocation should not be confused with cost sharing. Cost allocation refers only to an equitable division of costs among the various purposes served, with each purpose receiving its fair share of savings from multiple-purpose development. Cost sharing refers to the division of costs allocated to each purpose to the individual agencies involved. These costs can be borne by various federal, State, or local agencies according to prescribed policies as described above.

- Types of Allocated Costs. Costs that are included in a cost allocation process are:
    - Specific costs: Costs of facilities that exclusively serve only one project purpose.
    - Separable costs: Costs which could be omitted from the project if one purpose of the project were excluded. They may also be costs incurred for structures serving several but not all purposes. In some cases specific and separable costs are the same.
    - Alternative costs: the cost of the least costly single-purpose alternative means of providing the same benefits. The alternative may be a single-purpose project at the same site.
    - Justifiable costs: The lesser of benefits or alternative costs and is the maximum that can be allocated to any purpose.
    - Remaining benefits: Justifiable costs minus separable costs for each purpose.
- Cost Allocation Methods. There are various cost allocation methods, including Separable Costs-Remaining Benefits (SCRB), Alternative Justifiable Expenditures, and Proportionate Use of Facilities methods.[34] However, the most commonly used method is the SCRB method. The SCRB method distributes costs among the project purposes by identifying separate costs and allocating joint costs or joint savings in proportion to each purpose's remaining benefits. The SCRB method is applied to SWP water storage dams and reservoir projects.

[34] These methods are discussed in more detail (with some examples) in the draft DWR *Economics Practices Manual*, Chapter VII.

The SCRB method includes the following steps:

1) The benefits for each purpose are estimated.
2) The alternative costs of single-purpose projects to obtain the same benefits are estimated.
3) The lesser of the two items above is selected for each purpose as the maximum amount which can be allocated to the purpose and is designated as the justifiable cost.
4) The separable cost of each purpose is estimated. The project with the purpose omitted should be the least costly project capable of providing the same benefits for the remaining project purposes. That project can be at the same site, but can also be at another site as long as the service areas for the remaining purposes are the same.
5) The separable cost of each purpose is deducted from the justifiable costs to determine its remaining justifiable costs.
6) The percentage distribution of the remaining justifiable costs is determined.
7) The total separable cost is deducted from total project cost to determine the total remaining joint costs which are distributed proportionately by applying the percentages found in step 6.
8) The cost allocation to each purpose is the sum of the distributed remaining joint cost and the separable cost.

The Hamilton City Flood Damage Reduction and Ecosystem Restoration Study provides a good example of a SCRB cost allocation among purposes. This cost allocation is described in Appendix B.

## Determining Local Agency Repayment Capability

Repayment capability is determined by a year-by-year analysis of a district's income from and expenses of its water project. Such income may consist of receipts from water toll chargers or tax assessments, or both. The analysis also shows operation, maintenance, and replacement expenditures, payments to a reserve fund, and debt service payments (interest and principal). The analysis should be extended through each year of the repayment period, showing the manner in which the project will be repaid. If a development period or buildup period is necessary for financial feasibility, then that should also be taken into account.

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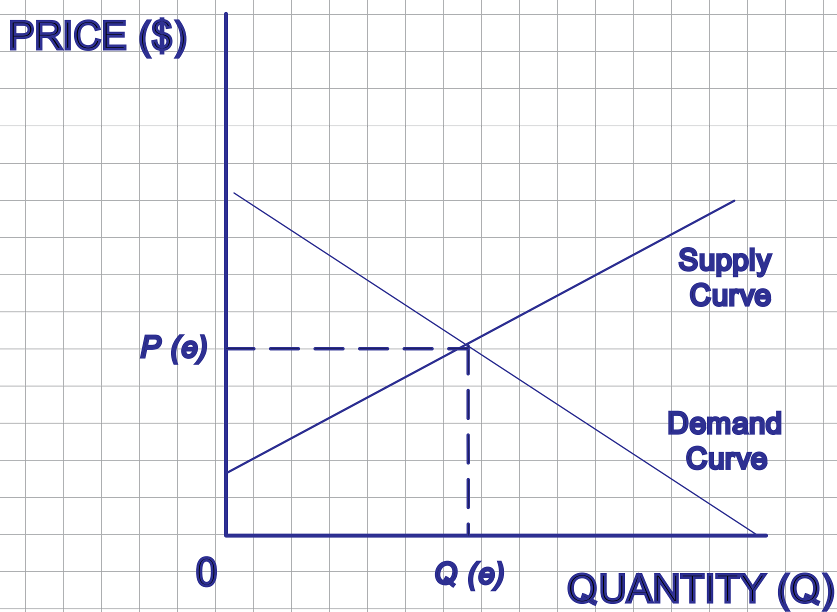
“Economics is the science which studies human behavior as a relationship between ends and scarce means which have alternative uses.”

–Lionel Charles Robbins




State of California

The Resources Agency

Department of Water Resources

# Appendix A Concepts Used in Economic Analyses

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# Appendix A  Concepts Used in Economic Analyses

This appendix describes the concepts that are critical to understanding the economic analysis methods discussed in Chapter 3. These concepts help define the topical, temporal, and geographic scope of economic analyses.

## Economic Values, Willingness to Pay, and Willingness to Accept

Although there are many ways to measure values, the use of economic values is important when choices must be made in allocating limited resources among competing programs. The theory of economic valuation is based upon individual preferences and choices. People express their preferences through the choices and trade-offs that they make, given constraints, such as those on income or time.

The economic value of a good or service to a person who is a buyer is measured by the maximum amount of other things that he or she is willing to give up in order to acquire that good or service. In a barter society, this trade-off is obvious. An example is when a person gives up three units of good A in order to obtain one unit of good B. However, in market economies, dollars (or other forms of currency) are the accepted indicator of economic value because the amount of dollars a person is willing to pay for an item indicates how much of other goods and services he or she is willing to give up for that particular item. In short, the economic value of a good to a buyer is equal to his or her "willingness to pay."

A comparable concept is called "willingness to accept" or "willingness to receive," which measures how much an individual who is a seller would accept or receive as payment if he or she could be induced to forgo a good or service. The amount of payment can then be equated to the economic value of the good or service. In short, the economic value to a seller is equal to his or her "willingness to accept." Although theoretically, willingness to pay and willingness to accept should always be equal, often they are not as shown by this example:

> A typical experiment consists of the following: a person is given an ordinary flashlight and then offered money to return it to the experimenter. The dollar amount the subject asks for is his compensation demanded (CD*) [also known as willingness to accept or WTA]*. Another person is not given a flashlight and instead is asked to pay for one. The dollar amount the subject offers is his willingness to pay (WTP). CD *[or WTA]* is usually substantially higher than WTP, by a factor of two to six times, and this disparity has been shown to occur in a variety of settings and for a wide variety of goods, including public goods."[1]

[1] John K. Horowitz, "A Test of Competing Explanations of Compensation Demanded", www.uq.edu.au/economics/johnquiggin/JournalArticles99/WTAWTPEconInq99.html

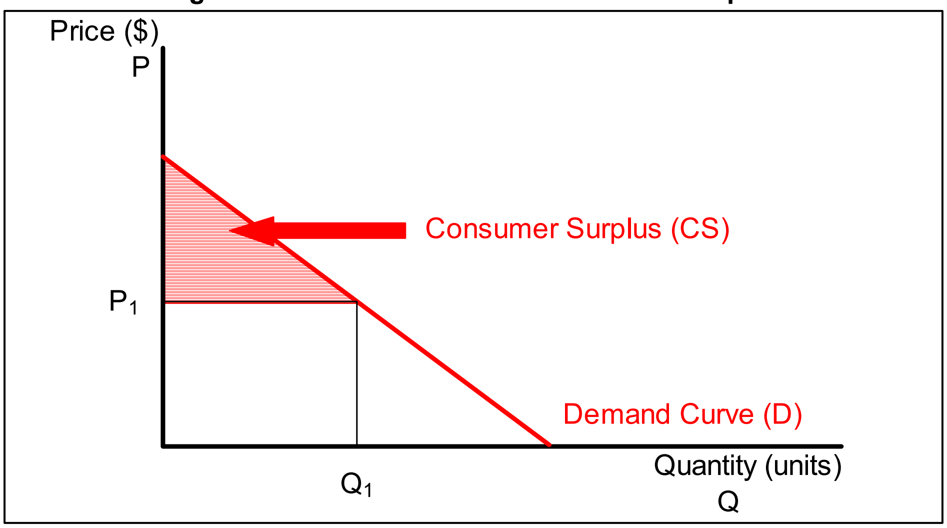
### Demand Curve and Consumer Surplus

In most cases, people will purchase less of a good or service as its price increases. In economics, this is known as the "law of demand." The demand curve for a good can be illustrated by plotting the amount of a good that buyers are willing to purchase at different prices. Because the purchased quantity for a good generally decreases as the price of the good increases, the demand curve slopes downward from left to right.

In many cases people are often willing to pay more for the good, and thus their perceived value for that good, or their willingness to pay, exceeds its market price. The difference between their willingness to pay and the market price is called consumer surplus.

The derivation of demand curves requires data on the quantity purchased at different prices, plus data on other factors that might affect demand, such as income or other data. Figure A-1 illustrates the demand curve and consumer surplus for a good or service. $P_1$ and $Q_1$ indicate the current market price and the quantity purchased. The hatched area above $P_1$ and under the demand curve represents consumer surplus. In other words, even though the current market price of the good or service is $P_1$, some consumers would be willing to pay more for it. It should be noted that if a good or service has no market price (as in the case of many environmental goods and services such as flood protection or water supply services provided by wetlands), then there is no price line in Figure A-1, and consumer surplus is the entire area under the demand curve.

**Figure A-1 Demand curve and consumer surplus**

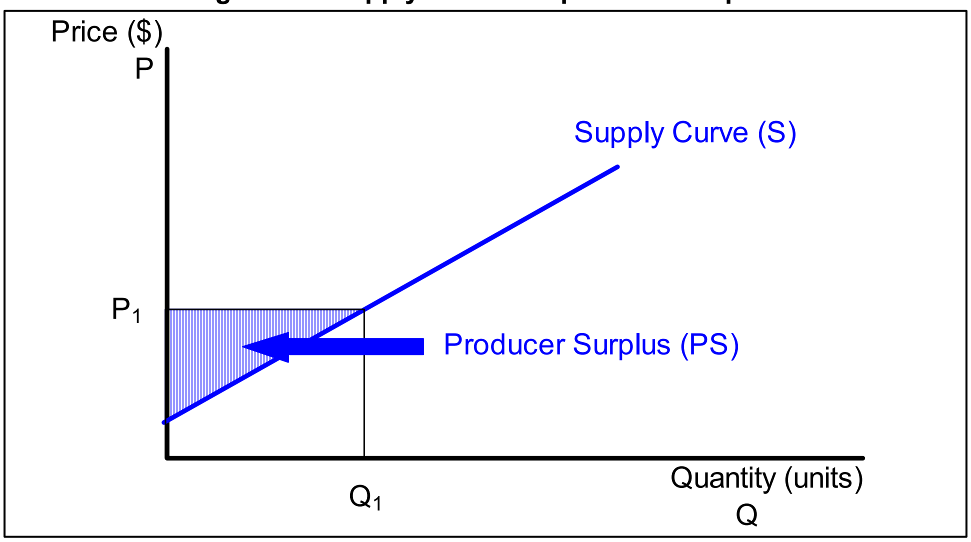


### Supply Curve and Producer Surplus

The above discussion of consumer surplus refers to economic benefits (or savings) received by consumers of goods and services. Producers also receive economic benefits based upon the (windfall) profits they make from selling goods and services. The supply curve indicates how many units of a good or service producers are willing to produce and sell at a given price. As prices increases, producers generally want to produce and sell more goods, thus this curve slopes upward from left to right.

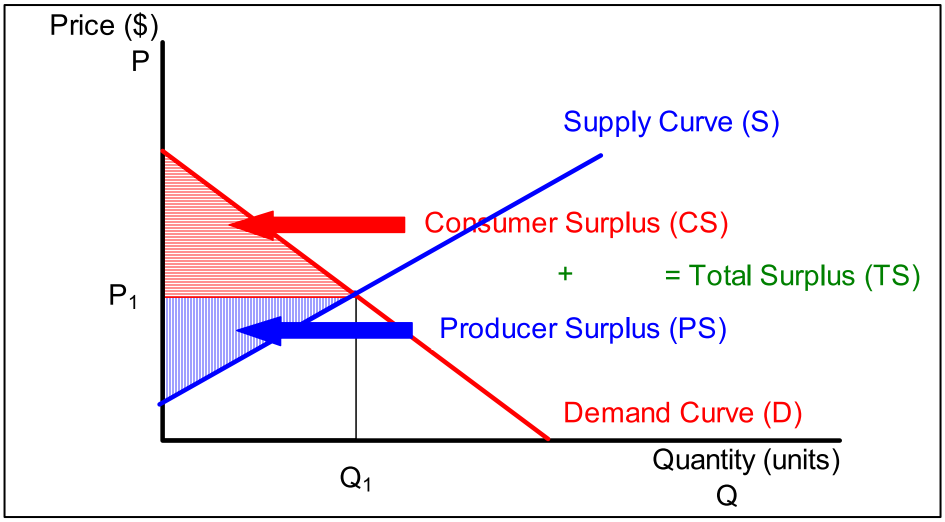
If producers receive a higher price than what it costs to produce the good, i.e. their willingness to accept for the good, then they receive an economic benefit (windfall profit) from the sale, called producer surplus. To estimate producer surplus, data are required on variable costs of production and revenues received from the good. $P_1$ and $Q_1$ in Figure A-2 indicate the current market price and the quantity sold. The shaded area illustrates producer surplus.

**Figure A-2 Supply curve and producer surplus**



Total economic benefit, or total surplus, is the sum of consumer and producer surplus. Figure A-3 illustrates both consumer and producer surplus based upon the intersection of the demand and supply curves.

**Figure A-3 Consumer and producer surplus**




## Changes in Consumer and Producer Surplus

The economic benefit of an action to the persons who are buyers is measured by changes in consumer surplus, which changes if there is a change in the price or the quality of a good. For example, if the price of a good increases but a person's willingness to pay remains the same, the economic benefit received or consumer surplus—willingness to pay minus price—will be less than before. Or, if the quality of a good improves, but the price remains the same, a person's willingness to pay may increase thus the economic benefit will also increase. To estimate changes in consumer surplus, the demand curves for conditions before and after the action must be determined.

Alternatively, the economic benefit to consumers, or consumer surplus, can be affected by changes in the prices of other related goods. If goods can be *substituted* for each other, then if the price of one good declines while the prices of other similar goods and incomes remain the same, a consumer can increase his or her satisfaction by purchasing more of the good that has fallen in price and less of the other goods. For example, if coffee and tea are close substitutes, then if the price of coffee goes up, there may be more demand for tea. The demand curve for tea will shift upward to the right, increasing consumer surplus.

Conversely, if goods are *complementary*, then changes in the price of one good will lead to a change in the demand, and thus consumer surplus, for the other good. For example, if sugar is purchased and consumed along with coffee, then increases in prices for coffee (and thus reductions in its coffee consumption) may also result in less demand for sugar. Thus, the consumer surplus for sugar is also decreased because its demand curve is shifted downward to the left.

