CRP Regional Servicing Study: Decision Analysis

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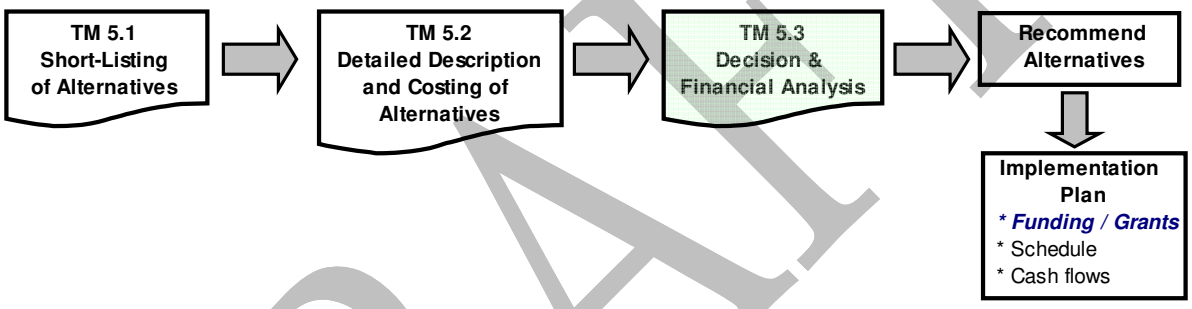
PROJECT NUMBER: 340461

This Technical Memorandum (TM) describes the decision analysis process used to evaluate the different technical alternatives for regional water and wastewater servicing.



The diagram above shows how this Technical Memorandum (and the Decision Analysis) fits into the overall process of evaluating alternatives. TM 5.3 follows the earlier work done to short-list alternatives (TM 5.1) and to develop technical concepts, together with order-of-magnitude cost estimates, for the short listed alternatives (TM 5.2). This memorandum outlines the methodology used for the Decision-Analysis process done before making recommendations and developing an implementation plan.

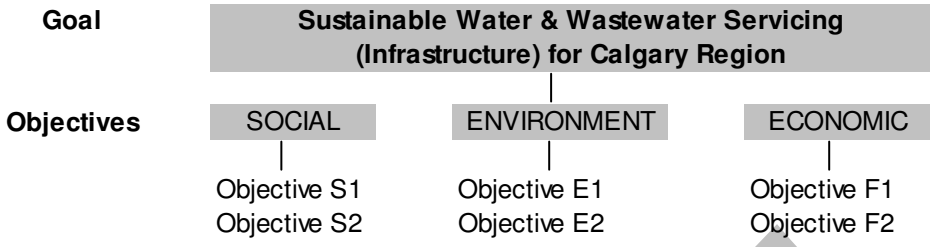
This memorandum is divided into four major sections:

- An overview of decision analysis, with a focus on value modeling
- A description of the preliminary decision model used for this project
- A brief description of the financial model approach used to assess the life-cycle costs of the different alternatives under consideration. (More details on the capital and operations/ maintenance cost estimates are provided in Technical Memorandum 5.2.)

Decision Model Overview

The decision model approach is based on a "triple bottom line" (TBL) philosophy and uses a value modeling approach, where the three primary values are identified as: (1) Social, (2) Environmental, and (3) Economic, in additional to a financial (cost) evaluation.

The basic TBL model is shown conceptually below:



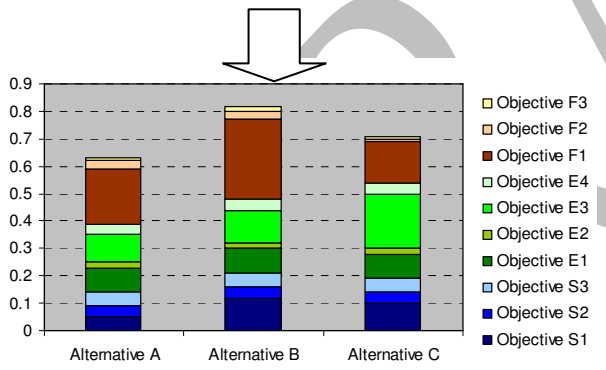
The objectives used in the decision analysis need to be consistent with, and relevant to, the study goals and the alternatives under consideration in the study. The purpose of the decision analysis is to assist in recommending which of the alternatives evaluated in the study should be implemented. Combining the value model output with the costs of the alternatives results in an objective cost-benefit analysis of the alternative (for each servicing area), as shown conceptually below:

VALUE MODEL

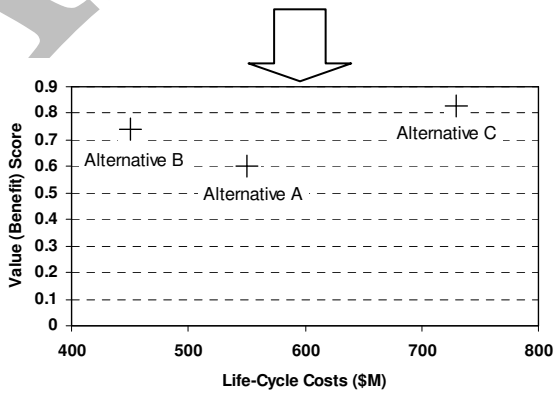
- **Objectives** – categorized as "economic", "environmental" or "social"
- Objective **Weighting** – importance and relative trade-offs
- **Performance Measures** – for Scoring

FINANCIAL MODEL

- **Capital Costs** – Conceptual (-50% to +100%)
- **Life-Cycle Costs** – NPV over 30 years



Value Model Outputs



Combined Value-Financial Model Outputs

Value Model Overview

Value modeling is a quantitative technique for making decisions that involve multiple economic, environmental, and social objectives. Value modeling is often referred to in the decision making literature as multi-criteria decision analysis and proceeds through a series of defined steps:

- Establish the decision goal

- Identify and specify fundamental objectives
- Develop performance measures to assess project performance against objectives
- Add technical detail to the performance measures, and assign scores to the performance measures
- Assign weights to each of the objectives
- Calculate value scores and conduct sensitivity analysis

The importance of multi criteria in the decision analysis process can be understood as a means to incorporate often competing as well as synergistic processes. At the same time both qualitative (e.g. aesthetics) and quantitative (e.g. costs) criteria can be combined into a forum for discussion that allows each criteria to be considered, discussed and managed to ensure that decisions have been grounded in a holistic and systematic approach.

Decision Goal

The decision goal is the overall purpose of the evaluation. It is that which is to be accomplished by making a decision. It should clarify what is included and excluded from the scope of the evaluation.

Values, Objectives, and Criteria

In the decision making process, values may range from services or assets that are important to communities or individuals affected by a series of proposed alternatives. Values are often intrinsic (such as general health and well being of a community or group), or direct such as market impacts . For example values may include the preservation of the landscape aesthetic of a place (intrinsic), the recreational opportunities afforded by an alternative (indirect), or simply that the alternatives are good value for money and will contribute to property value (direct).

Objectives are the important non-monetary aspects of a decision that are arrived at through careful thinking about issues. In essence, they reflect repeated efforts to answer a simple question: "Why is this issue important?" When the response becomes, "Because it is," a fundamental value or objective has been identified. Objectives are often aligned with larger goals of a region or organization that wishes to minimize impacts of proposed alternatives (i.e costs, environmental impact) and maximize their potential application (recycling offsets, improved recreational opportunities).

Values, objectives, and criteria are often used almost interchangeably in decision analysis. Although this is not strictly correct, it rarely affects the quality of the analysis. Simply stated, values underlie and motivate objectives.

As part of the value modeling process, the triple bottom line (TBL) approach was applied to incorporate ***environmental***, ***social*** and ***economic*** criteria most appropriately associated with the regional strategy. The Triple bottom line process provides opportunities for stakeholders to understand the relationship between various elements within the context of the project. For example, the construction of a stormwater wetland may provide multiple benefits to a development venture by providing marketability (economic value), improved water quality and habitat (ecological value), and improved recreational and health opportunities (social values).

