City and County of San Francisco
2030 Sewer System Master Plan

TASK 300
TECHNICAL MEMORANDUM NO. 301
DECISION ANALYSIS FRAMING FOR PRIORITIZATION OF CONFIGURATIONS

FINAL DRAFT
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2700 YGNACIO VALLEY ROAD • SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • (925) 932-1710 • FAX (925) 930-0208

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DECISION ANALYSIS FRAMING FOR PRIORITIZATION OF CONFIGURATIONS

Please note this memo is a combination of memos created in September and October of 2007 that were not updated. It was determined by the SFPUC and the consultants that it was important to capture the information at the time of development so the reviewers could see the progression of information and decisions made at the time of the memo development. Please also note that the word 'alternative' was used instead of 'configurations' for the memos reflecting the existing wording at the time it was written. In the Summary Report, the term was updated to 'configuration' so as not to confuse the CEQA review process. The configurations mentioned herein may have changed or been eliminated and are not considered full CEQA alternatives.

1.0 PURPOSE

The purpose of this project memorandum (PM) is to summarize the goals, objectives, and evaluation criteria developed for comparing and assessing the alternatives developed for the San Francisco Public Utilities Commission (SFPUC) Sewer System Master Plan (SSMP). In addition, a summary of the prioritization of the project alternatives through the application of decision analysis and support of Criterium DecisionPlus (CDP) software is provided. A glossary of terms used in this PM is provided in the Appendix.

2.0 MASTER PLAN GOALS, OBJECTIVES, AND EVALUATION CRITERIA

The mission of the San Francisco Public Utilities Commission Wastewater Enterprise (SFPUC WWE) is to protect public health, public safety, and the environment by providing safe, reliable, and cost-effective and efficient collection, treatment, and disposal of wastewater and stormwater. The underlying values, which form the basis of the SFPUC WWE Mission, have been documented through previous work.

Therefore, the goals of the SSMP are to support the SFPUC WWE Mission by seeking to:

- Provide a unifying vision, and a long-range (30-year) plan consisting of policies, programs, and projects, to cost-effectively manage the City of San Francisco's wastewater and stormwater systems,
- Protect public health and safety,
- Protect the environment,

- Minimize customer impacts, and
- Provide a recommended financial analysis that equitably distributes public benefits and burdens.

The SSMP objectives are summarized in Table 1, along with the associated evaluation criteria for assessing how well the alternatives developed during the master planning process meet those objectives.

As can be seen in Table 1, the objectives have been organized into four major categories: 1) technical/functional, 2) economic, 3) social, and 4) environmental. The organization of objectives into these categories is based on the definition of sustainable development (World Commission on Environment and Development report of 1987), as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” The SFPUC is in the process of developing a Sustainability Plan in which sustainability has been preliminarily defined as “the framework through which SFPUC will responsibly manage the resources under its care, protect public health and balance its social and environmental responsibilities to the citizens and community, while providing cost effective services to its ratepayers.” The concept of considering society (“people”), the environment (“planet”), and economics (“prosperity”) is commonly referred to as the “triple bottom line.”

In addition, the category of technical/functional has been added to address the requirement that all alternatives must be technically sound, and must meet minimum industry standards in terms of performance, ability to implement, and ability to operate and maintain the physical facilities described in the alternatives.

The economic category relates to the costs and benefits of the master planning alternatives under consideration. The social category relates to non-economic benefits and considerations associated with the alternatives. Finally, the environmental category addresses considerations related to the impact on the environment associated with implementation of master planning alternatives.

Table 1 SFPUC Sewer System Master Plan Objectives

Objective	Criteria (Favors alternatives that…)
Technical/Functional	
Maximize system reliability and redundancy	❑ Are robust against seismic events. ❑ Are resistant to operational upsets. ❑ Employ proven technologies. ❑ Have relatively low risks for implementation associated with land acquisition, permitting, and constructability.
Maximize system adaptability to respond to changing conditions	❑ Can be readily adapted to accommodate changing conditions in regulatory requirements, reuse water demand, and technological advances.
Economic	
Maximize Benefit to Cost Ratio	❑ Have relatively lower construction, operations and maintenance, and "life cycle" costs, relative to benefits achieved. ❑ Have relatively lower financial impact on ratepayers.
Social	
Minimize neighborhood impacts	❑ Reduce visual impacts associated with collection, treatment, and pumping facilities.
Maximize community benefits	❑ Create community amenities.
Maximize public health and safety	❑ Minimize backups/flooding from the sewer system.
Environmental	
Minimize impacts to the local, natural environment.	❑ Cause less impact on local water quality and natural habitat during construction and operation of facilities.
Maximize ecological sustainability	❑ Cause less impact on global environmental quality.