The economic benefit of an action to producers is measured by *changes* in producer surplus. These changes can occur because of changes in the availability and/or prices of goods and services used in the production process.

Figure A-4 and Figure A-5 show changes in total surplus, i.e. total economic benefits, resulting from shifts in the demand and supply curves. Economic benefits are a key input into benefit-cost analysis, which (as discussed in Chapter 3) is used to determine the economic justification of the project.

**Figure A-4 Changes in total surplus due to increased demand**

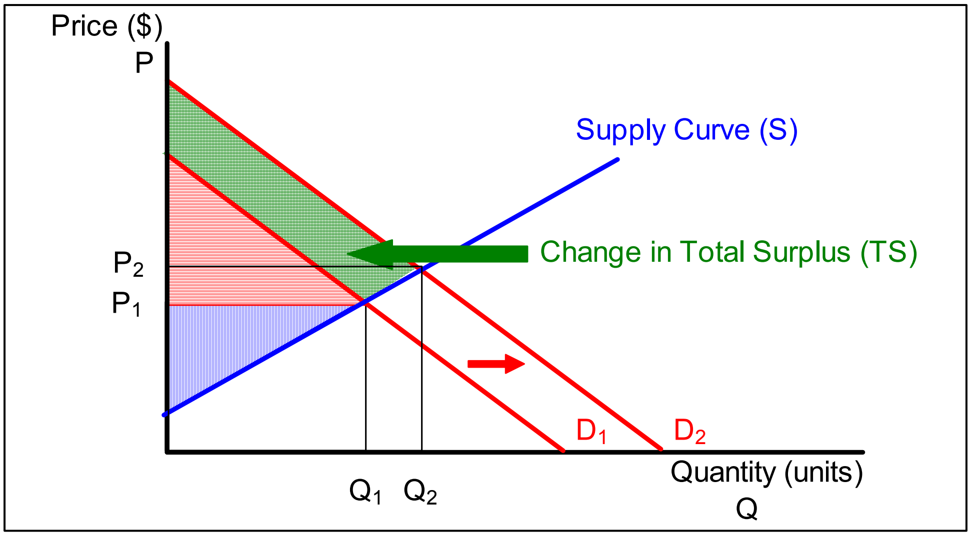
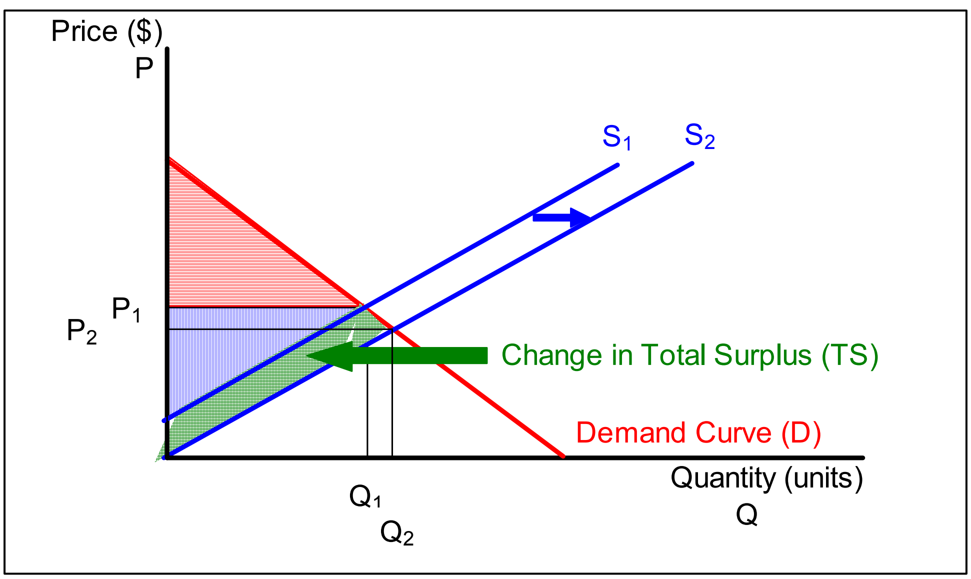



**Figure A-5 Changes in total surplus due to increased supply**



### Other Issues

The above discussion of willingness to pay, willingness to accept, and the related concepts of consumer and producer surplus were simplified. A number of issues can complicate economic analyses, including:

- Pure competition vs. other market types: Figures A-4 and A-5 illustrate a purely competitive market structure with the following characteristics: (a) there are many buyers and sellers, and no individual can significantly affect the market price; (b) all the firms produce and sell identical or homogenous products; and (c) buyers and sellers have perfect information and are able to freely enter or leave the market. Obviously there are very few markets that meet these very restrictive conditions. Other market types include oligopoly (few major sellers) and monopoly (one seller). The concepts describe above still apply, although they would be graphed differently for these different market structures. Other market distortions may also be present, such as economic rent (described below) taxes, subsidies, transfer payments, and externalities.
- Economic rent: a market distortion can occur if a productive good or factor is fixed in amount regardless of price and therefore the supply curves shown in Figure A-4 and Figure A-5 would be vertical (i.e., inelastic) rather than upward sloping. Therefore, higher prices will not increase the supply of these fixed resources. All payments made (other than for maintenance and depreciation) for an asset whose supply curve is perfectly vertical and available without any cost of production are "economic rent." Fixed resources yield economic rent because they are not only productive but because they are *scarce*. For example, with a vertical supply curve, increases in demand because of scarcity will raise the prices of the resource above what would be received for that resource based upon its productive capacity. The amount of "economic rent" received for a resource above its otherwise productivity potential should be excluded from benefit/costs analyses.
- Income vs. price effects: As illustrated above, shifts in the demand curve result in changes in consumer surplus, which provides the basis in measuring changes in consumer welfare. Although the goal is to measure changes in consumer surplus caused by price changes, there is concern among economists that the changes in consumer surplus include not only the effects of the price changes, but also the income effects that occur along with the price changes. (Any change in the price of a good generates two effects on the buyers, a price effect and an income effect.) Therefore, it may necessary to adjust for the income effects such that only price effects upon consumers are measured, which requires the derivation of "income adjusted" demand curves. This is very difficult to do, and some evidence suggests that there is not that much difference between the "adjusted" and "ordinary" demand curves.
- Income distribution: A consumer's desire for a particular good or service must be backed up with income that can translate that desire into an actual willingness to pay. If the current distribution of income were changed, it is likely that the willingness to pay for different goods would also change because different people would then have the ability to purchase alternative goods and services. For example, environmentally related goods and services may be important to residents in a relatively low-income community, but because of the lower income levels these residents are unable to pay for these amenities.

  If the income distribution in this community were somehow changed, then it might be possible to translate this desire into an actual willingness to pay. However, because economists and other policy-makers have no way of determining which income distribution policy is superior; the current income distribution must be accepted for the benefit and cost analysis.

- Individual vs. social effects: The above discussion focuses upon demand and supply curves of individual consumers and producers. However, it is necessary to evaluate the impacts of changes in goods and services (especially public ones) upon society as a whole. Welfare economics is a branch of economics that focuses upon how a society can allocate scarce resources to maximize social welfare (economic efficiency).

  The *Pareto optimality* criterion suggests that an efficient allocation of resources occurs only when there are no possible reallocations that could make at least one person better off without making another worse off. With this criterion, efficiency cannot be achieved by a project if it makes just one person worse off than before, even if many more are made better off. Obviously, this is a very restrictive criterion, and reliance upon it would result in very few programs or projects being implemented because most involve trade-offs among individuals, with some benefiting while others losing. This is especially true for multi-objective water management plans that can affect entire watersheds and multiple stakeholders with diverse and competing interests.

  A less restrictive criterion is called *potential Pareto optimality* which states that an increase in general welfare occurs if those who are made worse off could in principle be compensated for their losses, whether or not this compensation occurs. This is this the criterion upon which benefit and cost analysis (described below) is based.

- Public vs. non-public goods: Many goods and services exist that can be consumed at the same time by more than one consumer and for which it is not feasible to restrict any consumer's access to those goods or services (that is, there are no markets). These are called "public goods." For example, a floodplain management proposal might include the restoration of natural wetland and riparian habitat, which can be enjoyed by all of the inhabitants of a community. Although there are no traditional markets for habitat, they can provide numerous benefits to society, and as discussed in Chapter 4, different measurement methods can be used to incorporate these values into a benefit/cost analysis.
- Measuring ecosystem outputs: To successfully place monetary values on ecosystem services, it is essential to be able to first measure the physical outputs from those ecosystems. Unfortunately, measuring the physical outputs from ecosystems can be more difficult than the process of attempting to place monetary values on ecosystem services.

## Types of Values

Economists generally classify values as either *use* or *non-use* values. Use values include direct, indirect, option, and bequest values.

Direct use values contribute to consumer satisfaction or producer profits. For example, a restored wildlife preserve along a river creates values for those who visit the site to view wildlife or to those who harvest natural products (berries, fish, etc.) to be sold to others. Indirect use values are those that contribute to production or consumer utility by supporting other direct activities (or avoiding damages to those direct activities). For example, if the restored wildlife area also acts as a temporary floodwater storage site, then flood damage to downstream residential and commercial properties can be reduced. Option value is the value that people place on having the ability to enjoy something in the future, even though they may not currently use it. For example, a resident in a nearby community may not currently visit the restored wildlife area, but may plan to do so in the near future. Bequest value is the value that people place on something knowing that future generations will have the option to enjoy it. For example, another resident may not be planning on visiting the site, but it has value to them because their children may be able to visit the site in the future.

All of the above-mentioned values assume some sort of use—either now or in the future. However, it is also possible that a resident may value the restored wildlife area even if nobody can visit it (now or in the future); it has value simply because “it exists.” This is an example of a non-use existence value.

The fundamental problem facing economists is how to express all of these different types of values using a common monetary basis so that they can be directly compared to each other. While some of these values can be expressed relatively easily in monetary terms, others cannot. It is the latter group that poses special problems for economic analysis (particularly benefit/cost analysis), and methods to evaluate non-market values are discussed in Chapter 4.

## ‘Without’ vs. ‘With’ Project Conditions

Economic analysis (as well as all aspects of project evaluation) must focus upon the change in conditions expected to occur “without” the project vs. “with” the project. The “without” project conditions, which include not only historical and existing conditions but also future without-project conditions, become the baseline from which all project effects (positive and negative) are compared. Thus, the estimation of the existing and future without-project conditions is a critical step in the economic analysis. It not only involves the projection of key socioeconomic variables (such as population, employment, housing, etc.), but also other related projects that may become operational in the study period without the proposed project. Often the “without” vs. “with” comparison is confused with a “before” and an “after” comparison; this is not correct because some of the benefits forecasted to occur in the future with the project may also have occurred even without the project. Therefore they should not be attributed to the project.

## Planning Time Horizons

In any feasibility study, different planning time horizons may be encountered. Typically these time horizons include:

- Economic life: The period in which the project is economically viable, which means that the incremental benefits of continued use exceed the incremental costs of that use.
- Physical life: The period in which the project can no longer physically perform its intended function. Economic life may be shorter than physical life but not vice versa.
- Period of analysis: The length of time over which a project’s consequences are included in a study. Typical analysis periods for structural water resource projects are 50 to 100 years and 5 to 25 years for nonstructural projects. If the period of analysis is not an even multiple of physical lives, an adjustment can be made using either a negative cash flow or salvage value. However, often such a detailed analysis is not warranted because of discounting (discussed below) since this adjustment occurs at the end of the analysis period.

  Within the analysis period, a base year must be identified which generally is when project construction/implementation occurs, and project outputs (that is, 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. If project construction occurs over several years, then these are included in the analysis period prior to the base year, and these are numbered -1, -2, -3, etc. Analysis years prior to the base year are treated differently in the discounting process than years occurring after the base year.

- Short term vs. long term: Short term is the period of time in which capital investments cannot be changed. For example, a community has invested in a local reservoir to augment its water supplies. While it may be able to vary deliveries from that reservoir, it cannot add additional water supply facilities over a short period of time. In contrast, over the long term, the community can adjust to changing local water demand and supply balances by adding new water supply facilities, such as an aqueduct importing supplies from other basins or the construction of a seawater desalination plant.
- Financing period: The length of time required for bond repayment or other required paybacks, which may be shorter or longer than the period of analysis. This time horizon is only relevant for financial analyses.

## Analysis Perspectives

Economic analysis depends upon whose perspective is being taken in the evaluation. For example, a floodplain management project may remove crops currently in production along a river and restore the land for ecosystem restoration purposes that will affect numerous groups of people (stakeholders).

The growers will obviously be concerned with the loss of net income as their lands are removed from production. However, potential recreationists who might visit the restored area will be concerned with the quality and quantity of the restored habitat. A nearby community will be concerned about the potential losses to food processors, farm workers, farm suppliers, and others who will lose indirectly because of crops being removed from production. However, these losses would be partially offset by increased spending in the community from persons visiting the restoration area.

The community could also experience various fiscal effects, such as reductions in property taxes as private lands are converted to public ownership, loss of sales tax revenues from reduced sales of agricultural-related goods and services, and the potential for increased police and fire protection expenses necessitated by increased visitors to the restoration area. Some of these negative effects will be partially offset by increased sales tax revenue from visitors and reductions in flood response-related expenses. Collectively, all of these positive and negative indirect effects are sometimes called “third party impacts.” And finally, the nation will be interested in forgone investments elsewhere if funds are committed to a particular project, and possible changes in output elsewhere resulting from project induced production changes (for example, reduced visits to ecosystem restoration sites elsewhere that might occur if the proposed project were constructed).

One way or another, all of these effects can be included in an economic analysis. Some of these effects are direct effects (such as the loss of crop net income or the value of the habitat to recreationists) and would be included in a benefit-costs analysis to justify the project’s construction, assuming all benefits can be expressed in monetary terms. If they all cannot be expressed in monetary terms (for example, the value of the habitat), then the benefit-cost analysis may have to be combined with a trade-off analysis to evaluate the monetary gains and losses compared with physical changes in other types of project outputs (such as the quantity of habitat).

Many of the indirect effects (changes in sales of agricultural or recreational goods and services, changes in a community's fiscal conditions, etc.) can all be evaluated in an economic impact analysis, which can help decision-makers fully understand the consequences of their actions and can be disclosed in an environmental impact statement/report. If funding is to be obtained from the federal government, then the effect upon national economic development will also have to be taken into account. (See US Water Resources Council, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, March 10, 1983, Chapter II.)

## Inflation and Escalation

Inflation is the rate of change in general price levels throughout the economy. Inflation is usually measured by a broad-based price index, such as the Consumer Price Index. Although inflation can be included in an economic analysis, it is generally recommended that it not be included because of the extreme uncertainties about forecasting future inflation, especially over long planning time horizons.

When inflation is excluded, prices levels are evaluated in real (or constant) dollars. However, for items that are expected to experience a change in price different than the general inflation rate, the differential rate can be included in an economic analysis. For example, if the annual inflation rate is 4% but energy costs are expected to increase 6% on an annual basis throughout the planning period, then the differential between the two price levels (2%) can be used to increase annual energy costs in the analysis. This differential is called an *escalation adjustment*.

