pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Point and Non-Point Source Management

Applicant Guidance for Drinking Water Facility Cost-Effectiveness Analysis

Planning is a critical management function of all public water systems. The goal of water system planning is to make efficient use of available resources and to assure long-term system viability to meet drinking water standards (quality, quantity and reliability). A feasibility plan should, at a minimum, include an introduction, a definition of the service area, an analysis the future water demand, an evaluation of existing facilities and sources, an analysis of alternatives and an identification of needed system improvements. Design life should normally be 20 years for treatment plants and 40 years for distribution systems (note that a 50-year design life is possible for large projects).

The level of detail for water supply studies will vary depending upon the size and complexity of the system. Extensive detail on all of these topics may not be necessary for some small systems, but the need to provide this information must be considered.

Monetary costs shall be presented as present worth values for all capital and operation and maintenance (O&M) costs over the typical 20 year planning period of the project. Population growth beyond the 20 year planning period should not be considered. However, at times engineering consultants may find it more appropriate to perform the alternatives comparison over a longer time period. In this instance, the alternatives analysis can be adjusted to the 20 year project planning period with appropriate salvage value.

Cost to be considered must include present worth or equipment annual value of capital costs and operation and maintenance costs. The cost-effectiveness analysis is not affected by the source of funds, but compares costs uniformly for each alternative. The analysis includes non-monetary factors like environmental effects, implementation capability, operability, performance reliability and flexibility. Some factors, such as the use and recovery of energy and scarce resources and water conservation should be included in both the monetary and non-monetary cost analyses. The most cost-effective alternative is the alternative that has the lowest present worth value unless non-monetary costs are overriding. This alternative must meet all applicable drinking water standards. The following cost factors are associated with monetary evaluation:

1. Sunk Costs

Sunk costs are any investments or financial commitments made before or during facilities planning. These are not to be included in the cost-effectiveness analysis since they are incurred regardless of the alternative selected. Sunk costs include the cost of existing facilities and associated land, outstanding bond indebtedness and the cost of preparing the feasibility study.

2. Present Worth

Present worth, or net present value, is the sum of money that, if invested now at a given interest (discount) rate, would provide exactly the funds required to pay all present and future costs of the project over the planning period. It considers initial capital cost, O&M costs and salvage value at the end of the planning period. The recommended discount rate to be used in computing present worth is established by the U. S. Water Resources Council for each fiscal year (October 1 – September 30) and is communicated by the US Environmental Protection Agency to Department of Environmental Protection (DEP) on an annual basis. Contact your DEP regional project manager for the latest discount rate.

Capital construction costs used in a cost-effectiveness analysis shall include all construction costs including overhead and profit, land, relocation, rights-of-way, easement acquisitions, design engineering, field exploration, engineering services during construction, administrative and legal services including costs of bond sales, startup costs such as operator training and interest during construction. Capital costs shall also include contingency allowances depending on the cost estimate's level of detail.

The cost-effectiveness analysis includes the present worth of the annual O&M costs including routine replacement of equipment parts. These costs shall be adequate to ensure effective and dependable operation during the project planning period. Annual O&M costs shall be divided between fixed annual costs and variable costs.

3. Useful Life

The useful life of various project components to be used in a cost-effectiveness analysis should fall within the following ranges:

- Land - permanent.
- Reservoir and Impoundment Structures - 50 years.
- Distribution Systems – 40 years
- Other Structures (plant buildings, tanks, basins, pumping structures, etc.) - 30 to 50 years.
- Process Equipment - 15 to 20 years.
- Auxiliary Equipment - 10 to 15 years.

Major components with a useful life of less than the planning period should show the present value of the replacement cost.

4. Salvage Value

Portions of the project's structures and equipment may have monetary value beyond the planning period and should be reflected in salvage value. If the structures and equipment have reached the end of their useful life during the planning period, the salvage value may be scrap value.

5. Interest During Construction

If interest during construction is anticipated to vary significantly from alternative to alternative, it may be included in the cost-effectiveness analysis using one of the following methods:

- If expenditures are uniform and the construction period is less than 4 years, interest is calculated as the product of the construction period (in years), the total capital expenditures (in dollars), and the discount rate.

- Where expenditures will not be uniform, or where the construction period will be greater than 4 years, interest during construction shall be calculated on a year-by-year basis.

6. Construction Staging

Applicants may wish to stage construction to make projects more affordable or to provide flexibility for uncertain growth. As a guideline, the staging period should be based on the following (where Q_f is the flow at the end of the 20-year planning period and Q_i is the flow at the initiation operation):

Q_f/Q_i Ratio	Staging Period (years)
Less than 1.3	20
1.3 to 1.8	15
Greater than 1.8	10

7. Green Technologies

“Green” technologies which save energy or water or satisfy other relevant criteria are considered by design engineers at all decision-making levels including system, unit process and component levels. Such technologies should receive careful consideration and should be proposed if they are cost-effective. Applicants should be prepared to discuss their thought process on green technologies with their DEP project manager.

Applicants who select green technologies may be asked to describe the basis for the decision in a brief “business case” report. The documentation of green technology use will display the environmental awareness of the applicant as well as increase the likelihood of project funding.

8. Cost Estimation

Construction cost estimates reflect standard engineering practice as used for preliminary planning.

9. Examples

The example below shows how to calculate present worth and equivalent annual cost for one drinking water treatment facility option. The analysis should be performed on all options being considered before selecting the most cost-effective alternative that also meets any necessary non-monetary factors such as environmental effects, implementation capability, operability, performance reliability and flexibility.