3.0 EVALUATION CRITERIA, PERFORMANCE PARAMETERS, AND UNITS OF MEASURE

The master planning objectives and associated evaluation criteria shown in Table 1 have been further developed to identify performance parameters and units of measure (metrics). These are organized into a two-phase evaluation criteria process as shown in Table 2. The pairings of parameters and units of measure for a given objective form the basis for assessing the alternatives developed during the master planning process.

All alternatives are developed with the following common baseline performance features:

- Ability to meet existing and anticipated regulations.
- Operational resistance to plant upset, including standby and/or storage facilities to allow for routine maintenance.
- Noise levels not to exceed ambient conditions at the plant and/or facilities fence line.
- Treatment plant odors to be undetectable at the plant, and/or facilities fence.
- Collection system odors to be reduced from existing baseline conditions today.

An important consideration to be addressed concerns the cross-media transfer of pollutants. Although advanced treatment of wastewater reduces the release of conventional and toxic pollutants into the water environment, it also results in cross-media transfer of conservative pollutants (e.g., metals) to land and/or air. In addition, treatment beyond what is necessary to protect the water environment requires energy and results in increased greenhouse gas emissions and further depletion of non-renewable resources. The concept of sustainability for the master planning effort is defined as the treatment required to protect public health and the environment that minimizes the use of resources (e.g., maximizes benefits through the conservation of resources). Therefore, implementation of advanced wastewater treatment processes that consume greater amounts of energy and resources do not always result in a net environmental benefit.

Table 2 SFPUC Sewer System Master Plan Evaluation Criteria

Master Plan Objectives		Parameter	Unit of Measure
Objective	**Criteria**		
PHASE I - "Fatal Flaw" Screening			
Technical / Functional			
Maximize system reliability and redundancy	Proven technology.	Operating record.	❑ Years of proven operation.
PHASE II			
Technical / Functional			
Maximize system reliability and redundancy	Impact from seismic event.	Plant and conveyance redundancy.	❑ Percent redundancy.
	Ability to implement.	Implementation time.	❑ Implementation schedule in years.

Master Plan Objectives		Parameter	Unit of Measure
Objective	**Criteria**		
Maximize system adaptability to respond to changing conditions	Flexibility to respond to changes in regulatory requirements, reuse water demand, or technological advances.	Project cost differential.	❑ Incremental cost (to go to filtration, and/or "zero" combined sewage discharges (CSD)).
Economic			
Maximize Benefit: Cost Ratio	Minimize capital costs	Capital costs	❑ $(Total project costs).
	Minimize operations and maintenance costs	O&M costs	❑ $(O&M costs) per year.
	Minimize "life-cycle" costs	"Life-cycle" costs	❑ $(Total annual costs).
	Minimize rate increase	Residential Sewer Rate	❑ $/month per residence.
	Maximize economic benefits relative to costs	Benefit/Cost Ratio	❑ ($ Benefits)/($ Costs) (Note: mitigation cost = benefit)
Social			
Minimize neighborhood impacts	Minimize exposure to residential neighborhoods.	Ability to visually screen plant from public view.	❑ Distance to nearest residential neighbor.
Maximize community benefits	Community benefit projects, programs.	Investment in community jobs.	❑ Number of jobs created.
Maximize public health and safety	Reduce flooding and sewer backups.	Predicted flood events.	❑ Number of flood events per year for the design storm. ❑ Sewer failure rate.
Environmental			
Minimize impacts to the local environment.	Minimize CSDs.	Frequency x Volume of CSDs.	❑ MG per year. ❑ Number CSDs per year.
	Maximize resource recovery and reuse.	Biosolids reuse.	❑ Dry tons per year.
		Water reuse.	❑ MG per year.
Maximize ecological sustainability.	Minimize impacts on the global environment.	Energy Use.	❑ kWh per year.
		Greenhouse gas emissions.	❑ Metric tons of CO_2 equivalent emissions per year.