The application of triple bottom line (TBL) thinking has become integral to private and public sectors wishing to apply holistic solutions and integrate multiple objectives to provide social, ecological and economic benefits to a given context.

Performance Measures

Once the objectives are fully developed and the decision-maker(s) agree that they represent the important issues in the problem, performance measures are required to determine how well alternatives perform against the objectives. Performance measures may be quantitative or qualitative, depending upon the objective and the availability of data for each measure.

Performance measures are generally arithmetically transformed to a scale of zero-to-one. Table 1 at the end of this Memo show the *Performance Measures* developed for each of the objectives outlined above.

Weighting Objectives

Based on the value system of the decision-maker(s), some objectives may be more or less important than other objectives. For example, loss of an ecosystem may be more important to a particular decision-maker than adverse impacts to groundwater. Obviously, different stakeholders faced with the same problem may have different underlying value systems, and, therefore, may have a different sense of what's most important in the given problem.

This leads to the concept of "weighting" objectives. Assigning weights to objectives is a subjective exercise based on the values of the stakeholder(s). This is typically done in a workshop setting where a trained facilitator ensures that participants think clearly about the relative importance of different values. Weighting is done after the performance measures have been developed, so stakeholders can include in their consideration the extent to which the full set of alternatives vary in performance.

One approach that has worked well on prior value modeling analyses is to ask stakeholders in a workshop setting to assign weights by allocating 100 points among the objectives.

Alternatives

Alternatives are the actions that may be taken to accomplish objectives. A well-considered value model includes a complete set of alternatives. Care must be taken to think creatively about possible alternatives and to not exclude or overlook alternatives that might meet the stated objectives.

Alternatives are often the first components identified when evaluating infrastructure solutions. As soon as a need or problem is identified, alternatives come to mind. Typically, alternatives are identified then the attributes are compared. It is important to re-examine alternatives generated this way after the objectives hierarchy is well-defined so that the important values can be used to define the alternatives, instead of the other way around. This is a key reason why the Decision Model framework and objectives for this study were developed early on, before the alternatives were identified.

Rating Alternatives and Aggregating Scores

Rating or scoring alternatives is the process by which the performance measurement scales are applied to the alternatives. This is essentially a weighted averaging process where scores are weighted by the value weights and summed for each alternative.

Interpreting Results

The results of any decision analysis are best regarded and applied as decision aids.

Results should inform rather than dictate the decision.

The analysis provides a way of organizing and comparing complex information. To the extent the decision-maker(s) believe that the structure of the value model represents the important issues, the weights and performance measures are appropriate, and the scores are accurate, they may be confident in the objective nature of results.

It is also valuable to evaluate the model for sensitivity to weighting. If the results of the model do not change unless there are substantial changes in weights, then decision-maker(s) may again be confident in the results.

Objectives Adopted for this Study

A preliminary decision model and draft objectives for evaluating infrastructure options using TBL criteria was developed early in the study. At a Work Shop with the CRP Project Management Team on June 19, 2006, evaluation objectives were identified under the three major standard TBL categories. These objectives and weighting were later validated at a subsequent workshop involving a broader group of stakeholders on July 14, 2006.

Certain important issues that are common to all alternatives are not listed as separate objectives. For example, all alternatives considered will meet applicable environmental regulations and, thus, it is redundant to use this as an objective in the value model analysis.

The objectives chosen for this study are described below:

Environmental:

- Reduces or avoids impact on greenfield lands or utilizes existing sites and utility/ infrastructure corridors.
- Reduces or avoids impact on environmentally sensitive areas. Maintains or enhances in-stream flows. In-stream flows will be compared to AENV Water Conservation Objectives (WCOs).
- Minimizes adverse effects on groundwater resources. This includes the conservation of groundwater in areas of limited volumes, as well as the protection of groundwater quality by improved sewage treatment.
- Minimizes the use of energy (and green house gas emissions) to build and operate.
- Minimizes water transfers between river sub-basins, tributaries, and/ or reaches. AENV regulations discourage water transfers between basins (such as between the North Saskatchewan and South Saskatchewan River basins), but allow transfers between sub-basins (such as between the Red Deer River and Bow River sub-basins) and between

tributary streams (such as between the Sheep and Bow Rivers). However, the underlying principles of sustainability favour maintaining natural river regimes and discourage all transfers between river sub-basins, tributaries, and/ or reaches.