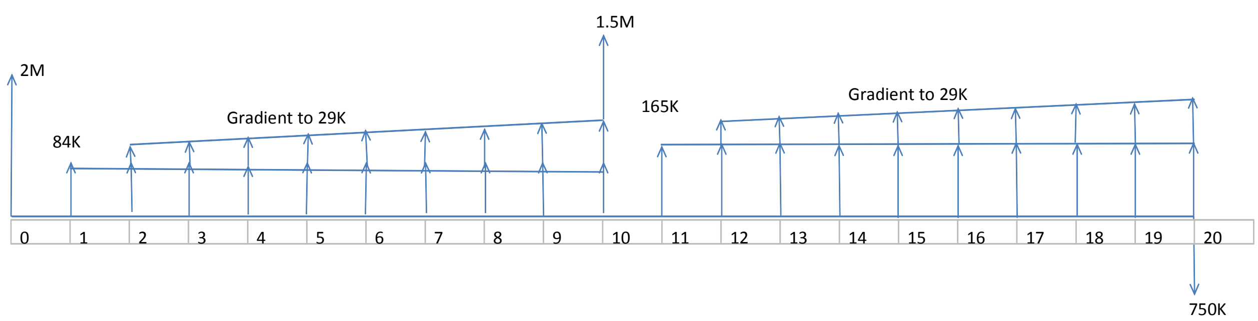
Example 1: A new drinking water treatment facility is needed. One alternative is to stage the construction. The facility will have a capacity of 5 MGD for years 1 through 10 of its life and 10 MGD for years 10 through 20.

Determine: Present Worth and Equivalent Annual Cost of this plant over the 20-year life.

Given:

- The estimated salvage value at the end of 20 years is $750,000.
- The estimated cost for constructing the 5 MGD plant is $2,000,000 and the estimated cost of the expansion to 10 MGD in year 11 (i.e. at the end of year 10) is $1,500,000.
- The estimated annual fixed O&M costs for years 1 through 10 are $84,000/year.
- The estimated annual fixed O&M costs for years 11 through 20 are $165,000/year.
- The estimated variable O&M costs for years 1 through 10 are $0 in year 1 to $29,000 in year 10, increasing linearly.
- The estimated variable O&M costs for years 11 through 20 are $0 in year 11 to $29,000 in year 20, increasing linearly.
- The Discount Rate is 7.625 percent.

Cash Flow Diagram – Costs at the end of each year over the 20 year planning period



Method: Present Worth considers the initial capital cost, operation and maintenance costs (years 1-10), the expansion costs, O&M costs for years 11 through 20 and salvage value. Equivalent Annual Cost equals the present worth multiplied by the appropriate capital recovery factor.

Step 1:

Initial Capital Cost $2,000,000

Step 2:

Present Worth Of Constant Operating and Maintenance Costs

A. Present Worth of constant annual cost for years 1 through 10 equals given cost multiplied by the uniform series present worth factor for 7.625 percent for 10 years (6.825). Therefore,

   $84,000 (6.825) = $573,300

B. Present Worth of constant annual cost for years 11 through 20 equals given cost multiplied by the uniform series present worth factor for 7.625 percent for 10 years (6.825). However, this yields the present worth for year 10, which must be converted to the present worth for year 0. This is accomplished by multiplying the present worth for year 10 by a single payment present worth factor at 7.625 percent for 10 years. Therefore,

   $165,000 (6.825) (0.4796) = $540,100

Step 3:

Present Worth Of Variable Operating and Maintenance Costs

A. Present Worth of the variable O&M costs for years 1 through 10 is calculated using a gradient series where the gradient or slope is $29,000 / (10-1 years). The gradient factor is multiplied by the present worth factor for a gradient series for 7.625 percent and 10 years. Thus,

   ($29000 / 9) (26.612) = $85,700

B. Present Worth of variable annual cost for years 11 through 20 equals gradient cost multiplied by the gradient series present worth factor for 7.675 percent for 10 years (26.612). However, this yields the present worth for year 10, which must be converted to the present worth for year 0. This is accomplished by multiplying the present worth for year 10 by a single payment present worth factor at 7.625 percent for 10 years. Therefore,

   ($29,000 / 9) (26.612) (0.4796) = $41,100

Step 4:

Present Worth of the expansion cost that occurs at year 10 must be multiplied by the single payment present worth factor for 7.625 percent for 10 years to calculate present worth of the expansion at year zero (0). Thus, Present Worth of expansion ($1,500,000) (0.4796) = $719,400

Step 5:

Present Worth of the salvage value at the end of 20 years equals the salvage value multiplied by the single payment present worth factor for 7.625 percent and 20 years (0.230). Therefore,

$750,000 (0.230) = $172,500

Step 6:

The sum of the values obtained in steps 1 through 4 minus the value obtained in step 5 is equal to the present worth of the plant. Thus,

Initial Capital Cost	$2,000,000
Present Worth of constant O&M years 1 - 10:	$573,300
Present Worth of constant O&M years 11 - 20:	$540,100
Present Worth of variable O&M years 1 - 10:	$85,700
Present Worth of variable O&M years 1: - 20:	$41,100
Present Worth of expansion at year 10:	$719,400
Subtotal	$3,959,600
Minus present worth of salvage value:	$172,500
Present Worth of Plant	$3,787,100

Step 7:

Multiply present worth of plant from Step 6 by the capital recovery factor for 7.625 percent and 20 years (0.099) to get:

Uniform Annual Cost = $3,787,100 (0.099) = $375,000