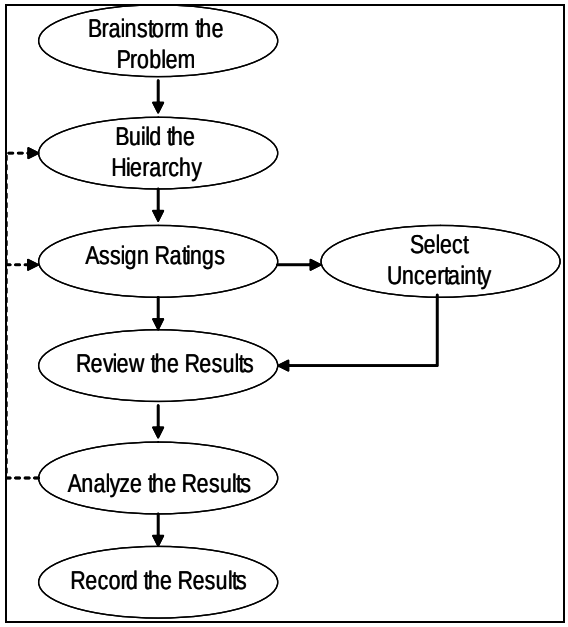
4.0 EVALUATION PROCESS

Decision analysis includes using methods and metrics for considering risk and competing environmental trade-offs. Quality management decisions include capital budgeting, plant expansion, master planning, rate design, and stakeholder involvement. These different decisions require systematic approaches to ensure they are sound, transparent, and defensible. Capital budgeting often requires comparisons across many possible projects, ranging from maintenance priorities to staff training to improving effluent quality. Plant upgrades usually involve only a few options but require more careful scrutiny. Challenges posed by environmental issues and shrinking budgets make risks and uncertainties important considerations. Therefore, a systematic method to integrate these project priorities is necessary to communicate the decision-making process.

Criterium DecisionPlus (CDP) is a decision management tool that helps organize and communicate complex decision-making tasks. The software allows you to input your goals and list your project objectives, evaluation criteria, subcriteria, and project alternatives, and assign a rating to each of the criteria. Assigning the rating can be accomplished one of two ways: the full pairwise comparison method or the direct rating method. Once the ratings are assigned, the software scores the alternatives using the ratings assigned to the evaluation criteria.

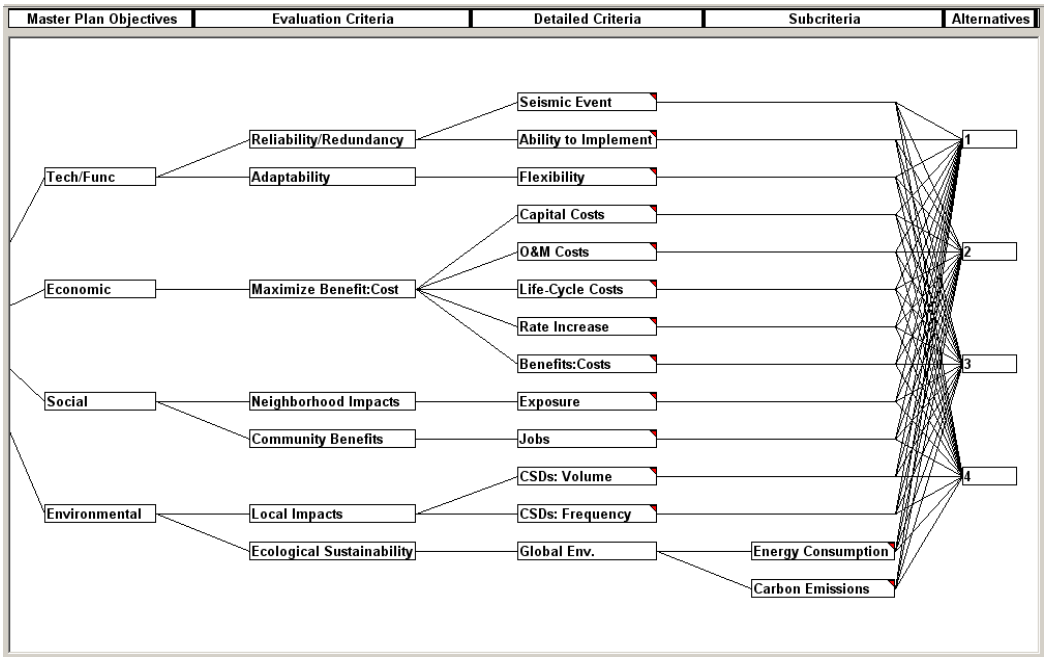
The evaluation process is summarized within the diagram of Figure 1 and is adapted from the CDP Users Guide. This process was followed for scoring of SSMP alternatives at the time of the Design Charette held in May 22, 2007 where the results were presented.

