3.3.9 Preliminary Operating Strategies

Once a preliminary size and location have been identified for an alternative, the municipality should develop conceptual operating considerations to ensure that the alternative can function reasonably in the context of its geographic location and relationship to the collection system. For an off-line storage/treatment facility, the preliminary operating considerations might include the location of regulators and conduits for diverting flow into the facility, identification of influent or effluent pumping needs, route of a dewatering force main and facility outfall, identification of solids handling needs, and coordination of dewatering rates with POTW capacity. For a deep tunnel, the alternative development process might include preliminary identification of diversion structures, consolidation conduits, dropshaft, access and work shaft locations, screening facilities, and pumping requirements.

3.4 Evaluation of Alternatives for CSO Control

The evaluation of CSO control alternatives can be a complex process, and no one methodology is appropriate for all CSO control programs. Certain general considerations, however, apply to most evaluation approaches. In general, evaluations focus on cost, performance, and non-monetary factors. Cost evaluations are quantitative, performance evaluations can be both quantitative and qualitative, and non-monetary factor evaluations are generally qualitative. One of the challenges to alternatives evaluation is how to assess the relative importance of cost, performance, and non-monetary factors in selecting a preferred alternative. The following sections present discussions and examples of ways to evaluate these issues.

3.4.1 Project Costs

Project costs include capital costs, annual O&M costs, and life-cycle costs. Capital cost, the cost to build a particular project, includes construction cost, engineering costs for design and services during construction, legal and administrative costs, and typically a contingency. The contingency is usually developed as a percentage of the construction cost, and the engineering, legal, and administrative costs are usually combined as a percentage of the construction plus contingency. Annual O&M costs reflect the annual costs for labor, utilities, chemicals, spare parts, and other supplies required to operate and maintain the facilities proposed as part of the project.

At the facilities planning level, published cost curves are usually acceptable for estimating capital and O&M costs. Care should be taken to determine whether the cost curves to be used are for a specific technology or for a complete facility. For example, a capital cost curve for a storage/sedimentation facility might not include costs for coarse screening, disinfection, pumping, or other unit operations, which are often included in such a facility. Most curves also do not include allowances for land acquisition, utility relocation, engineering and contingencies, and special site considerations, such as removal of contaminated material or difficult permitting.

Cost curves should also be indexed to account for inflation, using an index such as the Engineering News Record Cost Correction Index (ENR CCI). The ENR CCI allows a cost estimate based on, for example, 1990 costs to be adjusted to current costs by multiplying the 1990 cost by the ratio of the current ENR CCI to the 1990 ENR CCI. The ENR CCI varies with geographic location, so local ENR CCI information needs to be used.

Life-cycle costs refer to the total capital and O&M costs projected to be incurred over the design life of the project. Life-cycle costs can be conveniently expressed in terms of total present worth (TPW), which is the sum of money that, if invested now, would provide the funds necessary to cover all present and future costs of a project over the design life of the project. Life-cycle costs can also be expressed as an equivalent annual cost (EAC), which converts a non-uniform time-series of costs (such as 2 years of construction costs followed by 20 years of annual O&M costs) into a uniform annual cost over the design life of the project. One benefit of these analyses is that they allow for direct comparison of projects with high capital costs and relatively low annual O&M costs against projects with lower up-front capital costs but higher annual O&M costs. The TPW can also be expressed as a cost per volume of CSO controlled to indicate the relative cost-effectiveness of an alternative.

The TPW of a project is calculated by adding the initial capital cost to the present worth of annual O&M costs and then subtracting the present worth of the salvage value of the project (i.e., the depreciated value of the project at the end of its design life). The present worth of annual O&M costs is computed by multiplying the average annual O&M cost by the appropriate uniform series present worth factor, based on the given discount rate and design life. The discount rate to be used in the TPW analysis for facilities planning is set each year by EPA; the uniform series present worth factor can be obtained from tables in standard engineering economics textbooks. The present worth of the salvage value is computed by multiplying the salvage value by the appropriate single payment present worth factor, based on the given discount rate and design life. The value of land generally should not be depreciated and might even be assumed to increase in value over the course of the project design life. The value of the land should then be added to the depreciated value of the facility to obtain the total salvage value. Exhibit 3-4 presents an example using this procedure.