## Cost Indices

Cost or price indices are used to measure the relative change in the cost of a commodity (or groups of commodities) over time. Even though future inflation is usually excluded in economic analyses, it is still often necessary to convert dollar values from different time periods to one base year. For example, one cannot readily do a comparison of alternative projects' costs if one estimate was prepared in 2000 and the other in 2003. Although the 2003 cost estimate could be expressed in 2000 dollars, it is usually more common to bring the 2000 estimate up to current 2003 dollars by calculating the change in an appropriate cost index.

The most widely known price index is the Consumer Price Index (www.bls.gov/cpi/) that produces monthly data on changes in the prices paid by urban consumers for a representative basket of goods and services. However, this index is not appropriate for indexing water project construction costs. For indexing construction costs, indices include the Gross Domestic Product Implicit Price Deflator research.stlouisfed.org/fred2/series/GDPDEF/21), the US Bureau of Reclamation (Bureau) Construction Cost Indices (www.usbr.gov/pmts/estimate/cost_trend.html), the Engineering News-Record Construction Cost Index (enr.construction.com), or the US Army Corps of Engineers' (Corps) Civil Works Construction Cost Index System (www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1304/entire.pdf).[2] Producer Price Indexes can also be extremely valuable for agricultural and other commodities (www.bls.gov/ppi/home.htm and www.bls.gov/ppi/ppiesc.htm).

The use of the Gross Domestic Product Implicit Price Deflator is recommended to measure price changes for all goods and not just consumer goods.

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[2] The Corps' publication *Civil Works Construction Cost Index System* (EM 1110-2-1304; March 2000) provides an excellent discussion of how to use cost indices.

# Adjusting for Different Time Periods (Discounting)

Because analyses of water resource projects typically encompass long periods of time, it is necessary to adjust for the time value of money. Even if there is no inflation, a dollar received today is worth more than one received in the future because a dollar received today can be put to immediate use. Adjusting for different time periods is accomplished by estimating the present value of each benefit and cost in the future.

Present values are calculated with a simple formula ($P = F / (1+r)^n$), which involves dividing the future dollar amount of benefit or cost by a discount factor $(1 + r)$ raised to the nth power. In this equation, P equals the present value of the future cash flow, F = future cash flow, r = discount rate, and n = number of time periods into the future that the benefit or cost occurs. Alternatively, present value "factors" for different discount rates and analysis years may be found in financial tables.

## Discount Rate

The discount rate is used to adjust dollars received or spent at different times to dollars of a common value, usually present day dollars ("present worth" or "present value"). Although there are different methods for determining discount rates, generally the value to use for this rate is the real (that is, excluding inflation) rate of return that could be expected if the money were instead invested in another project. In other words, the discount rate is a measure of forgone investment opportunity (that is, "opportunity cost") if the money allocated to the project were invested elsewhere.

The selection of a discount rate is critical for the analysis because the larger the discount rate, the greater the reduction in future monetary values. This tends to affect benefits more than costs because the majority of costs are incurred early in the analysis period (for example, construction costs); whereas, benefits typically occur later in the analysis period. DWR is currently using a 6% discount rate, which approximates the marginal pretax rate of return on an average investment in the private sector in recent years. This rate will be periodically reviewed and revised as necessary. The US Treasury Department annually sets the discount rate used by the Corps and the Bureau.[3] The discount rate is very much different from the bond repayment interest rate that is used in the financial analysis.

## Present Value Analysis

A project's benefits and costs typically occur over different time periods. For most projects or programs, construction or implementation costs occur up front in a project's life, followed by smaller recurring annual operations and maintenance costs. In contrast, project benefits usually occur only after construction is completed, and they may gradually increase over time if a "build-out" period is required (for example, increasing water demand caused by increasing population growth). Because costs and benefits occur over different times, they cannot directly be summed and compared to each other but instead must be made comparable through a present value analysis.

In a present value analysis, all annual costs and benefits are discounted using the same discount rate, and total discounted benefits and costs can then be summed for the entire analysis period and directly compared to each other using a net benefit or B/C ratio analysis. The discounting occurs by multiplying

[3] The Corps discount rates are included in their Economic Guidelines Memorandum found on their General Planning Guidelines website: http://www.usace.army.mil/cw/cecw-cp/library/planlib.html

the present value factor times the appropriate benefit and cost data for each year. No discounting occurs for the base year (year 0), and decreasing present value factors are applied for succeeding years in the analysis period.

### Forgone Investment Value

If construction occurs prior to the base year, then the future value of these expenditures must be determined by multiplying these monetary costs by a future value factor (which is the reciprocal of the present value factor). Often this future value adjustment is called "interest during construction;" however, this terminology is not correct because it implies that this adjustment reflects actual interest charges incurred prior to construction. While these interest charges do occur, they are accounted for using a different procedure (which takes into account compound interest) in a financial analysis. These future value adjustments are more appropriately called "forgone investment values" to reflect the value of other investments that could have been pursued if the project were not undertaken ("opportunity costs").

### Example Present Value Analysis

An example present value analysis is presented in Table A-1 for a project with capital costs of $300,000. Project construction occurs over three years, which are shown as years -2, -1, and 0, with project benefits expected to occur for a 25-year period following construction. Prior to the base year, the annual construction costs are multiplied by a future value factor that effectively increases those costs. After construction, present value factors are multiplied times the annual operations and maintenance costs and the project benefit values, effectively reducing those values. Total discounted costs are about $572,200 compared to total discounted benefits of about $639,200. If a benefit/cost analysis is being conducted (described below), net benefits are equal to about $67,000 and the B/C ratio is about 1.12 (in other words, for every project dollar spent, benefits equal $1.12).

Another useful type of analysis computes the cost per unit (in this example, the cost per acre-foot of water deliveries). This is a cost-effectiveness analysis. In this example the cost per acre-foot is about $450. It should be noted that in addition to discounting project costs, the water deliveries are also discounted to keep them comparable to discounted costs.

In some cases it may be more useful to express benefits and costs in annual terms, which can be accomplished by multiplying total discounted benefits and/or costs by a capital recovery factor for the planning period to obtain average annual equivalents. Tables and formula for present value (discount) and capital recovery factors can be found in DWR's Draft *Economics Practices Manual* and most financial analysis textbooks. The B/C ratio would be the same whether total or annual discounted benefits and costs are used.

**Life Cycle Cost Analysis**

Life-cycle cost analysis (LCCA) is a method for assessing and comparing the total costs of alternatives. It takes into account all costs of acquiring, owning, and disposing of facilities and related equipment. LCCA is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to identify the one that maximizes net cost savings. The three key variables in a LCCA include identifying and evaluating for each alternative all pertinent costs, the period of time over which these costs can be compared, and the discount rate that is applied. The LCCA concepts are essentially the same as the cost analysis concepts included in this Guidebook. The key is identifying and collecting data for all "pertinent costs."

### Table A-1 Example discounting analysis: Present and future values

| | Year (a) | Discount factor (b) | Capital costs (c) | Operations & maintenance costs (d) | Total costs (e) | Discounted costs (f) | Water supply benefits (g) | Discounted water supply benefits (h) | Water deliveries (i) | Discounted water deliveries (j) |
|---|---|---|---|---|---|---|---|---|---|---|
| Future Value | -3 | 1.190 | $0 | ----- | $0 | $0 | ----- | ----- | ----- | ----- |
| Future Value | -2 | 1.124 | $70,000 | ----- | $70,000 | $78,652 | ----- | ----- | ----- | ----- |
| Future Value | -1 | 1.060 | $130,000 | ----- | $130,000 | $137,858 | ----- | ----- | ----- | ----- |
| Base Year | 0 | 1.000 | $100,000 | ----- | $100,000 | $100,000 | ----- | ----- | ----- | ----- |
| Present Value | 1 | 0.943 | ----- | $20,000 | $20,000 | $18,860 | $50,000 | $47,150 | 100 | 94 |
| Present Value | 2 | 0.890 | ----- | $20,000 | $20,000 | $17,800 | $50,000 | $44,500 | 100 | 89 |
| Present Value | 3 | 0.840 | ----- | $20,000 | $20,000 | $16,800 | $50,000 | $42,000 | 100 | 84 |
| Present Value | 4 | 0.792 | ----- | $20,000 | $20,000 | $15,840 | $50,000 | $39,600 | 100 | 79 |
| Present Value | 5 | 0.747 | ----- | $20,000 | $20,000 | $14,940 | $50,000 | $37,350 | 100 | 75 |
| Present Value | 6 | 0.705 | ----- | $20,000 | $20,000 | $14,100 | $50,000 | $35,250 | 100 | 71 |
| Present Value | 7 | 0.665 | ----- | $20,000 | $20,000 | $13,300 | $50,000 | $33,250 | 100 | 67 |
| Present Value | 8 | 0.627 | ----- | $20,000 | $20,000 | $12,540 | $50,000 | $31,350 | 100 | 63 |
| Present Value | 9 | 0.592 | ----- | $20,000 | $20,000 | $11,840 | $50,000 | $29,600 | 100 | 59 |
| Present Value | 10 | 0.558 | ----- | $20,000 | $20,000 | $11,160 | $50,000 | $27,900 | 100 | 56 |
| Present Value | 11 | 0.527 | ----- | $20,000 | $20,000 | $10,540 | $50,000 | $26,350 | 100 | 53 |
| Present Value | 12 | 0.497 | ----- | $20,000 | $20,000 | $9,940 | $50,000 | $24,850 | 100 | 50 |
| Present Value | 13 | 0.469 | ----- | $20,000 | $20,000 | $9,380 | $50,000 | $23,450 | 100 | 47 |
| Present Value | 14 | 0.442 | ----- | $20,000 | $20,000 | $8,840 | $50,000 | $22,100 | 100 | 44 |
| Present Value | 15 | 0.417 | ----- | $20,000 | $20,000 | $8,340 | $50,000 | $20,850 | 100 | 42 |
| Present Value | 16 | 0.394 | ----- | $20,000 | $20,000 | $7,880 | $50,000 | $19,700 | 100 | 39 |
| Present Value | 17 | 0.371 | ----- | $20,000 | $20,000 | $7,420 | $50,000 | $18,550 | 100 | 37 |
| Present Value | 18 | 0.350 | ----- | $20,000 | $20,000 | $7,000 | $50,000 | $17,500 | 100 | 35 |
| Present Value | 19 | 0.331 | ----- | $20,000 | $20,000 | $6,620 | $50,000 | $16,550 | 100 | 33 |
| Present Value | 20 | 0.312 | ----- | $20,000 | $20,000 | $6,240 | $50,000 | $15,600 | 100 | 31 |
| Present Value | 21 | 0.294 | ----- | $20,000 | $20,000 | $5,880 | $50,000 | $14,700 | 100 | 29 |
| Present Value | 22 | 0.278 | ----- | $20,000 | $20,000 | $5,560 | $50,000 | $13,900 | 100 | 28 |
| Present Value | 23 | 0.262 | ----- | $20,000 | $20,000 | $5,240 | $50,000 | $13,100 | 100 | 26 |
| Present Value | 24 | 0.247 | ----- | $20,000 | $20,000 | $4,940 | $50,000 | $12,350 | 100 | 25 |
| Present Value | 25 | 0.233 | ----- | $20,000 | $20,000 | $4,660 | $50,000 | $11,650 | 100 | 23 |
| | Total | | $300,000 | $500,000 | $800,000 | $572,170 | $1,250,000 | $639,150 | 2,500 | 1,278 |

| | Costs | Benefits |
|---|---|---|
| Total Present Value (6%; 25 years) | $572,170 | $639,150 |
| Average Annual Equivalents (6%; 25 years; CRF = 0.0782) | $44,744 | $49,982 |
| Net Benefits = Total Discounted Benefits - Total Discounted Costs = | | $66,980 |
| Benefit/Cost Ratio = Total (or Annual) Discounted Benefits/Total (or Annual) Discounted Costs = | | 1.12 |
| Cost/AF = Total (or Annual) Discounted Costs/Total (or Annual) Discounted Deliveries = | | $448 |

# Risk and Uncertainty

Risk and uncertainty are intrinsic in water resources planning and design and are defined by the National Research Council as follows:

> "*Risk*" is generally understood to describe the probability that some undesirable event occurs, and is sometimes used to describe the combination of that probability and the corresponding consequence of the event. The Corps measures risk by the probability that a levee fails or that an ecosystem restoration project fails to meet a standard. The complement of risk is *reliability*; the probability that a system operates without failing. The term "*uncertainty"* should be used to describe situations without sureness, whether or not described by a probability distribution.[4]

All measured or estimated values in project planning and design are to various degrees inaccurate due to sampling, measurement, estimation, forecasting, and modeling errors. Invariably the "true" values are different from any single point values currently used in many planning studies. The federal *Economics and Environmental Principles and Guideline for Water and Related Land Resources Implementation Studies* requires that planners characterize, to the extent possible, the different degrees of risk and uncertainty inherent in water resources planning and to describe them clearly so decisions can be based on the best available information. The Corps is a leading proponent of "risk-based analysis," which attempts to analytically incorporate considerations of risk and uncertainty.

## Sources of Risk and Uncertainty

There are two key sources of uncertainty in a planning study—model specification and data collection and measurement. The first arises because of the incredibly complex physical, social, and economic conditions and the inability to specify models that accurately portray them. Even if these models could be accurately specified, there can be considerable uncertainty in the collection and measurement of data that describe these conditions. For example, consider the following variable uncertainties encountered in a typical flood damage reduction study:

> Economic variables in an urban situation may include, but are not necessarily limited to, depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times, and flood evacuation effectiveness. Other types of variables may be important for other types of projects. For example, in agricultural areas seasonality of flooding and cropping practices may be important. The uncertainty of these variables may be due to sampling, measurement, estimation, forecasting, and modeling errors. For hydrologic and hydraulic analysis, the principle variables are discharge and stage. Uncertainty in discharge exists because record lengths are often short or do not exist where needed, precipitation-runoff computation methods are inaccurate, and the effectiveness of flood flow regulation measures is not precisely known. Uncertainty factors that affect stage might include conveyance roughness, cross-section geometry, debris accumulation, ice effects, sediment transport, flow regime, bed form, and others. For geotechnical and structural analysis, the principle source of uncertainty is the structural performance of an existing levee.

[4] NRC, *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*, Chapter 3.

Uncertainty in structural performance occurs due to a levee's physical characteristics and construction quality. These, in turn, influence the Probable Non-failure (PNP) and Probable Failure Point (PFP) required in the reliability assessment of existing levees.[5]

### Accounting for Risk and Uncertainty

Although it is impossible to account for all sorts of uncertainty and risk in a planning study, there are techniques that can be used to acknowledge their existence and to assign some quantitative importance to them in the analysis. These techniques include direct enumeration, sensitivity analysis, probability analysis, game theory, and in some cases, stochastic simulation.