Figure 1 Evaluation Process Diagram Adapted from the Criterium DecisionPlus Users Guide



The first step in evaluating the project alternatives is defining the SSMP goals, the project objectives that must be considered, and the criteria by which to measure the ability of the alternatives to meet the objectives. This step has been accomplished and is documented in Section 2 of this PM. This step is requisite to developing a logical decision structure (or hierarchy) and it imposes discipline in the decision-making process. The result is a hierarchy starting from the project goal, including the project objectives and evaluation criteria, and leading to the project alternatives as shown in Figure 2.

Figure 2 Criterium DecisionPlus Screenshot Showing the Hierarchy with Connections.



The next step is to assign ratings to the evaluation criteria. We will summarize two approaches that accomplish the same goal of scoring the alternatives: full pairwise comparison and the direct rating methods. Both approaches consider the goal, objectives, evaluation criteria, the project alternatives, and the information available.

The full pairwise comparison considers the criteria in pairs and involves comparing each criterion within a rating set to the other criteria in that set (Figure 3). Ratings are assigned with respect to and/or with special consideration to the common reference to the specific criteria.

In the direct rating method, quantitative data are entered for each criterion (Figure 4). The data used for each criterion within a rating set must be measured using the same unit. Each rating set can use a unique unit of measure. The data entered for each criterion within a rating set are assigned relative ratings using a scale common to all criteria. The result for both approaches is a prioritization of the project alternatives.

Figure 3 Criterium DecisionPlus Screenshot of the Full Pairwise Comparison Method.

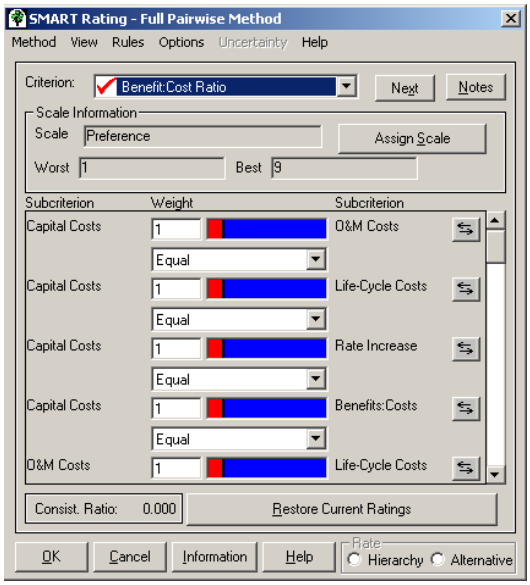
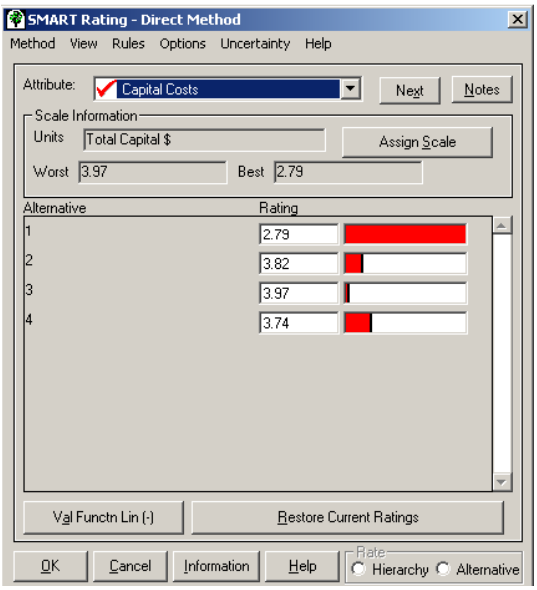
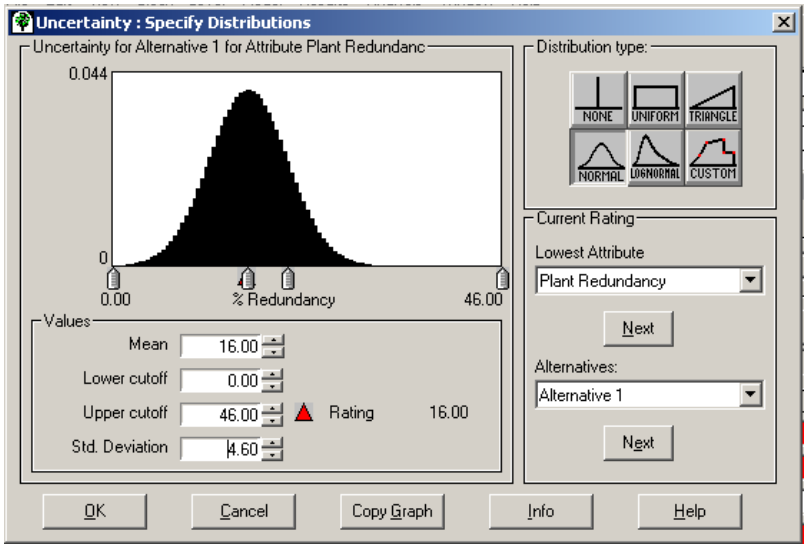