3.4.2 Performance

The expected performance of CSO control alternatives can be evaluated in a number of ways, depending in part on the technologies under consideration. The benefits of source controls are generally the hardest to quantify, particularly management practices such as street sweeping and catch basin cleaning. Although some studies have been conducted to quantify the benefits of BMPs, their performance is variable, site-specific, and difficult to quantify. Thus, the performance of source controls might need to be described qualitatively, such as "reduces floatables." Collection system controls, such as sewer separation or I/I removal, are more readily quantified and can be simulated in models such as SWMM. The performance of collection system controls can be expressed in terms of reduction in overflow volume and/or frequency as predicted by SWMM. If pollutant concentrations are known or can be predicted, then the overflow volumes can be converted into pollutant loads. These flows and loads, in turn, can be used as input to a receiving water model to assess the impact of load reduction on beneficial use criteria. The benefits of certain collection system controls, such as interceptor relief, can also be evaluated using a hydraulic model to assess the reduction in flooding or surcharging.

Exhibit 3-4. Example Calculating Total Present Worth

Two alternatives for CSO control are proposed, with the following estimated costs.

	Alternative A	Alternative B
Capital Cost	\$5,200,000	\$4,300,000
Annual O&M Cost	\$50,000	\$150,000
Salvage Value	\$500,000	\$400,000
Land Value	\$150,000	\$100,000

Assume that the following conditions apply:

- Design life = 20 years
- Discount rate = 8 percent
- Annual rate of increase in land value = 3 percent.

Based on these conditions, the following factors are obtained from tables:

- Uniform series present worth factor = 9.8181
- Single payment present worth factor = 0.2145.

The total present worth of each alternative is computed as follows.

Alternative A:

Present Worth, Capital Cost =		\$5,200,000
Present Worth, Annual O&M Cost \$50,000 x 9.8181 =		\$491,000
Present Worth, Salvage Value		
Land: \$150,000 x 1.03^{20} =	\$271,000	
Facility:	500,000	
	771,000 x 0.2145 =	(-) 165,000
Total Present Worth		\$5,526,000

Alternative B:

Present Worth, Capital Cost =		\$4,300,000
Present Worth, Annual O&M Cost \$150,000 x 9.8181 =		1,473,000
Present Worth, Salvage Value		
Land: \$100,000 x 1.03^{20} =	\$181,000	
Facility:	400,000	
	581,000 x 0.2145 =	(-) 125,000
Total Present Worth		\$5,648,000

Over the design life of the project, the lower annual O&M cost of Alternative A compensates for the higher capital cost, making it the lower cost alternative on a TPW basis.

Similarly, the performance of storage alternatives can be evaluated in terms of reduction in overflow volume and/or frequency, based on the volume to be stored. Storage facilities can be sized to capture the volume from statistical design storms, such as a 3-month, 6-hour storm, or a 1-year, 24-hour storm. SWMM can be used to develop the volumes to be captured from the selected design storm event(s). The volume reduction can then be translated into pollutant load reduction, based on estimated or simulated pollutant concentrations. Performance can also be evaluated on an annual basis, using a statistically average year or multiple years of rainfall data. For storage alternatives, a means of simulating the dewatering of the storage facilities is necessary in order to evaluate the impact of antecedent storms on facility performance.

The evaluation of treatment alternatives is less straightforward because pollutant removal performance criteria should be assigned to the treatment technology. The selected pollutant removal criterion is then applied to the volume predicted to be discharged from the treatment facility. For example, if a tank was sized to provide primary treatment for the 3-month, 24-hour storm, SWMM would predict the volume of flow tributary to the treatment facility. The resultant pollutant load to the receiving water would be calculated by subtracting the volume of the tank from the influent volume, multiplying by the assumed pollutant removal efficiency, and then multiplying by the appropriate conversion factor for units of measure. For time-varying performance assessments, a model that includes the treatment process can be considered.

The measures of performance used will depend on the water quality goals to be achieved, as well as the level of sophistication of the evaluation tools available to the municipality. If receiving water modeling is not available, the reduction in pollutant loads compared with future planned conditions or other appropriate baseline condition is another measure of performance. Changes in pollutant loads to receiving waters can be computed in a number of ways. For example, the reduction in pollutant load from a CSO can be determined as a percent of baseline load from a CSO, or the reduction in pollutant load from all sources (CSO, storm water, upstream sources) can be calculated as a percentage of baseline load from all sources.

The reduction in overflow frequency is also a useful measure of performance. If a municipality does not have the capability to perform long-term model simulations, overflow frequencies can be estimated from the recurrence interval of the storm serving as the basis of design. If receiving water modeling is available, isopleths (maps indicating areas of similar concentration) of in-stream pollutant concentrations can be developed. Other statistics can also be generated, such as hours of exceedances of water quality criteria, acre-days of exceedances, and changes in concentrations of pollutants at given locations over time.

