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Life Cycle Cost Analysis Worksheet For Evaluating Water Supply Projects

Introduction to the Worksheet for Evaluating Water Supply Projects

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I. Introduction and Overview

1.1 Background - ND Legislation and Statutes

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

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

The 65th Legislative Assembly also passed HB 1374, providing a definition for "life cycle analysis" in NDCC 61-02-02.

Life cycle analysis means the summation of all costs associated with the anticipated useful life of a project, including project development, land, construction, operation, maintenance, and disposal or decommissioning.

Project sponsors are required to submit a Life Cycle Cost Analysis (LCCA) for projects requesting cost-share. Sponsors are encouraged to use the current LCCA electronic model available for download from the State Water Commission website. The steps outlined in the Appendix provide a detailed description of the data required and how to use the fillable electronic LCCA model for municipal water supply projects and evaluation of alternative projects.

1.2 Purpose

To meet the statutory requirements of NDCC 61-03-21.4, this document, the North Dakota Guidance for Life Cycle Cost Analysis of Water Supply Projects has been developed to:

- Explain the Life Cycle Cost Analysis (LCCA) concept;
- Outline the basic elements of what is included in a LCCA;
- Provide an overview of why LCCA is conducted, how it’s used, and the benefits it provides; and
- Provide a process for conducting LCCA – from a North Dakota perspective.
Life Cycle Cost Analysis (LCCA) is an analytical method that can assist in selecting the most cost-effective water supply alternative that can achieve the desired long-term service life and meet the needs of a community. LCCA enables a community or project sponsor to compare the total costs, over time, of multiple alternatives, each of which may be appropriate for implementation. Under a simpler scenario, if a single alternative is selected, LCCA can be used to better understand the timing of total costs associated with that project – from its beginning stages, to the end of its useful life. LCCA considers general guidelines and best practices for application and follows basic economic principles to encourage uniformity and achieve useful results.

LCCA, in lieu of only calculating initial capital construction costs, is essential in evaluating all of the long-term implications of different strategies to achieving an extended service life, but which have different levels and timing of cost requirements. Generally speaking, key elements in the LCCA include initial costs and all relevant future costs associated with required inspection, maintenance, repair, rehabilitation, and possible component replacement, including associated demolition, disposal, and user costs.

It is important to note that the lowest life cycle cost option may not necessarily be implemented when other considerations such as risk, budget constraints, and political and environmental concerns are taken into account. LCCA provides critical information to the overall decision-making process, but not the final answer.
Basic Elements of LCCA

For the North Dakota Life Cycle Cost Analysis the costs for water supply projects should include:

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs</td>
<td>Construction costs to put the asset into initial service.</td>
<td>Construction costs may be obtained from historical records, current bids, and engineering judgment.</td>
</tr>
<tr>
<td>Annual Operations and Maintenance Costs (O&amp;M)</td>
<td>These costs include those for preventive maintenance activities that are planned to extend the life of the asset.</td>
<td>Day-to-day routine maintenance intended to address safety, and operational concerns.</td>
</tr>
<tr>
<td>Periodic Repair, Rehabilitation, and Replacement Costs</td>
<td>These costs include those for preventive activities that are also planned to extend the life of the asset but require more extensive action such as rehabilitation or replacement of equipment and infrastructure.</td>
<td>For example, pumping equipment may have a useful life of 10 years before needing more extensive servicing (rehabilitation) and eventually replacement. If using a 30-year period of analysis, the LCCA should include repair, rehabilitation, and replacement costs for pumping equipment at years 10, 20, and 30 (or other intervals as appropriate for a specific system).</td>
</tr>
<tr>
<td>Salvage Value</td>
<td>The final cost is the value of the infrastructure and equipment at the end of the life cycle. This may be considered end-of-life costs.</td>
<td>For example, if a distribution pipeline with an expected useful life of 50 years, which was installed in the first year of the study period (30 years), the salvage value would be approximately 40% (= (50-30)/50) of its initial cost. Salvage value may be positive (in the case where the component/system has value) or negative (in the case where demolition costs are incurred).</td>
</tr>
</tbody>
</table>

All of this information is compiled to calculate a total present value cost (PVC), which is the summation as shown below:

\[
PVC = PV \text{ factor (CAP)} + PV \text{ factor (O&M)} + PV \text{ factor (RRR)} +/− PV \text{ factor (SV)}
\]

Where:
- \( PVC \) Present value of all costs over time
- \( CAP \) Up-Front Capital Costs
- \( O&M \) Annual Operation and Maintenance Costs
- \( RRR \) Time-specific Repair, Rehab, and Replacement costs
- \( SV \) Salvage Value (may be either + or −)
It is important to note that the lowest life cycle cost option may not necessarily be selected for implementation when other considerations are taken into account. LCCA provides critical economic information to the overall decision-making process, but it is not the sole decision making criterion.