Social:

- Facilitates management of risks to community health and safety due to flooding, explosion, traffic impacts and accidents, chemical spills, security, and disease vectors.
- Minimizes the risk of water quality degradation or source contamination to downstream drinking and/ or recreational water users
- Provides a reliable, robust system that can be adequately staffed with qualified operators.
- Provides security of water supply. In accordance with AENV's license priority system, holders of junior water licenses may face water supply restrictions in low-flow years. These allocation limits may result in water use restrictions to affected communities.
- The alternative can be easily implemented on a technical, regulatory and practical basis (land availability, operational aspects, administrative requirements, public acceptance.)

Economic:

- Encourages development and settlement patterns that are aligned with Member and CRP vision and sustainability principles.
- Provides increased capacity for diversification of assessment base.

It is important to note that the TBL criteria noted above were selected by the project team to reflect the scale and context of the region. As more detailed development occurs in future iterations of the process, criteria may be focused on the means and application of a chosen alternative to a local scenario rather than a regional context. An example of this may be the methods of construction and reduction of waste materials during the construction of infrastructure.

The objectives were categorized and grouped according to various themes, as shown in Table 1 at the end of this Technical Memorandum.

Financial Model Adopted for this Study

The cost-benefit of the various alternatives is evaluated using the estimated life-cycle costs relative to the total benefit (value score). While it is recognized that there will be different implementation schedules for the various alternatives, the purpose of this study is to identify the best *long-term* alternatives for water and wastewater servicing in the Calgary region and, as such, the implementation schedule is not a factor in the financial evaluation.

To provide a consistent basis for estimating life-cycle costs, the following approach is used:

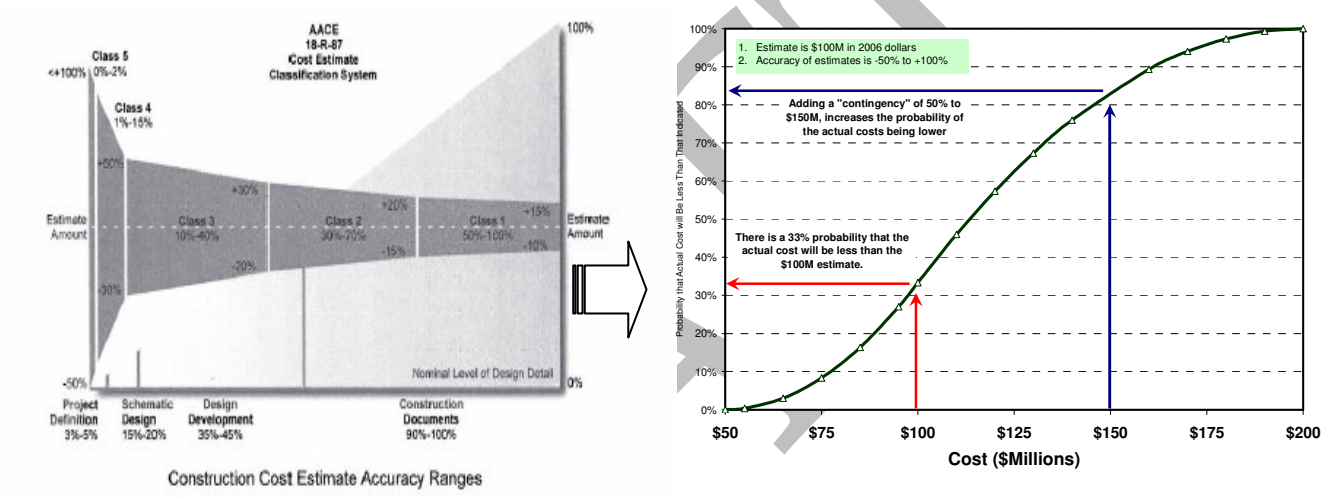
Life-Cycle Cost = Capital Cost + NPV (30-years of O&M)

As agreed with the CRP Project Management Team, a discount rate of 5% is used for Net Present Value (NPV) calculations. This is representative of typical discount rates used for public sector projects in Canada.