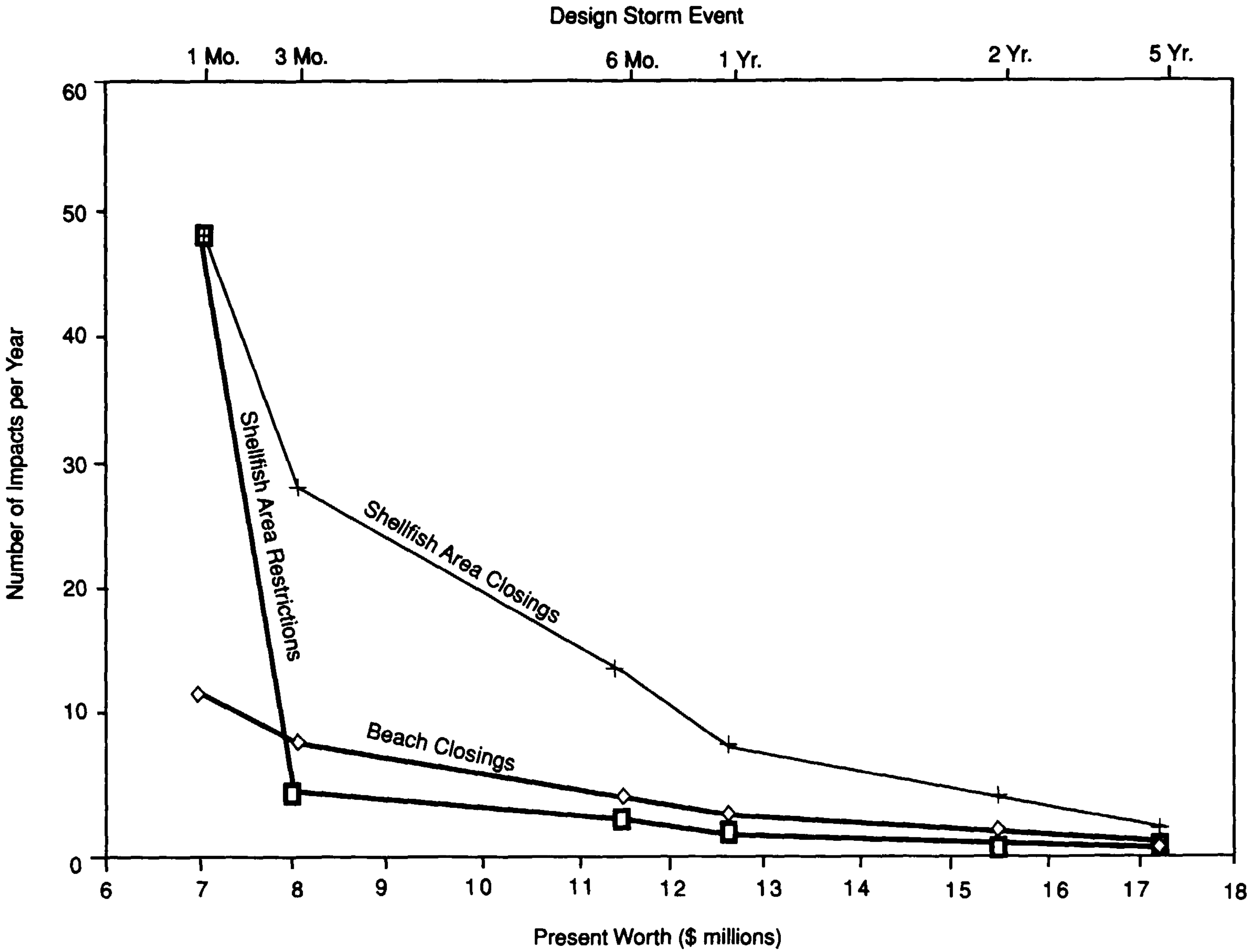
All of these factors can be valid measures of performance, depending on the circumstances. One of the challenges to alternatives evaluation is to determine ways to use such performance factors to make rational decisions on the relative merits of various CSO control alternatives. One method is to look at cost/performance relationships, while another is to apply qualitative rating and ranking methodologies to the performance data. These methods are discussed in following sections.