Figure 4 Criterium DecisionPlus Screenshot of the Direct Rating Method.



The values of the rating (or data) assigned to criteria are often not precise and have uncertainty associated with them that is quantifiable. In CDP, uncertainty or risk can be characterized by entering probability distributions for the ratings of project alternatives with respect to the lowest criteria (i.e. the criteria attached to the project alternatives in the hierarchy). Figure 5 shows the uncertainty input window where you specify the distribution that you want to be applied to the criteria to represent the uncertainty in the rating (or data) values entered.

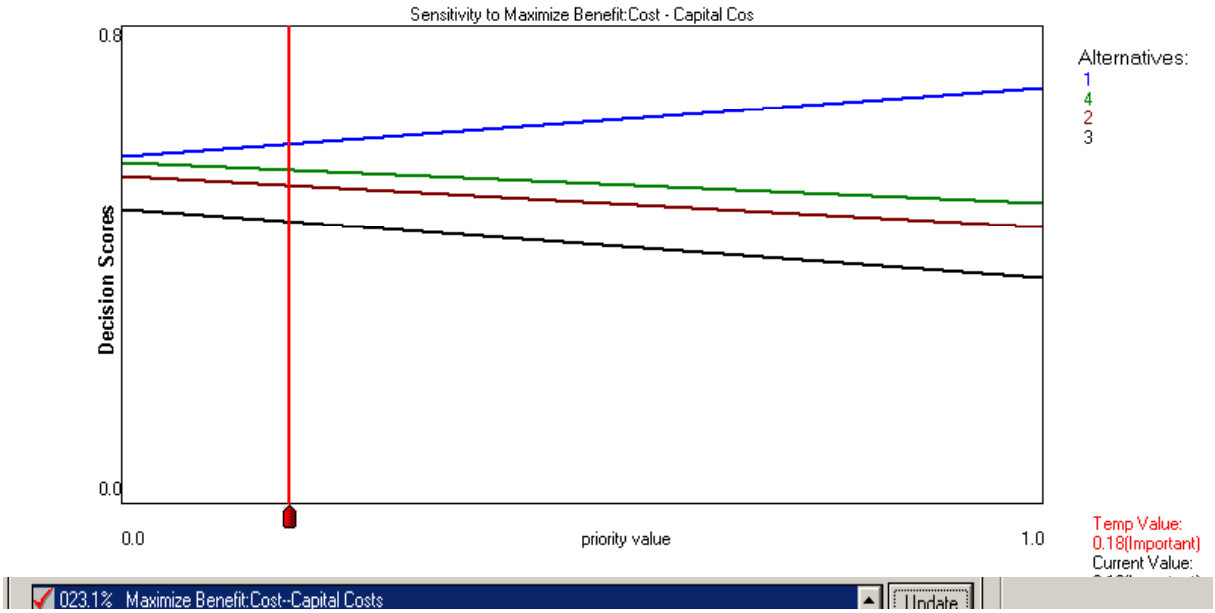
Figure 5 Criterium DecisionPlus Sample Screenshot of Uncertainty Input Window.



There are various ways to review and/or analyze the results. Two common ways include testing how sensitive the scores of the project alternatives are to changes in ratings of criterion or viewing how (and to what extent) the highest rated criteria contributed to the scores.