Decisions related to implementation of a water supply project should generally require that more than one reasonable alternative be considered. Many factors may contribute to a community’s decision to select a particular option, such as risk, budget constraints, and political and environmental concern. And, although initial project costs may dominate this decision, it is only part of the story.

Selection of an alternative will commit a community to future expenditures for operation, maintenance and rehabilitation actions over the life of a project. The LCCA framework provides the means to include initial construction costs, as well as all future expenditures associated with a project. Finally, LCCA provides a measure of transparency through documentation of the LCCA process, which then provides the project sponsor with the ability to demonstrate the best use of the public’s funds in selecting a project.
**LCCA incorporates several key economic concepts, such as discounting and present value, constant vs. real dollars, and financial vs. economic analysis. A clear understanding of these concepts is crucial to gaining local decision makers' acceptance of LCCA results.**

**Discounting and Present Value:** An inherent problem in any evaluation or decision analysis is the difficulty of making value comparisons among projects that are not measured in common units. For example, dollars spent today are not equal to dollars projected to be spent in 50 years. To account for this, all future costs are converted to present value costs through a process known as discounting, which shows what a dollar received in 50 years, for example, is worth today. Discounting is accomplished using a discount rate selected to represent the time value of money. For the ND LCCA guidance, the recommended rate is the annual discount rate published in US Army Corps of Engineers Economic Guidance Memorandum (EGM) Federal Discount Rate, table: Water Supply Interest Rates. The EGM is updated annually; the current federal rates should be used. For 2017, the federally approved discount rate is 2.875%. Higher discount rates benefit projects with more costs incurred in the future, while the lower discount rates benefit projects with more up-front costs. If the timing of costs is similar between projects, the discount rate has little effect on the economic analysis.

Life cycle costs are converted to present value using the following calculation:

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

Where:
- \(PV\): Present value of the cost or benefit
- \(FV\): The future value of the cost or benefit
- \(r\): The discount rate
- \(n\): The current time period in years

In an LCCA framework where costs occur over the life of the project, total present value costs are obtained by summing the present value of each annual cost.

For example, consider a project with costs occurring over 4 years. With a discount rate of 2.875%, the table below shows the calculation of present value in each year. The total present value cost is $11,395 or the sum of the costs in the last row.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>Discount Rate (2017)</td>
<td>2.875</td>
<td>2.875</td>
<td>2.875</td>
<td>2.875</td>
</tr>
<tr>
<td>PV Calculation</td>
<td>( PV = \frac{$5000}{(1.02875)^1} )</td>
<td>( PV = \frac{$5000}{(1.02875)^2} )</td>
<td>( PV = \frac{$1000}{(1.02875)^3} )</td>
<td>( PV = \frac{$1000}{(1.02875)^4} )</td>
</tr>
<tr>
<td>Present Value Cost</td>
<td>$4,860</td>
<td>$4,724</td>
<td>$918</td>
<td>$893</td>
</tr>
</tbody>
</table>

Financial vs. Life Cycle Cost Analysis: It should also be noted that economic and financial analyses are not the same. The objective of economic analysis and LCCA is to determine the least costly alternative. 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 key differences between economic analysis and financial analysis are as follows:

**Life Cycle Cost Analysis**
- Although LCCA can be evaluated from many different perspectives (individuals, communities, etc.), the State Water Commission is conducting these analyses from a statewide perspective.
- All project costs, capital and annual operation costs, are estimated in uninflated dollars.
- Costs are adjusted to show expected differences in their relative economic value over time.
- Economic discount rate is applied to account for time value of project costs produced by the project.
- Project inputs are valued at their economic opportunity cost.
- Financing costs are not included.

**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.
- Expected interest rate of bonds sold to finance the project is used as the time value of project costs.
- Project inputs are valued at their purchase cost.
- Bond sale and service costs are included.

**ANALYSIS PERIOD**
Water supply projects are constructed to provide service for current and future generations. Competing design alternatives may each have a different service life, which is the time period that the asset will remain functional without major repairs. Life-cycle cost analysis (LCCA), however, uses a common period of time to assess cost differences between these alternatives so that the results can be compared against one another in an apples-to-apples basis. This time period is termed the “analysis period.”

Allowing analysis periods to vary among design alternatives would result in the comparison of alternatives with different total benefit levels, which is not appropriate under LCCA. The analysis period should demonstrate the total cost differences between the alternatives. Accordingly, the analysis period should be long enough to include the initial construction or major rehabilitation action and at least one subsequent rehabilitation action for each alternative. However, each alternative does not need to have the same number of maintenance or rehabilitation activities during the analysis period.

*Please note, this guidance document provides a process for conducting life cycle cost analysis of water supply projects as required by statute. Financial analysis is a separate and independent process that is outside the scope of what is required within this guidance.*
LCCA involves five steps, ordered so that the analysis builds upon information gathered in prior steps. The analyst should review the worksheets presented in the Appendix to become familiar with the specific inputs needed in each step of LCCA.