Performance can also be evaluated in terms of conformance with general objectives. Criteria under this category include the control of major discharges, impact on sensitive areas, and elimination of problem areas. The degree to which a particular alternative incorporates control of the larger CSOs is important because the majority of the pollutant load from a community, in most cases, originates from the largest CSOs. Continuous modeling analyses have shown that a municipality's minor CSOs often contribute a smaller percentage of overflow volume and pollutant load on an annual basis than they do during a design event. Mitigating impacts on sensitive areas is a significant concern, as expressed in the CSO Control Policy (Section II.C.3). Sensitive areas are often the focus for public access and use of the receiving water and are identified by the NPDES permitting authority in coordination with State and Federal agencies, as appropriate. Eliminating existing problem areas identified in the CSS potentially can improve system performance in many ways. Existing problem areas can include locations of repeated sewer backups and flooding, as well as recurring system maintenance problems, including grit deposition, pumping station flooding, and river or tidal inflow. The effectiveness of each alternative in addressing each of these general objectives can be rated qualitatively (e.g., good, fair, poor) or quantitatively (e.g., number of large CSOs, sensitive areas, or problem areas abated).

3.4.3 Cost/Performance Evaluations

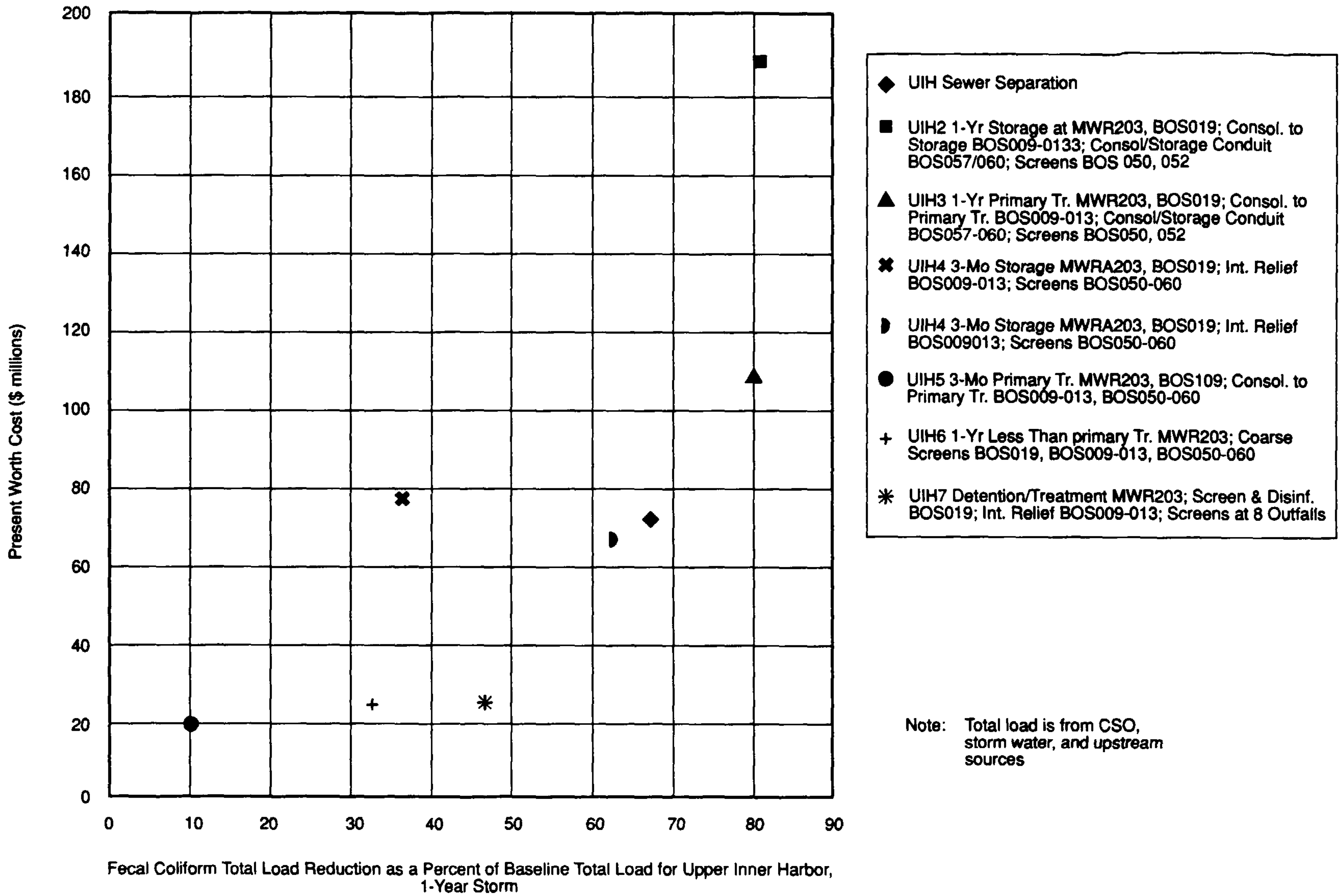
Having developed present worth costs and measures of performance, one of the traditional methods for evaluating engineering alternatives is by constructing cost/performance curves. Two common methods are to compare similar alternatives over a range of design conditions (such as 1-month, 3-month, 6-month, and 1-year storms) and to compare a range of control alternatives for a given design condition. Ideally, these comparisons would indicate that for lower levels of control, small increments of increased cost would result in large increments of improved performance, and for high levels of control, large increments of increased cost would result in small increments of improved performance. The optimal point, or "knee of the curve," is identified as the point where the incremental change in cost per change in performance changes most rapidly, indicating that the slope of the curve is changing from shallow to steep, or vice versa. Theoretically, if a smooth curve were fit through the data points, the knee of the curve would be the point where the second derivative of the function describing the curve is at a maximum. In practice, four or five points are plotted, then the point of the knee is determined from the shape of the curve. Because the points reflect planning-level estimates, a rigorous mathematical determination of the knee is generally not warranted and might imply false precision.