The sensitivity of the preferred alternative to changes in criterion rating values can be determined using the Sensitivity Analysis function. This function allows you to vary the priority value (i.e. weight a criterion has in project alternative prioritization) of the criterion and view the impact it would have on the scoring (and prioritization) of the project alternatives. Figure 6 is a screenshot from CDP illustrating the Sensitivity Analysis function. The red line represents the priority value. As the priority value is shifted left or right, you can see how the project alternatives scores and prioritization would respond.

Figure 6 Criterium DecisionPlus Sample Screenshot of the Sensitivity Analysis Function



To understand how (and to what extent) the highest rated criteria contributed to the scores of the project alternatives one must view the Contributions by Criteria Window. Figures 7 and 8 show examples of the CDP output generated for the Design Charette in May 2007 after running the four project alternatives. In Figure 7, you can easily see which Master Plan Objective made the largest contribution to the decision and which made the least. The CDP software also allows you to look at the contributions of lower criteria (e.g. in this case, evaluation criteria or detailed criteria) as shown in Figure 8.

Figure 7 Criterium DecisionPlus Sample Screenshot of the "Contributions by Criteria Window" Showing Contributions by Master Plan Objective.

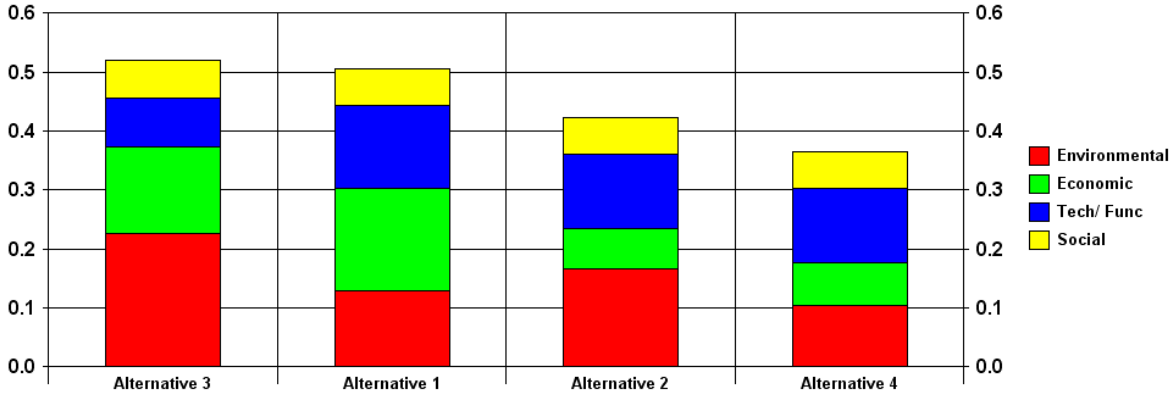
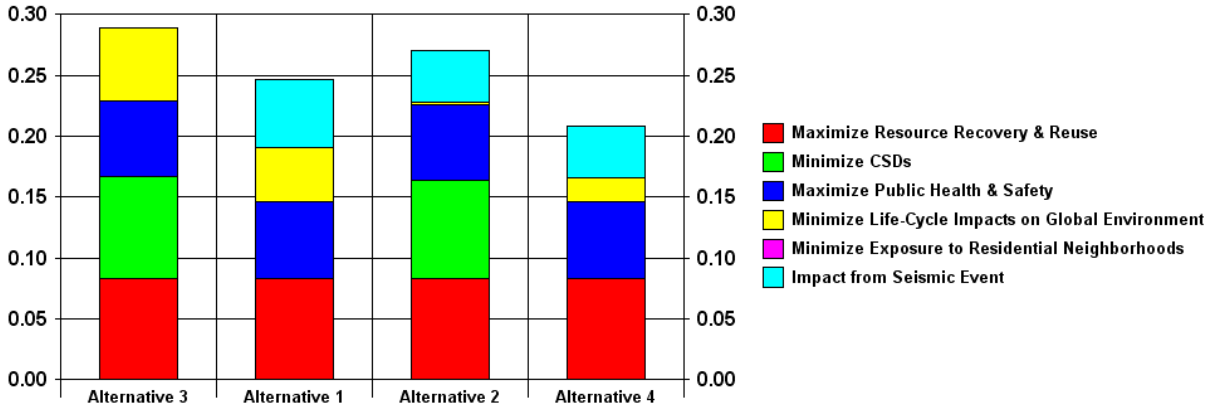


Figure 8 Criterium DecisionPlus Sample Screenshot of the "Contributions by Criteria Window" Showing Contributions by Master Plan Criteria.