- Direct enumeration. With this technique, all possible outcomes are listed. While this would provide decision-makers an idea of the possible outcomes of an action, it doesn't provide any clue as to the probability of one event happening over another. Also, given the complex relationships that are involved in most water resource related studies, all possible outcomes are not likely to be known.
- Sensitivity analysis. In sensitivity analysis, the values of key variables can be varied to determine their effects upon the variables being analyzed. A good example of this would be to vary the discount rate used for computing the present worth of benefits and costs of a proposed project. If the different discount rates do not have a significant effect upon the results, the analyst may feel more comfortable with the results than otherwise. Although sensitivity analysis is relatively easy to do, it has numerous drawbacks: (a) it frequently assumes that the appropriate range of values is identified and that all values are equally likely to occur, (b) the results of the analysis are often reported as a single, most likely value that is considered as perfectly accurate.
- Probability analysis. Although it is recognized that the "true" values of planning and design variables and parameters are not known with certainty and can take on a range of values, it may be possible to describe a variable or parameter in terms of a probability distribution. For example, for a normally distributed variable or parameter, indicators such as mean and variance can be identified which would allow confidence intervals to be placed around point estimates. In other words, instead of saying the B/C ratio for a project is 1.20, we might be able to say that we are 90% confident that the B/C ratio exceeds the value of 1.15, which gives the decision-makers more information to consider.
- Stochastic simulation. This is also known as Monte Carlo simulation or model sampling. An example of this type of analysis is the Corps' software program, HEC- FDA (Flood Damage Assessment) that directly incorporates uncertainties into a flood damage analysis. For example, direct inputs into this program include frequency/discharge, stage/discharge and structural inventories for which stage/damage curves are determined within the program. FDA statistically assigns error bands around all of these relationships, and then through a Monte Carlo analysis, samples within the various relationships' error bands in order to determine expected annual damage. Although this program is still subject to the same fundamental sources of uncertainty (model specification and data collection/measurement), at least it explicitly attempts to incorporate uncertainty into the flood damage analysis.

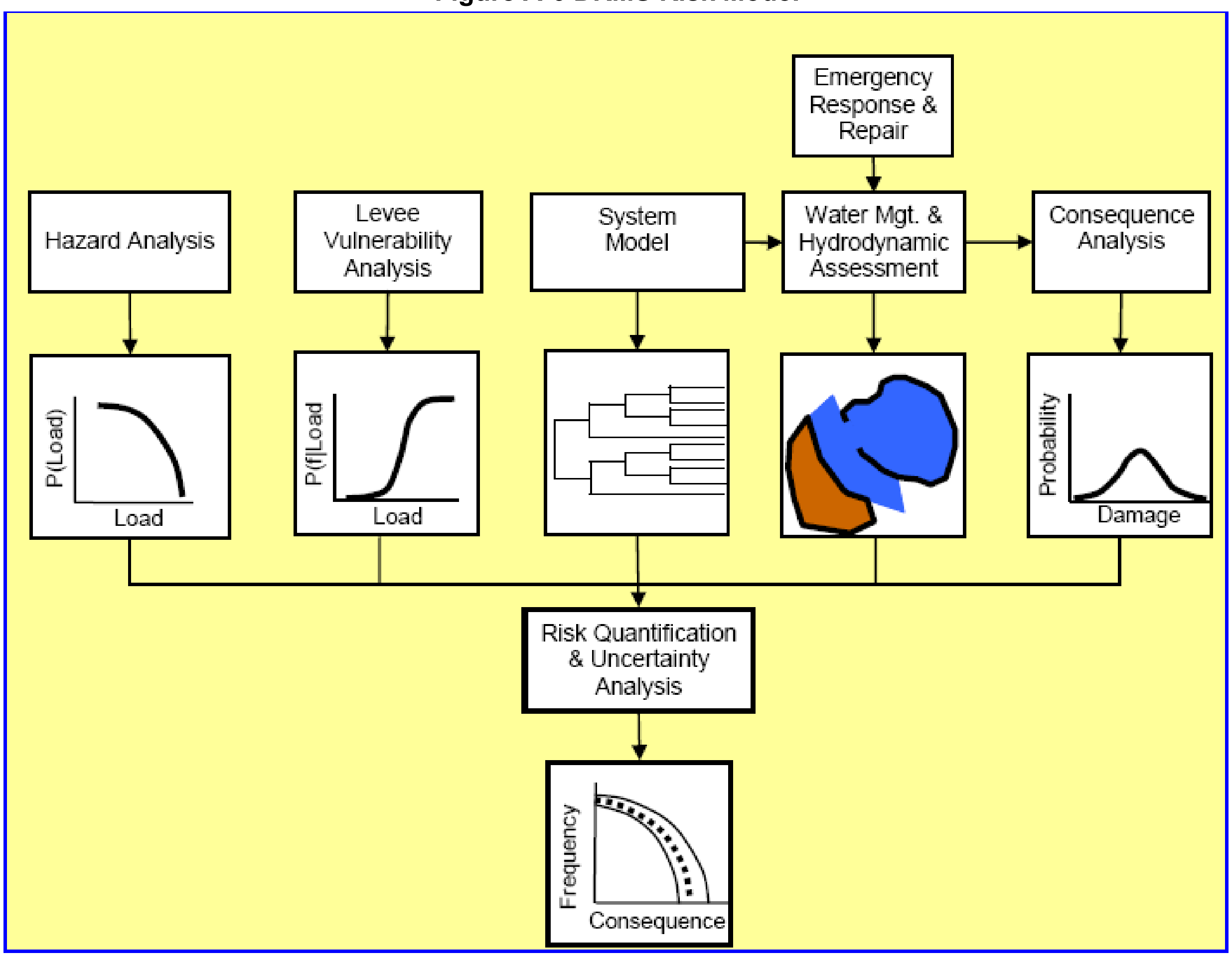
[5] USACE, Engineering Regulation 1105-2-101, *Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies*, March 1, 1996.

An excellent example of a risk-based analysis is the Delta Risk Management Strategy (DRMS) currently being conducted by DWR, the Corps and other agencies. Objectives of DRMS include:

- Evaluate the risk and consequences to the state (e.g., water export disruption and economic impact) and the Sacramento-San Joaquin Rivers Delta (e.g., levees, infrastructure, and ecosystem) associated with the failure of Delta levees and other assets considering their exposure to all hazards (seismic, flood, subsidence, seepage, sea level rise, etc.) under present as well as foreseeable future conditions. The evaluation shall assess the total risk as well as breaking the risk down for individual islands.
- Propose risk criteria for consideration of alternative risk management strategies and for use in management of the Delta and the implementation of risk-informed policies.
- Develop a DRMS, including a prioritized list of actions to reduce and manage the risks of consequences associated with Delta levee failure.

Figure A-6 illustrates the major components of the DRMS risk model. For more information on DRMS, visit the website at http://www.drms.water.ca.gov/.

**Figure A-6 DRMS Risk Model**



# Appendix B Example Analyses

## Contents



## Figures



## Tables

# Appendix B Example Analyses

## Economic Evaluation of Ecosystem Resources

Two recent federal/State/local studies (2004) incorporate both National Economic Development (NED) and National Ecosystem Restoration (NER) benefits—the Hamilton City Flood Damage Reduction and Ecosystem Restoration Study and the Colusa Basin Integrated Watershed Management Study. The Hamilton City study is being conducted by the US Army Corps of Engineers and the State Reclamation Board. It focuses upon improving flood protection for the Glenn County community of Hamilton City (and surrounding agricultural land) and restoring riparian habitat along the Sacramento River. The Colusa Basin Integrated Watershed Management Plan, being conducted by the Colusa Basin Drainage District, is evaluating alternative plans for improving flood protection for the City of Willows in western Glenn County along Interstate 5. Willows is subject to frequent flooding from three streams that flow east from the nearby coastal range mountains. This study is also evaluating various ecosystem restoration and watershed management measures. An interesting distinction between both of these studies is how the economic analysis is being conducted for the ecosystem measures. Corps guidance does not allow for monetary values to be placed on ecosystem benefits, thus it relies upon a cost-effectiveness/incremental cost analysis of proposed ecosystem measures in order to formulate combined NED/NER plans. In contrast, the Colusa Basin Study directly places monetary values on ecosystem restoration measures and incorporates these values into the net benefits analysis.

### Hamilton City Flood Damage Reduction and Ecosystem Restoration Study

In 2004, the Corps and State Reclamation Board completed the Hamilton City Flood Damage Reduction and Ecosystem Restoration feasibility study. [1] Hamilton City (2000 population of about 2,000) is along the west bank of the Sacramento River about 85 miles north of Sacramento. The community is protected by the privately owned "J" levee, which was built in 1914 very close to the river. The "J" levee does not meet any construction standards. Portions of Hamilton City flooded in 1974, and extensive flood fight efforts were necessary in 1983, 1986, 1995, 1997 and 1998. In addition to the flood problem, the native habitat and natural functioning of the Sacramento River have been altered by the construction of the "J" levee and the subsequent conversion of the floodplain to agricultural and rural development. The Corps conducted several single-purpose NED evaluations for Hamilton City focusing upon improving or rebuilding the "J" levee, but none were economically justified. Current expected annual flood structural and crop damage is estimated to be about $726,000 in the study area.

During the 2004 feasibility study, various flood damage reduction and ecosystem management measures were identified and screened using the Corps four basic planning criteria (completeness, effectiveness, efficiency, and acceptability).[2] Some measures were dropped, but others were retained for further analysis. Next, a primary project purpose was identified (ecosystem restoration) based upon the new Corps guidance (EC- 1105-2-4-4) for developing alternative combined NED/NER plans. [3] Although past studies focused upon only flood damage reduction, this area has significant opportunities for ecosystem

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[1] The Hamilton City final feasibility report may be viewed at http://www.spk.usace.army.mil/projects/civil/compstudy/hamilton.html. Appendix E: Economics describes the flood damage reduction analysis that was conducted for this project using HEC-FDA.

[2] These criteria are described in Chapter 2 for this report.

[3] EC 1105-2-404 : http://www.usace.army.mil/inet/usace-docs/eng-circulars/ec1105-2-404/toc.htm

restoration, especially if done in conjunction with a setback levee. Several stakeholders, including The Nature Conservancy (which owns significant acreage in the study area) and CALFED were very interested in pursuing ecosystem restoration. Further, based on previous flood damage reduction studies, it was considered unlikely that a single-purpose flood damage reduction project would be cost-effective, partially because of the low income and property values of the community.

Six alternative single-purpose ecosystem restoration alternative plans were formulated. They consisted of various setback levee alignments with habitat restoration on the waterside of the new levee. Some of these levee setbacks were close to the river (sometimes following the current alignment of the "J" levee), some were far from the river, and others were an intermediate distance from the river. Sometimes the levee setbacks differed depending upon if they were north of Dunning Slough (about mid-point along the Sacramento River in the study area) or south of Dunning Slough. The NER alternatives included:

- No Action
- Alternative 1 – Locally Developed Setback Levee (closest to the river; farthest from the community)
- Alternative 2 – Intermediate Setback Levee
- Alternative 3 – Ring Levee (farthest from the river; closest to the community)
- Alternative 4 – Locally Developed Setback Upstream of Dunning Slough, Intermediate Setback Levee Downstream of Dunning Slough
- Alternative 5 – Intermediate Setback Upstream of Dunning Slough, Locally Developed Setback Downstream of Dunning Slough
- Alternative 6 – Intermediate Setback Upstream of Highway 32, Locally Developed Downstream of Highway 32

Using the four planning criteria (including the cost-effectiveness and incremental cost analysis to determine a plan's efficiency), the most cost-effective single purpose NER plans were identified and grouped into the "final array" of NER plans: Alternatives 1, 5, and 6. An incremental cost analysis was performed for these three alternatives to determine "best buy" plans that provide the greatest increase in output (in this case, average annual habitat units or AAHUs) for the least cost increase and which has the lowest incremental costs per unit of output relative to other cost-effective plans. Alternatives 5 and 6 were identified as "best buy" plans. However, of these two plans, Alternative 6 produced AAHUs at an incremental cost of $4,900 per AAHU, compared to $7,300 per AAHU from Alternative 5. Thus, Alternative 6 was selected as the single-purpose NER plan. This plan consisted of an intermediate setback levee about 6.8 miles in length with a levee height approximately equal to the existing "J" levee (about 6 feet). This cost-effectiveness/incremental cost analysis was conducted using the Corps' IWR Plan software which is described in Chapter 6.

After the NER plan was identified, six alternative combined NER/NED plans were formulated that included both ecosystem restoration and flood damage reductions objectives. These six alternatives were essentially the same levee setback as the NER alternatives, except an additional 1.5 feet of levee height was included (bringing the total levee height to about 7.5 feet) to provide additional flood protection (NED) for the community. After an initial screening using the four Corps planning criteria (completeness, effectiveness, efficiency, and acceptability), only four of these plans were retained for further evaluation. The four combined alternatives produce flood damage reduction benefits (which can be monetized) and ecosystem restoration benefits (which can be quantified as AAHUs but were not monetized). The annual outputs of these four alternatives, plus their annual costs, are summarized in Table B-1.

**Table B-1 Hamilton City trade-off analysis combined NER/NED alternatives**

| Combined alternative | Annual flood damage reduction benefits | Average annual habitat units gained | Total annual cost |
|---|---|---|---|
| 1 | $576,000 | $783 | $2,606,000 |
| 4 | $536,000 | $642 | $2,541,000 |
| 5 | $568,000 | $937 | $3,048,000 |
| 6 | $577,000 | $888 | $2,687,000 |

These remaining four combined plans were evaluated and compared using a trade-off analysis, which allows for a comparison of plans that produce both monetary and non-monetary outputs. Although there are different methods for performing trade-off analyses[4], the "percentage of maximum" method was used by the Hamilton City study team. The criteria measurements used for the trade-off analysis included flood damage reduction benefits (monetized), average annual costs (monetized), and AAHUs gained by the plan (non-monetary). Because ecosystem restoration and flood damage reduction are equally important to stakeholders in the study area, the study team used an intermediate set of weighting factors to give equal weight to environmental and economic factors: 0.50 monetary (includes flood damage reduction and costs) and 0.50 non-monetary (environmental). Within the monetary category, a 0.42 factor was given to average annual total costs and 0.08 to flood damage reduction benefits. The rationale for the 0.42/0.08 split in the monetary category was to make a dollar of flood damage reduction benefits equal in weight to a dollar of costs. Thus, the "normalized" units of cost must be given a weight that is 5.3 times as much as the weight given to the normalized units of flood damage reduction benefits, because the maximum annual costs ($3,048,000) represented by one normalized unit of cost is 5.3 times as much as the maximum annual flood damage reduction benefit ($577,000) represented by one normalized unit of flood damage reduction benefit. Because of this normalization process, this subjective weighting implies that the maximum ecosystem restoration benefit (937 AAHUs) is equally as valuable as the sum of the maximum monetary annual flood damage reduction benefit ($577,000) and the maximum total annual costs ($3,048,000).

[4] See Corps IWR Report 02-R-2, "Trade-Off Analysis Planning and Procedures Guidebook", April 2002.

Table B-2 shows the resulting decision matrix combining "proportion of maximum values" along with the weighting factors. The column values show the percent of maximum value of each alternative compared to the maximum value for that column. For example, the 0.9844 value of flood damage reduction for Combined Alternative 5 means that the benefit value for this alternative ($568,000) is 98.44% of the maximum flood damage reduction value for all of the combined alternatives being compared ($577,000). A 1.00 values means that the benefit value for this combined alternative is the maximum value for all of the alternatives. The last row shows the weighting factor assigned to each benefit type. The weighted product column shows the results of multiplying each proportion of maximum value by the weighting factor, and then summing for all benefits. For example, the weighted product for Combined Alternative 6 was determined by multiplying 1.00 times 0.08, 0.9477 by 0.50, and -0.8816 by 0.42, and then adding these products together for the weighted product (0.1836). These weighted products can then be directly compared with each other, with the higher scores representing the most effective combined alternatives. In this case, Combined Alternative 6 has the highest score of 0.1836.