Exhibits 3-5 and 3-6 are examples of knee-of-the-curve analyses. In Exhibit 3-5, a proposed storage facility was sized to control CSOs from each of six design storm conditions, and the costs for each facility size were estimated. The impact of the various levels of control on critical uses (shellfishing and beach usage) was then determined. The resulting plot indicates the most cost-effective level of control using storage in terms of critical use impacts. In this example, the knee of the curve for shellfish area restrictions is clearly at the 3-month storm. For the other two criteria, shellfish area and beach closings, the location of the knee is less obvious. These curves are typical of the ambiguity often associated with knee-of-the-curve evaluations.



Source: Metcalf & Eddy, 1991

Exhibit 3-5. Example of Cost-Performance Curves Indicating Impacts on Critical Uses



SOURCE: Metcalf & Eddy, 1994

Exhibit 3-6. Example of Cost-Performance Curve Indicating Removal of a Specific Pollutant (fecal coliform bacteria)

Exhibit 3-6 is an example of the second method of using cost/performance evaluations. In this figure, alternatives were compared for controlling fecal coliform bacteria loads into a coastal receiving water during a 1-year, 24-hour storm. Ten CSO outfalls discharge to this receiving water segment, and the alternatives evaluated included a range of control technologies for individual outfalls and groups of outfalls. Performance is measured as the reduction in total fecal coliform loads (from CSO, storm water, and upstream sources) as a percent of baseline total load. In this case, the knee of the curve corresponded to alternative "UIH7." This alternative included continuing treatment at an existing detention/treatment facility, providing a screening and disinfection facility at outfall BOS019, reducing overflow frequencies and volumes at outfalls BOS009 to BOS013 through interceptor relief, and installing screens at the remaining outfalls, which activate approximately four times per year or less. Two other observations from Exhibit 3-6 are noteworthy. First, the most expensive alternative, which involves complete capture for storage of all CSOs active during the 1-year storm, only results in approximately 80-percent removal of bacterial loads to the receiving water. The remaining 20 percent of the baseline load is contributed by storm water, which is not affected by the CSO control technologies. This example demonstrates the importance of considering sources of pollutants other than CSOs.

The second point demonstrated by this example is the need to screen alternatives before reaching this level of evaluation. This receiving water segment was just one of fourteen receiving water segments evaluated as part of an LTCP. Within that one receiving water segment, the 10 outfalls were divided into four groups, based on system hydraulic relationships. For each of those four groups of outfalls, alternatives were initially developed to address a range of control levels. In order to evaluate cost/performance on a receiving water basis, alternatives for each group of outfalls had to be combined. In addition, other design conditions (e.g., annual rainfall series and other design storm events) were used during this project. Using this approach, the number of possible combinations of alternatives for this receiving water segment could become very large, very quickly. To obtain a reasonable number of alternatives, preliminary screening was necessary, along with reasonable judgment on possible combinations of alternatives for the various groups of outfalls. This concept applies both to large systems and smaller systems. Even for a municipality with only one receiving water segment and a total of 10 CSOs, the number of possible combinations of alternatives could be similar to this example.