The cost-benefit analysis considers the "full" life-cycle cost of each alternative under consideration. Once alternatives are selected, a more detailed implementation plan can be developed taking into account other factors such as government grants, financing alternatives, and forecast implementation schedule.

Capital Costs:

Given the high level at which this study is being carried out, the "accuracy" of the cost estimates is considered to be a Class 5 Conceptual Cost Estimate as defined in the AACEI Recommended Practice - 17 R-97 Cost Estimate Classification System developed by the American Association of Cost Engineers. All capital costs will be in $2007.



As indicated in the charts above, another way to look at an estimate that has an accuracy range of -50% to +100% is to consider that there is approximately a 33% probability (assuming a *triangular distribution*) that the actual costs will be lower than the estimate. Adding a contingency factor to the estimate increases the probability of the actual cost being lower than the estimate but there can be no guarantee of the final costs at this conceptual study level.

In the current Calgary/ Alberta construction market, estimating probable construction costs is extremely difficult and subject to higher levels of uncertainty than has typically been the case in the past. While market conditions cannot be predicted, it is important that the decision analysis undertaken for this study use a consistent methodology and basis for estimates of all alternatives such that the accuracy of the alternatives is mitigated in making decisions between different alternatives.

The capital costs developed in this study include the following major categories, where applicable:

- Land acquisition costs;
- Treatment plant (water or wastewater) and other facilities;
- Pumping stations (water or wastewater);
- Pipelines and conveyance costs;

- Contingency factor.

Potential grants or other sources of funding are not considered in the decision analysis, or in the capital cost estimates. Decisions are made on the basis of total cost, regardless of "who pays" and/ or the approach used for financing. Other factors will, however, need to be considered in developing an implementation plan.

For regional alternatives where the City of Calgary provides either (a) treated potable water and/ or (b) wastewater treatment services to outside communities, these costs are considered part of the annual O&M costs, rather as capital costs, and are calculated based on current volume usage rates for *Outside City* customers [1]. This is consistent with current City of Calgary practice for providing water and wastewater services to outside communities.

More details on the methodology and approach used for specific capital cost estimates are provided in Technical Memorandum 5.2.

Operations & Maintenance (O&M) Costs:

Given the conceptual level of this study and the lack of technical design details at this point, it is difficult to provide accurate O&M estimates for the various alternatives. However, it is important that these recurring costs be approximated so that alternatives are evaluated on a life-cycle cost basis rather than only on capital costs.

Annual O&M costs are approximated based on the following general categories:

- Power requirements;
- Chemicals requirements;
- Other (including labour) requirements;
- Volume usage-based fees to be paid to the City of Calgary for providing services to customers outside of the City (*Outside City* customer classification).

The regional alternatives considered in this study represent relatively small water and/ or wastewater volumes, compared to both the volumes used/ generated by the City of Calgary as well as for existing *Outside City* customers (e.g., City of Airdrie). Therefore, the existing rates charged to *Outside City* customers are used in this study for all proposed new facilities to account for capital (upgrades or extended faculties) and O&M costs within the City of Calgary water and wastewater systems:

Treated (potable) Water Supply	=	\$0.3379 / m^3
Wastewater Conveyance & Treatment	=	\$0.5727 / m^3

The above approach allows for a consistent basis of comparing regional alternatives. However, some alternatives may require special or unusual upgrades within the City of

[1] Waterworks and Wastewater Cost of Service Study. Report for the City of Calgary. April 2004. Black & Veatch.

Calgary systems and a *sensitivity analysis* approach may be adopted to assess if increases in the City of Calgary costs will materially influence the decision between alternatives.

More details on the methodology and approach used for specific O&M estimates are provided in Technical Memorandum 5.2.