**Table B-2 Decision matrix normalized by proportion of maximum method with assigned weighted factors**

| Alternative | Ecosystem restoration | Flood damage reduction benefits | Total annual cost | Sum of weighted products | Ranking |
|---|---|---|---|---|---|
| 1 | [783]<br>0.8356 | [$576,000]<br>0.9983 | [$2,606,000]<br>-0.8550 | 0.1386 | 3 |
| 4 | [642]<br>0.6852 | [$536,000]<br>0.9289 | [$2,541,000]<br>-0.8337 | 0.0668 | 4 |
| 5 | [937]<br>1.0000 | [$568,000]<br>0.9844 | [$3,048,000]<br>-1.0000 | 0.1588 | 2 |
| 6 | [888]<br>0.9477 | [$577,000]<br>1.0000 | [$2,687,000]<br>-0.8816 | 0.1836 | 1 |
| Weighting factor | 0.50 | 0.08 | 0.42 | ----- | ----- |

Note—actual amounts shown in brackets [ ].

It was recognized that different weighting factors might affect the results. Thus, a sensitivity analysis was conducted to test the effect if different weighting factors were used. The results of this sensitivity analysis are shown in Table B-3. In most cases, Combined Alternative 6 still ranked first, although in a couple of cases, Combined Alternatives 1 and 5 also ranked first. Thus, Combined Alternatives 1, 5, and 6 were selected as potential "final array" of combined alternative plans that would be subjected to a final incremental cost analysis. However, unlike Combined Alternatives 5 and 6, Combined Alternative 1 was not identified as a "best buy" plan in previous screenings, thus it was dropped from further consideration. An incremental analysis of Combined Alternatives 5 and 6 was performed considering ecosystem restoration benefits and "remaining costs" (total costs minus flood damage reduction benefits). Based on this incremental cost analysis, Combined Alternative 6 produces more output at less cost than Combined Alternative 5 ($7,550 vs. $2,380/AAHU). The results of this incremental costs analysis are shown in Table B-4.

**Table B-3 Weighting factor sensitivity analysis**

| Weighting factors | | | |
|---|---|---|---|
| FDR benefits | AAHUs gained | Total costs | Ranking |
| 0.14 | 0.10 | 0.76 | 1,4,6,5 |
| 0.13 | 0.20 | 0.67 | 6,1,4,5 |
| 0.11 | 0.30 | 0.59 | 6,1,5,4 |
| 0.10 | 0.40 | 0.50 | 6,1,5,4 |
| 0.08 | 0.50 | 0.42 | 6,5,1,4 |
| 0.06 | 0.60 | 0.34 | 6,5,1,4 |
| 0.05 | 0.70 | 0.25 | 5,6,1,4 |
| 0.03 | 0.80 | 0.17 | 6,5,1,4 |
| 0.02 | 0.90 | 0.08 | 6,5,1,4 |

FDR = flood damage reduction

**Table B-4 Incremental cost analysis of 'best buy' plans**

| Alternative | Average annual habitat units | Incremental output (AAHUs) | Remaining costs | Incremental cost | Incremental cost/unit output (AAHUs) |
|---|---|---|---|---|---|
| Combined Alternative 5 | 937 | 49 | $2,480,000 | $370,000 | $7,550 |
| Combined Alternative 6 | 888 | 888 | $2,110,000 | $2,110,000 | $2,380 |

The final step in selecting the recommended plan is to compare Combined Alternative 6 with the single-purpose NER plan discussed above. Using the data presented in Table B-5, Combined Alternative 6 produces $153,000 more annual flood damage reduction benefits and the same AAHUs as the NER plan. However, Combined Alternative 6 costs only $67,000 more than the NER plan, thus the additional benefits of Combined Alternative 6 exceed the additional costs of this plan. Combined Alternative 6 thus is the recommended plan.[5] This combined plan consists of a setback levee about 6.8 miles in length and a restored riparian habitat area of about 1,500 acres in an area currently devoted to agricultural uses (Figure B-1). The height of the levee was increased up to 1.5 feet higher than the existing "J" levees to achieve additional flood damage reduction benefits. The estimated total project first cost of this combined plan is about $45 million.

**Table B-5 Comparison of Combined Alternative 6 and single purpose NER plan**

| Alternative | AAHUs | Annual flood damage reduction benefits | Annual total cost |
|---|---|---|---|
| Single purpose NER plan | 888 | $424,000 | $2,620,000 |
| Combined Alternative 6 | 888 | $577,000 | $2,687,000 |
| Difference | 0 | + $153,000 | + $67,000 |

The identification of a recommended plan is very significant because the Corps had been unable to justify a single-purpose NED (flood damage reduction) plan in several previous analyses. This plan was justified because two purposes (NED and NER) were included. However, a critical question concerns cost allocation—How much of the total costs of the plan should be allocated to the ecosystem restoration vs. flood damage reduction objectives? After the cost allocation process, approximately 90% of the total costs were assigned to ecosystem restoration, with the remainder to flood damage reduction. Based upon the costs allocated to flood damage reduction resulting from the increased levee height, the NED benefit/cost ratio for this project purpose is about 1.8. Because this combined plan is cost-effective, it was recommended for implementation rather than the single-purpose NER plan.[6]

Figure B-2 summarizes the Hamilton City plan formulation process.

[5] Technically, this recommended plan is not the federal NED/NER plan because it is not the fully optimized plan (that is, other plans could provide additional NED and/or NER benefits). However, because of cost and "level of protection" issues, this plan is acceptable to the local sponsors, so it technically is called the "locally preferred plan."
[6] The cost allocation process for this recommended plan is also included in Appendix A.

**Figure B-1 Hamilton City recommended combined NED/NER plan**

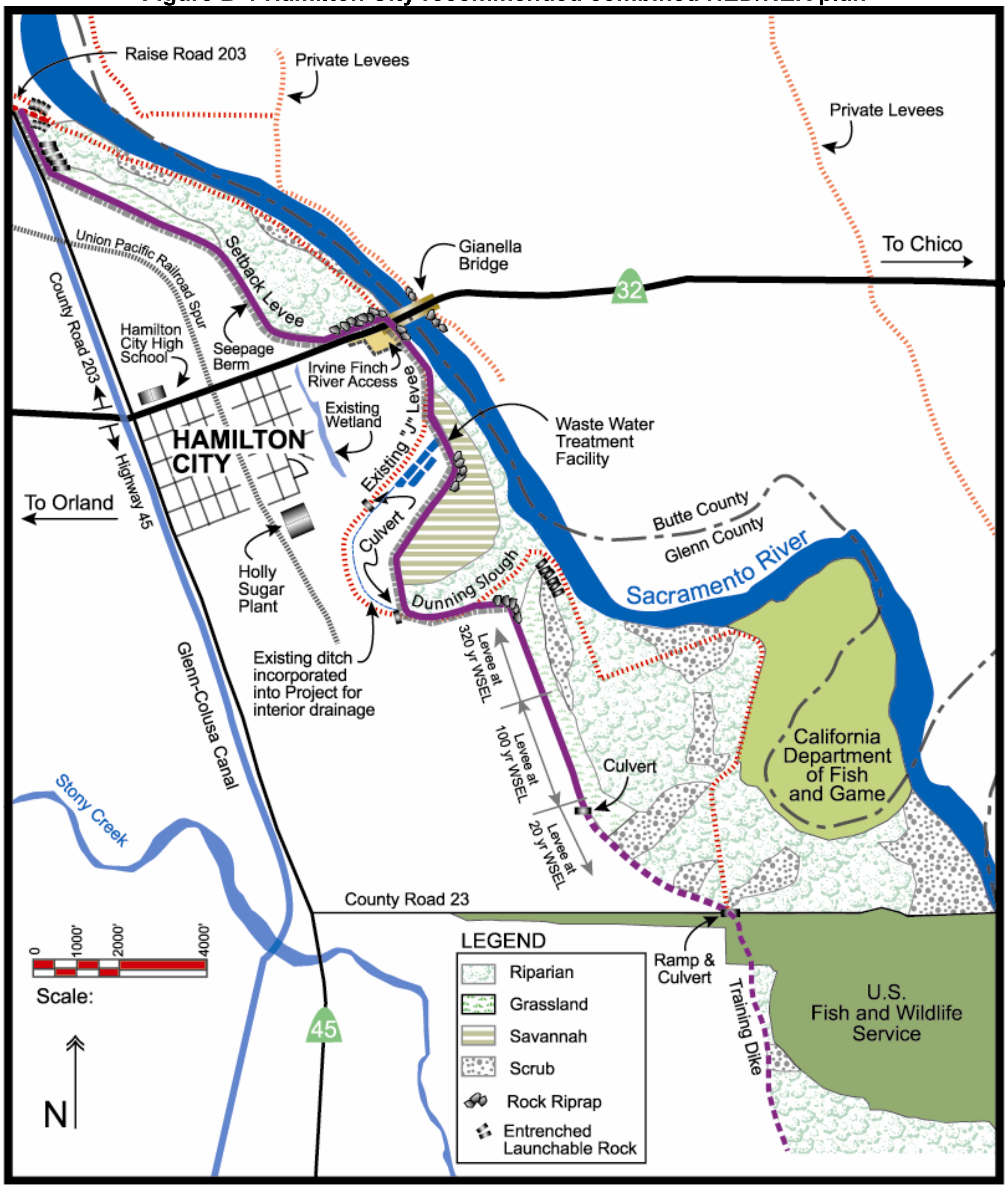
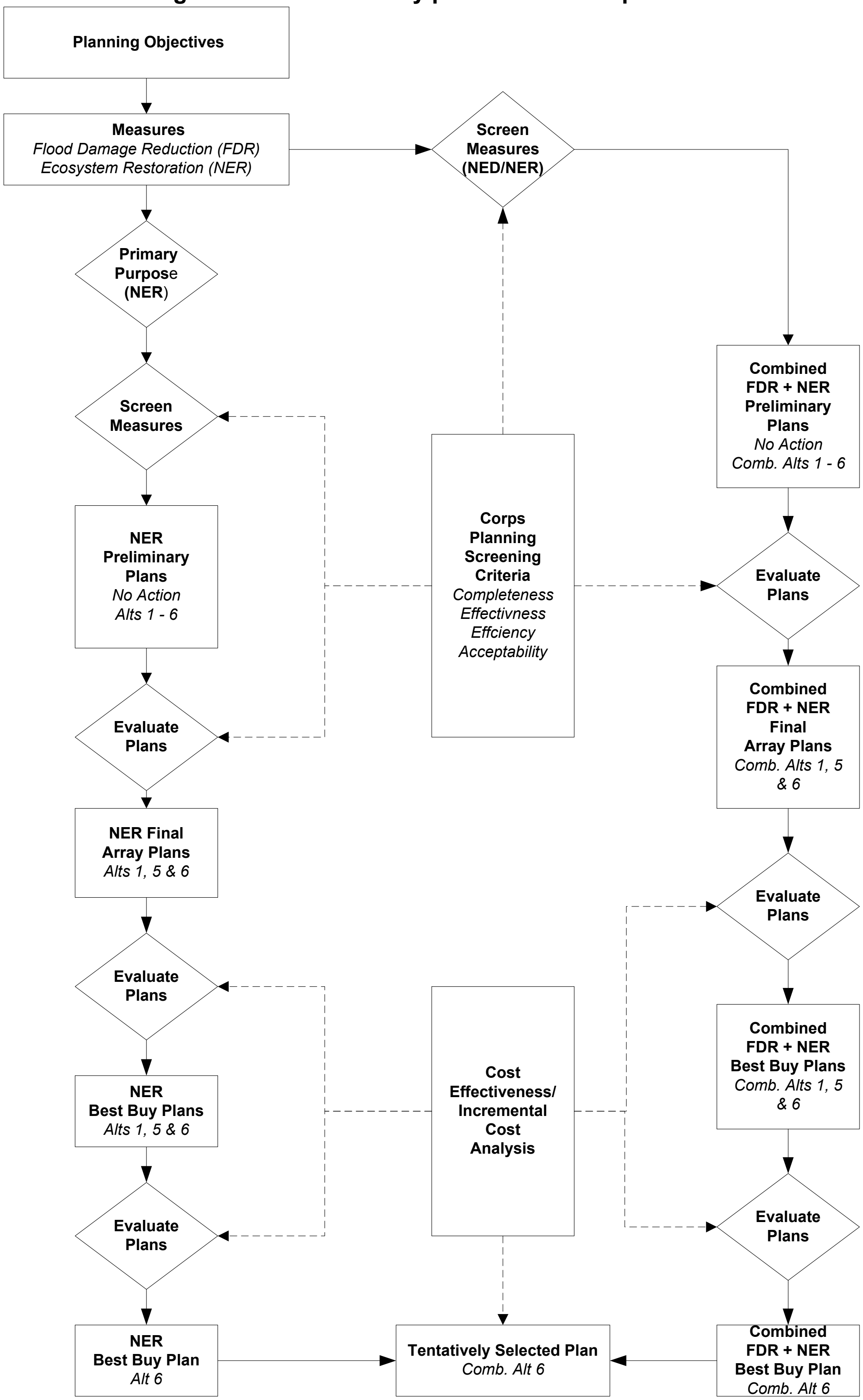


**Figure B-2 Hamilton City plan formulation process**



### Colusa Basin Integrated Watershed Management Study

This study area includes the city of Willows (2000 population of 6,220) and the surrounding rural area in western Glenn County. Surrounding land use is agricultural, primarily in field crops such as rice, sunflower, alfalfa, wheat, and corn. The principal sources of flooding in the study area are the creeks that flow east from the coastal foothills toward the valley floor. From the north to the south, these include Walker Creek, Wilson Creek, and South Fork Willow Creek. Flooding from these creeks occurs frequently and is relatively shallow. Northeast of Willows the creeks nearly converge just prior to crossing underneath Interstate 5, Highway 99W, and the Southern Pacific rail line. Although the creek channels do not physically merge, flood waters from them merge and forms ponds just to the west of Interstate 5 and Highway 99W. Although some of the creeks have unofficial “spot levees” in a few locations, there is no consistent levee system. Without project (existing conditions), equivalent annual damage is estimated to be about $6.5 million to structures and crops in the study area. The study area, which was limited to the 100-year (1% chance) floodplain, is shown in Figure B-3.

Seven plans were analyzed that combined various structural and non-structural flood management measures: no-action plan, non-structural plan (range and woodland management measures), detention basins-only plan (basins on South Fork Willow and Wilson Creeks), structural plan (detention basins plus rice field spreading basins and stream restoration), combined plan (includes measures from the structural and non-structural plans), ring levee plan (for northeast Willows) and floodplain management plan (residential structure raises). Of all of these plans, the one that produced the greatest damage reduction (about $2.5 million) was the ring levee plan. The reason the ring levee resulted in greater flood damage reduction compared to the detention basins is that the levee "removes" a large number of structures from the 100-year (and more frequent) floodplains, whereas the detention basins only reduce the depth and slightly reduce the extent of the floodplains, but do not completely “remove” a large number of structures from frequent flood impacts. However, the ring levee plan may also result in negative hydraulic impacts across and downstream. If these hydraulic impacts were to occur, then mitigation costs would have to be included for this plan.