### 1. Establish Design Alternatives
This step involves establishing the elements of initial design and identifying the associated activities that will be required throughout its service life for maintenance, rehabilitation, or element replacement within a system or subsystem—for each alternative being considered. An alternative is another way of accomplishing an objective, not simply a modification of one alternative.

### 2. Determine Activity Timing
The timing of associated activities tied to each alternative throughout the period of comparison must be determined. Estimating when certain activities must be performed is important in making valid comparisons between/among alternatives. This process might involve identifying required maintenance on a yearly basis, or levels of potential rehabilitation due to expected wear after a specified period of time, or when individual components or elements such as valves or bearings may have to be replaced. Project specific data are important in establishing when various levels of maintenance, rehabilitation or replacement may be required. In the absence of retrievable timing data, expert opinion can be used.

### 3. Estimate Costs
This step involves estimating the initial construction cost associated with each alternative and the costs associated with future operations, maintenance, rehabilitation, and replacement activities. Costs are computed on the basis of current cost data.

### 4. Compute Life Cycle Costs
This step involves computing PVC for each alternative.

### 5. Analyze Results
This step involves comparing the present value of all costs throughout a life-cycle across alternatives and determining the most cost-effective solution (the one with the lowest PVC).

Completion of these five steps in LCCA can be accomplished through the use of LCCA worksheets, which take the user step-by-step through the analysis. The worksheets are available via the Water Commission’s website at [www.swc.nd.gov](http://www.swc.nd.gov), under the “Project Development” tab. A users’ guidance manual that explains how to use the LCCA worksheets is included in the Appendix below and on-line.
The Life Cycle Cost Analysis Worksheet is an MS Excel-based worksheet designed to allow project analysts to carry-out a simplified and straightforward LCCA for up to four (4) water supply alternatives. The LCCA worksheet is available for download via the Water Commission's website at www.swc.nd.gov under the "Project Development" tab. For practical purposes and ease of use, users should be focused on data entry within worksheets ‘1- Inputs’ and ‘2- Detailed Costs,’ with results found in worksheets ‘3- Results Summary,’ and ‘4- LCCA.’

The worksheets are structured as follows:

**Title Page** – The first page which opens with the model.

**How To** – This worksheet provides the user information on each of the worksheets and where data can be entered.

**‘1 – Inputs’** – This is the primary data entry worksheet where users provide brief descriptions of the alternatives being considered (up to 4) as well as information on annual O&M and length of project construction.

**‘2 – Detailed Costs’** – This is the secondary data entry worksheet where users enter itemized costs by specific major categories. The worksheet will assign a standard useful life based on the category selected. Users may override this function and provide a useful life if professional judgement warrants doing so.

**‘3 – Results Summary’** – This worksheet serves as the summary for all outputs created in the model. For the given inputs, the Results Summary provides an overview of capital costs, annual O&M, repair, rehab, replacement costs; and salvage value. Under the Results Summary, the user will find costs for each category, and alternative.

**‘4 – LCCA’** – This worksheet is where the user can review the present value calculations for up to 4 alternatives.

**‘5 – LCCA Worksheet’** – This worksheet is a background calculation. In this sheet, the life cycle costs are computed for each alternative.

**‘6 – Analysis Years’** – This worksheet is a background calculation. In this sheet, costs for rehabilitation cycles and salvage values are estimated.

**‘7 – Cost Category List’** – This worksheet contains lists for functional cost categories and associated useful life of categories.

**Entering Data**

The user should be prepared to provide project descriptions, detailed timewise construction costs, assign construction costs to cost categories, provide the expected duration of construction, and an estimate of annual operations and maintenance.

In the data entry worksheets, ‘1 – Inputs’ and ‘2 – Detailed Costs,’ cells (intersections of rows and columns) are color coded for ease of use.

- **Yellow cells** show calculations or are references to other worksheets.
- **Orange Cells** are cells requiring the user to enter project specific data.
In the data entry worksheet "1 – Inputs," the necessary inputs for each alternative are outlined in the table below.

<table>
<thead>
<tr>
<th>Data Input</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volume of Water Provided by the Project</td>
<td>Year</td>
<td>This year will be the first year of the analysis and typically is set as the year in which the analysis is being conducted.</td>
</tr>
<tr>
<td>Base Year for the LCCA Model Period of Analysis</td>
<td>Thousands of Gallons Per Day</td>
<td>It is assumed that all alternatives will provide the same level of water supply.</td>
</tr>
<tr>
<td>Name of Alternative</td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td>Description of Alternative</td>
<td>Not Applicable</td>
<td></td>
</tr>
<tr>
<td>Years of Construction</td>
<td>Years</td>
<td>This should be based on anticipated project schedules.</td>
</tr>
<tr>
<td>Annual Operations and Maintenance</td>
<td>Dollars</td>
<td>This is an estimate of the expected annual O&amp;M for the alternative.</td>
</tr>
</tbody>
</table>