The CDP software provides the capacity to print the hierarchy generated, all results and analysis window contents, graphics or data from each model developed. In addition, notes, ratings, scores, scales, etc., can be printed as single items or as custom reports.

5.0 SUMMARY

Making decisions involves considering a number of options or alternatives that can best satisfy an objective or goal. We have integrated decision analysis with the engineering analysis to create an integrated project approach addressing relevant benefits and costs. The SFPUC SSMP goals, objectives, and evaluation criteria were used to determine the prioritization of project alternatives for the Design Charette in May 2007 in an efficient process based on available information, preferences of the decision-makers, and the support of CDP software.

GLOSSARY

GLOSSARY OF TERMS

- Alternatives – Alternatives are mutually exclusive solutions (structural and/or nonstructural) to a given problem. Alternatives can be combined to form scenarios.
- Approach – A term used to describe a plan for evaluating a specific issue, and/or developing an alternative to address a specific problem or concern. The “approach” typically starts with stating the overall goals and objectives, and describes the sequence of activities to complete the evaluation.
- Combined Sewage Discharge (CSD) – A term referring to the discharge of a mixture of storm water and sewage when the flow capacity of a sewer system is exceeded during rainstorms.
- Evaluation Criteria – The quantifiable indicators that show how an alternative performs relative to the desired goals. Evaluation criteria answer the question: How well does an alternative meet the desired goals?
- Goal – The purpose towards which an endeavor or activity is directed.
- Level of Service – A term used by municipalities (and private industry) to describe the minimum level of performance of a given element of the enterprises mission.
- Life Cycle – A term referring to the initiation, on-going operation, and retirement of a project. Inventory and definition of life cycle and what is internal versus external to the project varies widely in the industry.
- Metric – A measure of performance, either qualitative or quantitative, usually limited to measurements of number, space, time, mass, and/or currency. (Also called “unit of measure”).
- Objectives – Objectives are actions and/or outcomes that will result in the attainment of a given goal.
- Options – Options are typically “building blocks” that are available to solve a given problem. They are not necessarily mutually exclusive. Options can be combined to form alternatives, which are mutually exclusive.
- Projects – Projects typically involve investments in things that are built, and result in the creation of physical assets.

- Performance Parameters – Performance parameters are used to quantify the evaluation criteria. Performance parameters, when matched with the appropriate unit of measure, allow for the objective comparison of quantitative, and qualitative data. For example, the measurement parameter of “ecological footprint” is combined with the unit of measure of “acres,” in order to help quantify the evaluation criteria for sustainability for each alternative.

- Performance – The degree to which a project, program, and/or policy achieves its intended purpose, or meets its intended function.

- Programs – Programs are a combination of nonstructural (including institutional) activities (e.g. new building codes, incentive programs for water conservation, etc.) that are sequenced throughout a given planning time horizon.

- Policy – Policies are rules and/or directions established by the enterprise to guide the outcome of decisions.

- Scenarios – Scenarios are a given set of planning assumptions and predictions that form the physical and regulatory constraints and framework for planning strategy.

- Strategy – Strategy refers to a set of decision rules that help guide the direction and deployment of resources to accomplish an enterprise’s mission. A strategy recognizes the dynamic nature of things, and allows for adjustments and realignments to keep the enterprise directed towards its mission in response to changing future conditions. Also known as “contingency planning.”

- Sustainability – In 1987 the World Commission on Environment and Development developed the most commonly used definition of sustainability: “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs”. This concept of ecological sustainability is the one that has been adopted for the development of the Master Plan.

- Units of Measure – A unit of measure is the physical accounting for number, space, time, mass, and/or currency.

- Values – A quality or characteristic considered intrinsically worthwhile or desirable. In planning, values provide a basis for direction of both how an action is implemented, and the desired outcome, (for example: “We will strive for excellence in our performance”).

REFERENCES

REFERENCES

Criterion DecisionPlus User's Guide, The Complete Decision Formulation, Analysis, and Presentation for Windows. (2005) Version 3.0. InfoHarvest, Inc. Seattle, WA.