**Figure B-3 Colusa Basin Study Area (100-year floodplain)**

Another element being considered is environmental enhancement within the watershed. Where possible, the flood management measures include environmental enhancements such as designing the detention basins to include seasonal wetlands and augmenting the rice field spreading basins with riparian habitat. However, stand alone environmental enhancements are also proposed. While the stand alone measures do not control flooding directly, they can over time increase the ability of the soil to retain water, decrease the velocity of runoff, and provide seasonal flooding for wetlands. The environmental enhancements assumed in the analysis were approximately 3,000 acres, assuming 75% (2,250 acres) would be wetlands and 25% (750 acres) would be riparian. It was also assumed that the habitat associated with environmental enhancements would be maintained comparable to the habitat at a conservation bank and that the acreages would be accessible for recreation.

Unlike the Hamilton City analysis, this study attempts to directly monetize the environmental benefits. Two types of environmental benefits were identified—habitat services and recreation. Examples of habitat services are improved water quality, biodiversity, threatened and endangered species habitat, and carbon sequestration (Table B-6) provides a complete list of the habitat services provided by the various proposed environmental enhancements. Although the value of some of the habitat services could be quantified in monetary terms, it requires data not readily available and as such was beyond the scope and resources available for this study. Thus, an "imputed willingness to pay" method was used, which assumes that the value of the proposed habitat is at least equal to the costs incurred by others to produce similar types of habitat in the project area.

Using this method, both lower and upper bound environmental benefit values were estimated. The lower bound estimates were based on either (1) actual expenditures to create similar types of habitat in the nearby Natomas Basin or (2), where similar projects could not be found, the actual costs of the proposed restoration projects.[7] The lower bound habitat values were based on two primary sources of data. The first was the range of actual and estimated wetlands/riparian construction and operations and maintenance costs from wetlands projects implemented by Wildlands Inc. in the nearby Natomas Basin. These projects included the construction of wetlands and riparian habitats from existing land uses (rice fields and creek riparian areas), which are similar to the proposed Colusa Basin projects. Where similar projects could not be found, the second data source was engineering cost estimates developed for this project by CH2M HILL.

[7] Which assumes, of course, that the project's benefits equal its costs.

**Table B-6 Description of environmental benefits (habitat services and recreation)**

| Habitat services | Description |
|---|---|
| Improved aesthetics from managed grazing | Increased plant diversity and vegetation structure from grazing management will improve aesthetic character. |
| Improved aesthetics from floodplain restoration | Creation of a complex of riparian and wetland will enhance the aesthetic character of the streams |
| **Water quality** | |
| Reduced sediment | Reduced sediment loads in streams improves habitat for many aquatic species, such as anadromous salmonids. |
| Nitrogen removal | High nitrogen levels encourage algal blooms that can deplete oxygen to the detriment of aquatic species. Thus, removal of nitrogen from water improves habitat quality. |
| Temperature | Provision of cool water temperature improves survival and reproductive success of anadromous salmonids. |
| Increased groundwater recharge | Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs. |
| Local aquifer recharge | Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs. |
| Erosion control/soil productivity | Erosion control benefits aquatic organisms by minimizing sediment input to streams. Soil productivity is improved by retention of topsoil. |
| Biodiversity | Creation and provision of native habitats such as wetland, riparian and oak woodland habitats will contribute to increasing and maintaining native wildlife species. Habitat diversity provided by these habitats will contribute to maintaining a diversity of wildlife species. |
| Special Status Species habitat | Provision of riparian, wetland and oak woodland habitats will contribute to maintaining populations of special-status species. |
| Fall-run Chinook[2] | Improved habitat quality will enhance survival of fall-run Chinook salmon |
| **Endangered Species Benefit** | |
| Giant Garter Snake (GGS) | Creation of wetland habitat will increase habitat for giant garter snakes may contribute to increasing the population size and distribution of this species. |
| Valley Elderberry Longhorn Beetle (VELB) | Planting elderberry shrubs will increase habitat for the valley elderberry longhorn beetle and may contribute to increasing the population size and distribution of this species. |
| Winter-run Chinook[2] | Improved habitat quality will enhance survival of winter-run Chinook salmon. |
| Steelhead[2] | Improved habitat quality will enhance survival of steelhead. |
| Carbon sequestration | Carbon dioxide is a greenhouse gas. By using carbon dioxide, plants remove this greenhouse gas from the atmosphere. |
| Improved forage production (Animal Units) | Increased plant biomass and nutrient content in pastures provides better quality forage for livestock. |

*Table B-6 continued on next page*

| Habitat services | Description |
|---|---|
| *Continued: Table B-6 Description of environmental benefits (habitat services and recreation)* | |
| Downstream water quality benefits[1] | Reduced nutrient and sediment input can improve aquatic habitat quality in downstream reaches. See water quality above |
| Complements NWRs and WAs | Creation of wetland and riparian habitat adjacent to refuges enhances the habitat value of the refuges by providing a larger contiguous area of habitat. |
| **Recreation** | |
| Deer hunting | Maintenance of open space and improving habitat quality can provide opportunities for deer hunting. |
| Duck/waterfowl hunting | Created wetlands can be managed to attract waterfowl and support hunting. |
| Fishing | Improved aquatic habitat quality could increase sport fish populations and enhance fishing. |
| Bird-watching | Wetlands and riparian habitat in particularly will attract birds and become favorable for bird watching. |
| Wildlife viewing | Increased habitat quality, quantity and diversity could contribute to increased wildlife populations and diversity and be favorable for wildlife viewing. |
| Walking/hiking | Maintenance of open space and creation of aesthetically pleasing natural areas will be attractive as walking/hiking areas. |
| . | |

1. Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.
2. Assumes the enhancement is adjacent to an anadromous stream

However, actual expenditures may not fully capture an agency's willingness to pay for habitat services. Thus, an upper benefit bound was estimated based upon *market prices* paid for habitat services through a habitat conservation bank in the region. The upper bound habitat benefit values were based on Sheridan Bank May 2004 credit prices. The specific prices were $50,000 for a wetland one acre credit[8] and $58,000 to $65,000 for a riparian one acre credit.

Although recreation benefits were estimated for this study, they were ultimately not included in the benefit/cost analysis because it is uncertain which activities would be compatible with the environmental enhancements. Thus, the environmental benefits would increase if recreation benefits were included. The range of habitat and recreation values is summarized in Table B-7.

Six benefit and cost scenarios were formulated using low, average, and high benefits paired with low costs and high costs.[9] The low benefits and high cost scenario is considered the most conservative

[8] A credit is assumed to be one acre in this analysis.
[9] This sensitivity analysis was done only for environmental benefits. Flood damage reduction benefits were not subject to a sensitivity analysis, although they were computed using the Corps' HEC-FDA, which incorporates "risk and uncertainty" in the analysis as described in Chapter 6.

estimate of the benefit/cost ratio. Likewise, the high benefits and low cost ratio would be the least conservative. All benefits and costs are expressed in July 2004 dollars and streams of benefits and costs were discounted by the fiscal year 2004 federal discount rate of 5-5/8%. Table B-8 summarizes the ratios for each alternative and flood management measures. As of November 2004, the Colusa Basin Drainage District Board had not yet decided on a preferred alternative.

**Table B-7 Range of habitat and recreation values summarized by alternative flood management measures**

| Flood Management Measure | Environmental benefits (in July 2004 $) | | | | | |
|---|---|---|---|---|---|---|
| | Habitat ($/acre) | | | Recreation ($/visitor day) | | |
| | Lower Bound (a) | Average (c) | Upper Bound (b) | Lower Bound (d) | Average (c) | Upper Bound (d) |
| S. Fork Willow Detention Basin | | | | | | |
| Habitat | 8,555 | 29,278 | 50,000 | | | |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Bird Watching | | | | na | 33 | na |
| Walking/Hiking | | | | 2 | 44 | 264 |
| Wilson Creek Detention Basin | | | | | | |
| Habitat | 8,097 | 29,049 | 50,000 | | | |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Bird Watching | | | | na | 33 | na |
| Walking/Hiking | | | | 2 | 44 | 264 |
| Rice Field Spreading Basins | | | | | | |
| Habitat | 11,751 | 16,032 | 20,313 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Stream Restoration Upper Watershed | | | | | | |
| Habitat | 74,109 | 79,814 | 85,519 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Stream Restoration Valley Floor | | | | | | |
| Habitat | 69,978 | 76,362 | 82,745 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Ring Levee | | | | | | |
| Habitat | 0 | 0 | 0 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Rangeland Management | | | | | | |
| Habitat | 170 | 374 | 577 | | | |
| Recreation | | | | 0 | 0 | 0 |
| | | | | *Table B-7 continued on next page* | | |

*Continued: Table B-7 Range of habitat and recreation values summarized by alternative flood management measures*

| Flood Management Measure | Environmental benefits (in July 2004 $) | | | | | |
|---|---|---|---|---|---|---|
| | Habitat ($/acre) | | | Recreation ($/visitor day) | | |
| | Lower Bound (a) | Average (c) | Upper Bound (b) | Lower Bound (d) | Average (c) | Upper Bound (d) |
| Reforestation | | | | | | |
| Habitat | 13,657 | 20,239 | 26,821 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Floodplain Management | | | | | | |
| Habitat | 0 | 0 | 0 | | | |
| Recreation | | | | 0 | 0 | 0 |
| Environmental Enhancements | | | | | | |
| Habitat | 9,797 | 29,899 | 50,000 | | | |
| Duck Hunting | | | | 3 | 38 | 173 |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Walking/Hiking | | | | 2 | 44 | 264 |

Notes:
na = not available
shaded = not applicable
(a) The lower bound estimates of habitat benefits are based upon actual expenditures in the Natomas Basin for wetland project costs. These projects are assumed to be representative of habitats associated with the detention basins, the rice field spreading basins, and environmental enhancements. The benefit estimates for the stream restorations (upper watershed and valley), rangeland management, and reforestation measures are assumed to be equal to the costs of creating habitat for those measures. The Ring Levee and Floodplain Management measures are assumed not to have any habitat benefits.
(b) The upper bound estimates of habitat benefits for the detention basins, rice field spreading basins, and environmental enhancements are based on the Wildlands, Inc., Sheridan conservation bank credit price for wetlands. The cost estimates for the stream restorations (upper watershed and valley), rangeland management, and reforestation measures are based on the least cost alternative estimates (O&M varies). The Ring Levee and Floodplain Management measures are assumed not to have any habitat benefits.
(c) The average estimates are the average of the lower and upper bounds.
(d) The lower and upper bound estimates of recreation benefits are from the recreation and natural resource economics literature. See the benefit/cost analysis technical memorandum for citations.

**Table B-8 Summary of benefit/cost ratios Colusa Basin Drainage District Integrated Watershed Management Study**

| Alternative Plans | High Cost Scenario [d] | | | Low Cost Scenario [e] | | |
|---|---|---|---|---|---|---|
| | Low benefits | Avg benefits | High benefits | Low benefits | Avg benefits | High benefits |
| **Flood Management and Environmental Restoration Plans** | | | | | | |
| Ring Levee + Environmental Enhancement Acreage [a] | 1.34 | 2.46 | 3.58 | 2.43 | 4.46 | 6.49 |
| Floodplain Management + Environmental Enhancement Acreage [a] | 1.08 | 2.17 | 3.28 | 1.87 | 3.82 | 5.78 |
| Detention Basins Only + Environmental Enhancement Acreage [a] | 0.74 | 1.48 | 2.27 | 1.18 | 2.37 | 3.62 |
| Structural (w/o ring levee) + Environmental Enhancement Acreage [a] | 0.74 | 1.21 | 1.69 | 0.98 | 1.61 | 2.26 |
| Non-Structural (w/o floodplain management) + Environmental Enhancements Acreage [a] | 0.91 | 1.22 | 1.53 | 1.07 | 1.69 | 2.32 |
| Combined (w/o ring levee and floodplain management) + Environmental Enhancement Acreage [a] | 0.89 | 1.11 | 1.34 | 1.00 | 1.38 | 1.75 |
| **Flood Management Plans** | | | | | | |
| Ring Levee [b] | 10.91 | 10.91 | 10.91 | 13.10 | 13.10 | 13.10 |
| Floodplain Management [c] | 6.36 | 6.36 | 6.36 | 6.36 | 6.36 | 6.36 |
| Environmental Enhancement Acreage | 0.59 | 1.79 | 3.00 | 1.11 | 3.39 | 5.68 |
| Non-Structural (w/o floodplain management) | 1.02 | 1.02 | 1.02 | 1.05 | 1.05 | 1.05 |
| Detention Basins | 0.96 | 1.01 | 1.16 | 1.24 | 1.30 | 1.49 |
| Combined (w/o ring levee and floodplain management) | 0.95 | 0.96 | 0.98 | 0.98 | 1.00 | 1.03 |
| Structural (w/o ring levee) | 0.84 | 0.86 | 0.91 | 0.93 | 0.97 | 1.02 |

Notes:

a. Environmental enhancement acreage assumes 3,000 acres of land is managed to maximize habitat (assuming same quality of habitat as a mitigation bank); access for public viewing and/or hunting was not assumed, but would increase the assumed benefit.

b. The ring levee B/C ratio changes across cost scenarios only, because the estimated avoided flood damage remains the same in all 6 scenarios.

c. The floodplain management B/C ratio does not change because the avoided flood damages were only estimated for 67% participation and a range of cost levels was not estimated. Costs are based on FEMA estimates. (A structure raising project in Tehama County is currently seeing costs 5 to 6 times its FEMA estimate because older structures needed to be brought up to current construction codes. Therefore, costs for this measure could be understated, depending on the age and condition of the structures that would be raised.)

d. High costs represent a 10% increase on capital and O&M costs estimated for structural flood control measures; and the upper end of capital and O&M estimates developed for the non-structural measures and environmental enhancement acreage.

e. Low costs represent a 10% decrease on capital and O&M costs estimated for structural flood control measures; and the lower end of capital and O&M estimates developed for the non-structural measures and environmental enhancement acreage.

# Cost Allocation and Cost Sharing

Multiple purpose projects are cost shared among federal and non-federal sponsors in accordance with cost sharing principles applicable to each project purpose. For flood damage reduction and ecosystem restoration, this cost share is 35% federal and 65% non-federal sponsors. However, before determining the project's required cost sharing, an allocation of total project costs to each purpose must be accomplished. The Hamilton City Flood Damage Reduction and Ecosystem Restoration Study provides a good example of cost allocation among project purposes as well as cost sharing among federal and non-federal (state and local) sponsors[10]. This study recommends a combined flood damage reduction and ecosystem combined plan (Combined Alternative 6) which consists of a setback levee about 6.8 miles in length and a restored riparian habitat area of about 1,500 acres from existing agricultural uses (see Table B-1 Hamilton City trade-off analysis combined NER/NED alternatives). The height of a new replacement levee to be built as part of the ecosystem restoration component is equal to the existing "J" levee, or about 6 feet; plus an additional 1.5 feet to achieve additional flood damage reduction benefits. The estimated total project first cost of this combined plan is about $45 million. Previous Corps attempts to justify a single-purpose flood damage reduction project were unsuccessful because of inadequate benefit/cost ratios.

## Cost Allocation

Total project first (construction) costs are estimated to be about $45 million for the recommended combined plan. Table B-9 shows the estimated project first (capital) costs by the primary project features. Table B-10 shows the preliminary separable cost-remaining benefit (SCRB) cost allocation between the flood damage reduction and ecosystem restoration objectives for the recommended plan. Separable costs were assigned to their respective project purposes, and all joint costs were allocated to the purposes for which the project was formulated.

**Separable costs.** Separable ecosystem restoration costs would be incurred for the following activities: removal of the existing "J" levee, habitat restoration, and land purchase (1,500 acres). Separable flood damage reduction costs would be incurred for the additional levee height (1.5 feet) and additional rock costs associated with the increase in levee height.

**Table B-9 Estimated first costs of recommended plan**

| Cost category | Total first cost (in $1,000) |
|---|---|
| Land and damages | 13,347 |
| Relocation | 563 |
| Fish and wildlife | 24,540 |
| Levees | 921 |
| Cultural resources | 170 |
| Planning, engineering, and design | 3,123 |
| Construction management | 2,212 |
| Total first cost | 44,876 |
| Annualized first cost 1 | 2,687 |

1. 50-year analysis period; 5 5/8% discount rate.

[10] The Hamilton City final feasibility report may be viewed at http://www.compstudy.net/hamilton.html.

**Table B-10 Preliminary cost allocation using SCRB Method (October 2003 price levels)**

| | | | Annual costs (in $1,000) |
|---|---|---|---|
| Total project annual first cost (a+b+c) | | | 2,687 |
| (a) Flood damage reduction (FDR) separable costs | | | 67 |
| (b) Ecosystem restoration (ER) separable costs | | | 1,797 |
| (c) Joint costs | | | 823 |
| | Annual costs and benefits (in $1,000) | | |
| | FDR | ER | Total |
| (d) Average annual benefits | 577 | 888 AAHUs | |
| (e) Least cost single purpose alternative plan | 922 (Alt 1) | 3,521 (Alt 3) | |
| (f) Limited benefits (lesser of d and e) | 577 | 3,521 | |
| (g) Separable costs (a and b) | 67 | 1,797 | |
| (h) Remaining benefits (f - g) | 510 | 1,724 | 2,234 |
| (i) Percentage of remaining benefits | 23% | 77% | |
| (j) Allocated joint costs (c x h) | 189 | 634 | 823 |
| (k) Total allocated costs (I + a and i+b) | 256 | 2,431 | 2,687 |

**Joint costs.** The setback levee, up to the 6 foot height, would be required for either ecosystem restoration or flood damage reduction. Setback levee costs include mobilization/demobilization, clearing and grubbing, levee material, the road crown, hydro seeding, fencing' construction of a seepage berm, entrenched rock protection, and the relocation of various utilities, irrigation ditches and roads. To allocate joint costs, a "least cost alternative" must be identified for each project purpose that produces the same amount of benefits as the recommended plan. For ecosystem restoration, a least cost alternative must produce the same level of non-monetary output as would be provided by the multipurpose project; be cost effective when compared to other single-purpose plans (but not necessarily more cost-effective than the multipurpose plan); and be a dissimilar project. One of the single-purpose NER plans (Alternative 3) was identified as the "least cost alternative" for ecosystem restoration. A variation of Alternative 1 was identified as the least cost flood damage reduction plan. Using this procedure, about 23% of *joint costs* were allocated to flood damage reduction, and about 77% were allocated to ecosystem restoration. However, only about 10% of *total costs* were allocated to flood damage reduction, and 90% were allocated to ecosystem restoration. This cost allocation favorably affected the flood damage reduction benefit/cost ratio discussed below.

Table B-11 presents the economic costs and benefits for the recommended plan. The flood damage reduction purpose is justified because the benefit/cost ratio (1.8) is greater than one, and as shown above, this plan provides the most cost-effective level of ecosystem output (888 AAHUs). Thus, using this analysis for a combined flood damage reduction and ecosystem restoration project, a project is economically justified, whereas a single-purpose flood damage reduction project could not be justified.

**Table B-11 Economic costs and benefits of recommended plan (in $1,000; October 2003 price levels)**

| | Flood damage reduction | | Ecosystem restoration | | Total | |
|---|---|---|---|---|---|---|
| Benefit and cost category | Allocated costs | Benefits | Allocated costs | Benefits | Allocated costs | Benefits |
| Investment costs | | | | | | |
| First cost | $4,260 | | $40,446 | | $44,706 | |
| Interest during construction | $271 | | $3,066 | | $3,337 | |
| Total | $4,531 | | $43,512 | | $48,043 | |
| Annual cost | | | | | | |
| Interest and amortization[1] | $272 | | $2,615 | | $2,887 | |
| OMRR&R[2] | $47 | | $8 | | $55 | |
| Total | $319 | | $2,623 | | $2,942 | |
| Annual benefits | | | | | | |
| Monetary (FDR) | | $577 | | | | $577 |
| Non-monetary (Ecosystem) | | | | 888 AAHUs | | 888 AAHUs |
| Net annual FDR benefits | | $258 | | | | $258 |
| FDR benefit/cost ratio | | 1.8 | | | | 1.8 |

1. Amortized over a 50-year analysis period with a 5 5/8% discount rate; includes interest payments.
2. Operation, maintenance, repair, replacement, and rehabilitation
FDR = flood damage reduction

### *Cost Sharing*

Table B-12 presents the cost-sharing responsibilities for the federal and non-federal project sponsors by project purpose. The non-federal flood damage reduction sponsors include the State Reclamation Board and a levee maintenance (or similar) district to be established at Hamilton City. The most likely non-federal ecosystem restoration sponsor is the California Department of Fish and Game. The flood damage reduction cost share between the State Reclamation Board and the yet-to-be-established maintenance district could be up to 70% State and 30% local because the proposed project is multi-objective.[11]

**Table B-12 Summary of cost-sharing responsibilities**

| Project purpose | Federal | Non-federal |
|---|---|---|
| Ecosystem restoration | 26,290 | 14,156 |
| Flood damage reduction | 2,769 | 1,491 |
| Cultural resource preservation | 170 | 0 |
| Total | 29,229 | 15,647 |
| | 65% | 35% |

[11] AB 1147 (February 1999) changed the State's contribution for flood control projects from 50/50 to a possible 70/30 split with local agencies if the proposed project incorporated multiple-objectives.

# Appendix C References

# Appendix C References


## Federal Economics Guidelines

President's Office of Management and Budget, Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, (October 29, 1992) http://www.whitehouse.gov/omb/circulars/index.html.

US Bureau of Reclamation, various Planning Instructions (for example, Planning Instruction No 82-03: Recreation, Fish and Wildlife Benefits). USBR guidance is not as centralized and codified as the Corps'; assistance concerning USBR guidance can be obtained through their Economics Technical Support Center at http://www.usbr.gov/pmts/economics/

USACE Planning Manual, Planning Guidance Notebook (ER 1105-2-100), the US Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, and other planning and economics guidance may be found at http://www.usace.army.mil/cw/cecw-cp/library/planlib.html

USACE Institute of Water Resources' software and research reports available at http://www.iwr.usace.army.mil/

## State Economics Guidance

CA Department of Water Resources. *Planning Manual: Economics*, August 1968.

CA Department of Water Resources. *Economics Practices Manual (Draft)*, January 1977.

Governor's Office of Planning and Research. *Economics Practices Manual: A Handbook for Preparing an Economic Impact Assessment,* 1978.

State Water Resources Control Board, Office of Water Recycling. *Interim Guidelines for Economic and Financial Analyses of Water Reclamation Project,* February 1979.

## Ecosystem Valuation

Allen, Jeff, et al. "The Value of California Wetlands," August 1992.

Apogee Research, Inc. Monetary Measurement of Environmental Goods and Services: Framework and Summary of Techniques for Corps Planners. USACE IWR Report 96-R-24 (Evaluation of Environmental Investments Program), November 1996.

Cole, R.A., J.B. Loomis, T.D. Feather, and D.F. Capan. Linkages between Environmental Outputs and Human Services. USACE IWR Report 96-R-6(Evaluation of Environmental Investments Program), February 1996.

Contra Costa Times, "Plan to revive chinook run carries a price of $475 for each resident and that's the cost for just one city in the Puget Sound area," February 28, 1999.

Feather, Timothy, et al. Review of Monetary and Nonmonetary Valuation of Environmental Investments. USACE IWR Report 95-R-2 (Evaluation of Environmental Investments Program), February 1996.

Freeman, A. M. *The Benefits of Environmental Improvement*. Resources for the Future, 1979.

Freeman, A. Myrick. *The Measurement of Environmental and Resource Values*, 1993.

Gregerson, Hans, et al. *Valuing Forests: Context, Issues, and Guidelines*, 1995, pgs. 23-26.

Horowitz, John. "A Test of Competing Explanations of Compensation Demanded," http://www.uq.edu.au/economics/johnquiggin/JournalArticles99/WTAWTPEconInq99.html

Hufschmidt, Maynard M.; James, David E.; Meister, Anton D.; Bower, Blair T.; and Dixon, John A. *Environment, Natural Systems and Development: An Economic Valuation Guide*, East - West Environment and Policy Institute, 1983.

King, Dennis and Mazzotta, Marisa. Ecosystem Valuation (website). http:/www.ecosystemvaluation.org

Leschine, Thomas, et al., Washington State Department of Ecology. The Economic Value of Wetlands: Wetlands Role in Flood Protection in Western Washington, October 1997.

Morrison, Jim. "How Much Is Clean Water Worth?" National Wildlife, Feb/Mar 2005, vol. 43 no 2.

National Academies. Valuing Ecosystem Services: Toward Better Environmental Decision-Making, 2005.

National Park Service. Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors, 1995.

## Cost Indices

Consumer Price Index http://www.bls.gov/cpi/

Engineering News-Record Construction Cost Index http://enr.construction.com/features/conEco/

Gross Domestic Product Implicit Price Deflator http://research.stlouisfed.org/fred2/series/GDPDEF/21

Producer Price Indexes http://www.bls.gov/ppi/home.htm and http://www.bls.gov/ppi/ppiesc.htm

USACE Civil Works Construction Cost Index System http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1304/entire.pdf

USBR Construction Cost Indices http://www.usbr.gov/pmts/estimate/cost_trend.html

## Books

Anderson, Lee and Settle, Russell. *Benefit-Cost Analysis: A Practical Guide*, 1977.

CA Department of Water Resources. Bulletin 132 *Management of the California Water Project,* annual series.

James, L. Douglas and Lee, Robert. *Economics of Water Resources Planning,* 1971.

Musgrave, Richard. *Public Finance in Theory and Practice*, 1980.

National Research Council. *Restoration of Aquatic Ecosystems*, 1992.

National Research Council. *Risk Analysis and Uncertainty in Flood Damage Reduction Studies*, 2000.

## Reports/Studies

California Bay-Delta Authority. Draft Report on In Delta Storage Program Economic Analysis, January 2004. http://calwater.ca.gov/Programs/Storage/InDeltaStorageReports_2003/Economic%20Analyses/Draft_Report_on_Economic_Analyses_1-30-04.pdf

CH2M Hill (prepared for the Colusa Basin Drainage District). Integrated Watershed Management Plan: Draft Environmental Impact Report, July 2003.

Cole, R.A.; Loomis, J.B.; Feather, T.D; and Capan, D.F. Linkages Between Environmental Outputs and Human Services. USACE IWR Report 96-R-6 (Evaluation of Environmental Investments Program), February 1996.

Cowdin, Steve; CA Department of Water Resources. Ecosystem Evaluation Methods, Natural Floodplain Functions and Societal Values, Middle Creek Ecosystem Restoration Project Case Study: Benefit and Cost Analysis, Floodplain Management Benefit and Cost Analysis Framework

Dunning, Mark C. and Durden, Susan (USACE). Theoretical Underpinnings of the Other Social Effects Account. Alexandria VA: Army Engineer Institute for Water Resources. September 2007

Lee, Nancy (CH2M Hill). Colusa Basin Benefit Cost Technical Memo, November 2004.

Lew, Daniel, Phd, et al. to the SWRCB. Assessing Economic Impacts of Water Pollution on Beneficial Uses in California Water Bodies: The Lost Beneficial Use Value Calculator, December, 2003.

Metropolitan Water District of Southern California and the US Bureau of Reclamation. Salinity Management Study, Final Report, Technical Appendices, June 1999.

USACE and State Reclamation Board. Hamilton City Flood Damage Reduction and Ecosystem Restoration, California: Final Feasibility Report and Environmental Impact Statement/Environmental Impact Report, July 2004. http://www.spk.usace.army.mil/projects/civil/compstudy/hamilton.html

Zhang, Shidong. Washington State Department of Ecology. An Evaluation of Probable Benefits and Costs for the Proposed Rule to Establish the Columbia River Water Resources Management Program. Report nr: Chapter 173-565 WAC; #04-11-032. December 2004. Available at http://www.ecy.wa.gov/pubs/0411032.pdf.

## Other Web sites

CA Department of Water Resources Loans and Grant Program http:/www.grantsloans.water.ca.gov

# Appendix D Economics Guidebook Glossary

Benefits

Benefits are the values of goods and services produced by the project. Different types of benefits include:

- Primary vs. secondary: *primary benefits* are the increased values of goods or services and/or the reduction in costs, damage, or losses to those directly affected by the project (primary beneficiaries). *Secondary (indirect) benefits* are the net values that accrue to persons other than primary beneficiaries as a result of economic activity induced by or stemming from a project. Generally only primary benefits are included in benefit/costs analyses.
- Tangible vs. Intangible: *tangible benefits*, either primary or secondary, can be expressed in monetary terms. *Intangibl*e benefits can not be expressed in monetary terms.
- Private vs. public: *private benefits* are obtained from goods and services purchased by individual producers and consumers through markets. *Public benefits* are obtained from providing "public" goods and services, i.e., goods that are consumed by society as a whole (national defense, police protection, highways, parks, etc.). Consumption of these goods by one individual does not preclude consumption by other individuals.

Benefit-Cost Analysis

A type of economic analysis that identifies and measures (usually in monetary terms) the different primary benefits and costs of proposed projects and then compares them with each other to determine if the benefits of the project exceed its costs over the analysis period. Benefit-cost analysis is the principal method used to determine if a project is economically justified. Benefit-cost comparisons of projects are most commonly made using these criteria:

- Net benefits: determined by estimating discounted benefits and costs over the study period, and then subtracting discounted costs from the discounted benefits. The optimum scale of development for a project occurs where net benefits are at a maximum. However, the net benefit criterion does not take into account the absolute level of costs involved to achieve project benefits, thus it is most appropriately used when comparing projects of similar sizes and objectives.
- Benefit/cost ratio: determined by dividing discounted benefits by discounted costs. A project is economically feasible if its B/C ratio is greater than 1.00. The B/C ratio is a measure of relative rather than absolute merit, thus it can be used to select from projects of different scales and objectives. However, the most economic use of a resource rarely occurs at the scale of development where the B/C ratio is at maximum. Thus, a net benefit analysis may be needed to size an alternative once it is selected using the B/C ratio.
- Internal rate of return: determines the rate of return, or discount rate, which just equates project discounted benefits with discounted costs. If the computed rate of return is greater than a specified discount rate, then the project is determined to be economically efficient. Although the IRR criterion usually produces the same result as the net benefits or B/C ratio criteria, it is possible for the IRR to compute more than one solution depending upon the time stream of benefits and costs.

California Agriculture Model
A DWR PC-based regional mathematical programming model of irrigated agriculture production and economics that simulates the decisions of agricultural producers in California. CALAG is an expanded version of an earlier model, Central Valley Production Model.

Consumer Surplus
The value consumers place on goods in excess of prices paid for those goods and it is graphically shown as the area under a demand curve but above the market equilibrium price determined by the intersection of the demand and supply curves.

Contingent Valuation/Choice Methods
Survey methods used to determine people's willingness to pay for goods and services in the absence of market data. Contingent valuation surveys ask how much people would be willing to spend for specific goods and services. Contingent choice surveys ask people to state preferences for different goods and services based upon their costs. An alternative application of this method is to ask people how much they would be willing to accept in order to give up a specified amenity or benefit.

Costs
All costs necessary to obtain project benefits over the analysis period. Conceptually, all costs in the economic analysis should reflect the opportunity costs of using resources to construct and operate the project. Practically, however, the cost information used in the analysis is often limited to the actual purchase expenditures which are used in financial analyses:

- Capital: expenditures necessary to complete the project so operations can commence. Capital costs (e.g., construction, "fixed" or "first" costs) include expenditures for land, structures, materials, equipment, and labor, as well as allowances for contingencies. Financial costs (such as interest during construction and long-term debt service interest) are not included, although they are important in a financial analysis.
- Operation, maintenance and replacement: include the project's annual administrative, maintenance, energy and replacement costs and are often called "variable costs" because they vary with different levels of project output.

Cost Allocation
Cost allocation is the process by which financial costs of a project are distributed equitably among project purposes. A common cost-allocation method is Separable Costs-Remaining Benefits which distributes costs among the project purposes by identifying separate costs and allocating joint costs or joint savings in proportion to each purpose's remaining benefits.

Cost-Effectiveness Analysis
A type of economic analysis that identifies the least costly method for achieving specific physical objectives. Cost-effectiveness analysis is often used to evaluate projects in which the outputs can not easily be expressed in monetary terms (for example, projects that produce ecosystem benefits). Cost-effectiveness analysis can also be combined with incremental cost analysis to measure changes in costs and outputs among alternative plans.

Crop Budgets
Descriptions of hypothetical farm sizes for various crops, “sample” establishment/production operating and overhead costs, yields, and prices received by growers. The University of California Crop Extension Office publishes budgets for crops throughout the state.

Demand Curve
A graphical representation of the amount of a good demanded at different prices with prices plotted on the vertical (y) axis and quantity purchased on the horizontal (x) axis. Demand curves generally slope downward (to the right) because people generally purchase less of a good as its price increases.

Discounting
A process used to adjust for the time value of money. Even if there is no inflation, a dollar received today is worth more than one received in the future because a dollar received today can be put to immediate use. Adjusting for different time periods is accomplished by estimating the present value of each benefit and cost in the future. Present values are calculated with a simple formula ($P = F / (1 + r)n$ ), which involves dividing the future dollar amount of benefit or cost by a discount factor $(1 + r)$ raised to the nth power. In this equation, $P$ equals the present value of the future cash flow, $F$ = future cash flow, $r$ = discount rate, and $n$ = number of time periods into the future that the benefit or cost occurs. Alternatively, present value “factors” for different discount rates and analysis years may be found in financial tables. All annual costs and benefits are discounted using the same discount rate and total discounted benefits and costs can then be summed for the entire analysis period and directly compared to each other.

Discount Rate
The discount rate is used to adjust dollars received or spent at different times to dollars of a common value, usually present day dollars (“present worth” or “present value”). Although there are different methods for determining discount rates, generally the value to use for this rate for an economic analysis is the real (i.e., excluding inflation) rate of return that could be expected if the money were instead invested in another project. In other words, the discount rate is a measure of forgone investment (i.e., “opportunity cost”) if the money allocated to the project were instead invested elsewhere.

Economic Analysis
Determines if a project represents the best use of resources over the analysis period and is therefore economically justified. The economic analysis answers questions such as: should the project be built at all, should it be built now, or should it be built to a different configuration or size? A project is economically justified if its expected total discounted benefits exceed project discounted costs over the analysis period. The comparison of benefits and costs must be done using with and without project conditions and not before and after conditions.

Ecosystem
An interdependent community of plants and animals interacting with one another and with the chemical and physical factors making up their environment.

Ecosystem Functions
The self-sustaining processes (physical, chemical and biological) of an ecosystem, many of which result in services that have value to humans.

Ecosystem Services
In addition to providing services for plant and animal life, ecosystems provide goods and services which are valuable to humans, including improved water supply and quality, flood damage reduction, recreation, scientific investigation and commercial products (fish, berries, wood products, etc.).

Ecosystem Structure
Includes all of an ecosystem's complex physical and socioeconomic characteristics.

Ecosystem Valuation Methods
Methods to estimate consumers' "willingness to pay" for ecosystem goods and services not normally found in the marketplace. Four general types of methods can be used:

- Revealed willingness to pay: measures value of ecosystem goods and services based upon actual prices paid for these products or related goods and services (using hedonic pricing and travel cost methods).
- Imputed willingness to pay: measures value of ecosystem goods and services based upon the (1) cost of avoiding damage caused by the loss of these services, (2) cost of replacing ecosystem services, or (3) cost of providing substitute services.
- Expressed willingness to pay: measures value of ecosystem goods and services based upon consumer surveys (using contingent valuation/choices methods).
- Benefit transfers: measures value of ecosystem goods and services by transferring available information from studies already completed in another location and/or context.

Externalities
Costs (or benefits) imposed upon others from the activities of producers or consumers for which no compensation is received.

Federal *Circular* A-94
Economic analyses conducted by non-water and related land resource federal agencies must follow this document issued by the President's Office of Management and Budget which provides guidance for conducting benefit/cost and cost-effectiveness analyses. Water and land resource federal agencies (such as the Corps and Bureau) must follow the *Principles and Guidelines*.

Federal Decision Criteria
The federal *Principles and Guidelines* identify four broad decision criteria for the evaluation of all federal plans:

- Completeness: the extent to which a given plan has all the necessary investments and other actions to ensure the realization of the planned effects.
- Effectiveness: the extent to which an alternative plan accomplishes its planning objectives.
- Efficiency: the extent to which an alternative plan is the most cost-effective means of accomplishing its planning objectives and is the criteria which is addressed by the economic analysis.
- Acceptability: the workability and viability of the alternative plans with respect to acceptance by state and local entities and the public as well as compatibility with existing laws, regulations, and public policies.

Project *justification* is determined by how well a proposed project meets all four criteria.

Federal Objective

The federal *Principles and Guidelines* state that the federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment, in accordance with national environmental statues, applicable executive orders, and other federal planning requirements.

Federal Planning Accounts

The federal *Principles and Guidelines* establish four planning accounts to facilitate project planning:

- National Economic Development (NED): displays contributions to national economic development which are increases in the net value of the national output of goods and services, expressed in monetary units, and which are the direct net benefits that accrue in the planning area and the rest of the Nation.
- Environmental Quality (EQ): displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans (discussed below).
- Regional Economic Development (RED): displays changes in the distribution of regional economic activity (e.g., income and employment).
- Other Social Effects (OSE): displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and other effects.

Display of the national economic development and environmental quality accounts is required whereas display of the other two accounts is discretionary.

Federal Planning Process

The federal planning process consists of six steps as described in the *Principles & Guidelines*: (1) specification of water and related land resources problems and opportunities; (2) inventory, forecast and analysis of water related land resources within the study area; (3) identification of alternative plans; (4) evaluation of the effects of alternative plans; (5) comparison of the alternative plans; and (6) selection of the recommended plan based upon the comparison of the alternative plans. *Plan formulation* consists of the third, fourth and fifth planning steps. It is a highly iterative process that involves cycling through the formulation, evaluation, and comparison steps many times to develop a reasonable range of alternative plans and then narrow those plans down to a "final array" of feasible plans from which a single plan can be identified for implementation.

Federal Plans

The criteria for selecting the recommended federal plan differ depending on the type of plan. While the NED Plan is common to all agencies that follow the P&G, the Corps has authority to implement other plans as well:

- National Economic Development Plan: for single project purposes, such as water supply or flood damage reduction where project outputs can be measured in dollars, project selection is based on maximizing net monetary benefits.
- National Ecosystem Restoration Plan: the Corps incorporated ecosystem restoration as a project purpose in response to the increasing national emphasis on environmental restoration and preservation; however, the Corps does not place monetary values on ecosystem benefits. The Bureau does not have authority for national ecosystem restoration plans (as of September 2005).

- Combined NED/NER Plan: Corps' projects that produce both NED and NER benefits will result in a "best" recommended plan so that no alternative plan has a higher excess of NED monetary benefits plus NER non-monetary benefits over project costs. This plan shall attempt to maximize the sum of net NED and NER benefits and to offer the best balance between two federal objectives.
- Locally Preferred Plan: Projects may deviate from the NED, NER or combined NED/NER Plans if requested by the non-federal sponsor. For example, if the sponsor prefers a more costly plan and the increased scope of the plan is not sufficient to warrant full federal participation based on the NED analysis, the Locally Preferred Plan may be approved as long as the sponsor pays the difference in costs between the NED (or NED/NER) plans and the LPP.

Federal *Principles and Guidelines*
Economic analyses conducted by federal agencies working with water and related land resource problems (such as the Corps and the Bureau) must follow the *Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* published by the Water Resources Council in March, 1983. The first "principles" part of the *P&G* establishes project planning policies to be followed whereas the second "guidelines" part describes "how to" procedures.

Financial Analysis
Determines if project beneficiaries are willing and able to raise sufficient funds to construct and operate a project over its repayment period. The financial analysis answers questions such as: who benefits from a project, who will repay project costs and will they be able to meet repayment obligations? A project is financially feasible if beneficiaries are able to pay for reimbursable costs over the repayment period, sufficient capital is authorized and available to finance construction to completion, and estimated revenues are sufficient to cover reimbursable costs over the repayment period.

Forgone Investment Value
If construction occurs over several years, then the future value of these expenditures must be determined in an economic analysis by multiplying these monetary costs by a future value factor (which is the reciprocal of the present value factor). These future value adjustments reflect the value of other investments that could have been pursued if the project were not undertaken ("opportunity costs"). Forgone investment value is often erroneously called "interest during construction" which is the financial interest paid on borrowed funds during construction.

Hedonic Pricing Method
This method can be used to estimate economic benefits associated with environmental amenities (such as aesthetic views or proximity to recreational sites) or environmental costs (such as the effects of air, water or noise pollution). Most hedonic price applications use differences in residential housing prices to estimate the value of the environmental amenities.

Incremental Cost Analysis
Incremental cost analysis computes the change in cost per unit of output that results from different sizes of project alternatives. This analysis determines which alternative has (a) the greatest increase in output for the least cost increase and (b) the lowest incremental costs per unit of output relative to other cost-effective plans.

Input/Output Analysis
A quantitative description of the relationship among industries within an economy which shows the interdependence among various sectors of the economy as they combine to meet a given final demand for goods and services.

Interest During Construction
The financial compound interest paid on borrowed funds during construction.

Least Cost Planning Simulation Model
A DWR PC-based simulation/optimization model that assesses the economic benefits and costs of increasing urban water reliability at the regional level.

Life Cycle Cost Analysis
Life-cycle cost analysis (LCCA) is a method for assessing and comparing the total costs of alternatives. It takes into account all costs of acquiring, owning, and disposing of facilities and related equipment. LCCA is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to identify the one that maximizes net cost savings. The three key variables in a LCCA include identifying and evaluating for each alternative all pertinent costs, the period of time over which these costs can be compared, and the appropriate discount rate.

Mathematical Programming
A mathematical solution to an objective function (such as maximizing or minimizing a specific variable) subject to a set of constraints. A common mathematical programming tool is linear programming, whose objective function and constraint equations are expressed as linear relationships.

Net Crop Revenue Model
A DWR PC-spreadsheet program which estimates average net crop revenues for important crops for recent years in California counties and regions.

Opportunity Costs
The value of productivity forgone by not investing a resource in the next optimal project.

Payment Capacity
A measure of the maximum ability of most agricultural producers in a specific area to pay for water at their head gate, on a per acre-foot basis, over a specified period. Payment capacity is the difference between gross returns from the sale of crops and the costs of production (including an imputed cost for the grower's own labor and management), excluding the cost of water.

Planning Time Horizons
Different planning time horizons may be used for feasibility analyses:

- Economic life: The period in which the project is economically viable, which means that the incremental benefits of continued use exceed the incremental costs of that use.
- Physical life: The period in which the project can no longer physically perform its intended function. Economic life may be shorter than physical life but not vice versa.
- Analysis period: The length of time over which a project's consequences are included in a study. Typical analysis periods for structural water resource projects are 50 to 100 years and 5 to 25 years for nonstructural projects.
- Short- vs. long-term: Short-term is the period of time in which capital investments cannot be changed, compared to the long-term in which new capital investments can be undertaken.
- Financing period: The length of time required for bond repayment or other required paybacks, which may be shorter or longer than the period of analysis. This time horizon is only relevant for financial analyses.

Producer Surplus
This is the benefit producers receive if prices received for goods exceed production costs for those goods. This value is graphically shown as the area above a supply curve but less than the market equilibrium price determined by the intersection of the demand and supply curves.

Regression Analysis
Statistically assesses the relative contribution of one or more independent variables upon a dependent variable.

Risk
The probability that some undesirable event will occur which is usually linked with a description of the corresponding consequences of that event.

Socioeconomic Impact Analysis
A type of economic analysis that focuses upon changes in regional population, secondary economic and fiscal effects expected to occur from proposed projects. Results from socioeconomic impact analyses are often included in environmental impact studies/reports and, for federal studies, are included in the Regional Economic Development and/or Other Social Effects planning accounts.

Supply Curve
A graphical representation of the amount of a good produced at different process with prices plotted on the vertical (y) axis and quantity produced on the horizontal (x) axis. Supply curves generally slope upward (to the right) because suppliers generally produce more of a good as its price increases.

Total Surplus
The sum of consumer and producer surplus minus any associated production costs which represents the total economic value of a good.

Trade-off analysis
Displays all monetary and non-monetary effects of a project such that the "gains and losses" among different plans can be identified.

Travel Cost Method
Used to estimate the value of recreational and/or ecosystem benefits assuming that the time and travel costs people incur to visit sites can be used as indicators of their willingness to pay for benefits obtained at those sites.

Uncertainty
Situations without sureness, whether or not described by a probability distribution.

Willingness to Accept
The amount of money that an individual would be willing to accept as payment in order to forego a good or service.

Willingness to Pay
The amount of money that an individual would be willing to pay for a good or service, which indicates the benefit of that good to that individual.

Without vs. With Conditions
Economic analysis (as well as all aspects of project evaluation) must focus upon the change in conditions expected to occur "without" the project vs. "with" the project. The "without" project conditions, which not only include historical and existing conditions but also future without project conditions, become the baseline from which all project effects (positive and negative) are compared. Thus, the estimation of the existing and future without project conditions is a critical step in the economic analysis. Often the "without" vs. "with" comparison is confused with a "before" and a "after" comparison, but this is not correct because some of the benefits forecasted to occur in the future with the project may also have occurred even without the project and therefore they should not be attributed to the project.