3.4.4 Non-Monetary Factors

Non-monetary factors that can influence the selection of a recommended alternative generally fall into three categories: environmental issues and impacts, technical issues, and implementation issues. These factors are more qualitative than cost and performance evaluations, but they address decision factors critical in alternative evaluation and provide a necessary "reality check" on the overall implementability of CSO control alternatives, which cannot be obtained from cost and performance numbers alone.

3.4.4.1 Environmental Issues/Impacts

The evaluation of environmental issues and impacts involves site inspection, with reference to zoning, soils, floodway, and similar types of maps, as well as coordination with local and State agencies. Depending on the potential cost of the alternatives and scope of the planning effort, more detailed field surveys and/or geotechnical or hazardous waste investigations might be necessary. During this evaluation process, it may be appropriate to identify the various permits that would be required to implement the proposed CSO control alternatives, because the permit application process can require significant effort to support the implementation of certain types of projects. The specific environmental impacts to be evaluated vary from municipality to municipality, but the following general categories of impacts should typically be covered:

- **Land Use**—This category includes existing or planned land use of the proposed site; difficulty of property, easement, and right-of-way acquisition; zoning; and surrounding land use issues. Each of these issues could be considered a separate category for evaluation, if appropriate.
- **Traffic and Site Access**—Traffic impacts can include disruptions of traffic patterns or increases in truck traffic during construction, potential effects of traffic disruptions on local businesses, availability of alternate routes, changes to long-term traffic patterns following facility start-up, and impacts on residential areas. Site access considerations also include feasibility and/or impacts of new access roads.

- **Utilities Relocation**—Potential impacts on existing utilities can be rated qualitatively (e.g., high, medium, or low potential for impact) or, in some cases, included as an allowance on the estimated cost. Detailed investigation of utilities locations is usually performed during the design phase.

- **Noise and Vibration**—The impact of noise and vibration from construction and facility operation can be evaluated by comparing ambient and predicted noise and vibration levels and by determining the number, type, and proximity of sensitive receptors—i.e., land uses or facilities that might be particularly sensitive to project impacts, especially increased noise and traffic. Sensitive receptors typically include open space areas (including cemeteries), picnic areas, playgrounds, recreation and sports areas, parks, residences, hotels and motels, schools, churches, libraries, and hospitals.

- **Historic and Archaeologic Resources**—A project's effects on historic and archaeological resources can be determined by consulting with the local or State historic preservation commission or similar agency.

- **Soils/Rock**—The suitability of the soils at a proposed site to provide a foundation for CSO facilities is considered in this evaluation. In addition, ground-water table and bedrock depths should be considered with respect to constructibility and to effects on adjacent structures.

- **Wetlands**—The existence and location of wetlands on a site is a major factor in determining a site's suitability for a proposed facility. Depending on local or State wetlands regulations, the potential for indirect impact due to activities within specified buffer zones around coastal or riverine wetlands should also be considered. Upland sites are generally considered more favorable than sites with wetlands, within wetland buffer zones, or within regulated coastal resources areas.

- **Floodplains**—The extent to which proposed facilities would encroach upon the 100-year floodplain and the potential for mitigation by providing compensatory storage should be identified.

- **Water Quality**—Construction of the CSO facilities is intended to improve receiving water quality. Construction activities, however, can temporarily degrade water quality, and this should be considered in the evaluation process.

- **Air Quality**—Construction-related dust and odors from operating facilities can create significant air quality impacts, which could cause concern at sites located close to residential areas, hospitals, or other sensitive receptors.

- **Threatened and Endangered Species**—The presence of Federal- or State-listed threatened or endangered species or critical habitat for these species would likely eliminate a potential site from further consideration.

- **Hazardous Materials**—The potential for encountering hazardous materials at a proposed site should be evaluated carefully. A review of previous land use records can provide insight on the existence of hazardous wastes or contaminated soils.

  State agencies should maintain records of known hazardous waste spill locations. Detailed and rigorous onsite investigations are typically not undertaken in the planning phase of a project; however, a planning level review of existing documentation can reveal whether a proposed location was previously a site of commercial or industrial use or the location of routine use, storage, or disposal of hazardous materials. Some field testing might be necessary.

3.4.4.2 Technical Issues

Various technical issues require qualitative evaluation in addition to financial considerations. These include the following:

- **Constructibility**—While it is recognized that costs can be associated with anticipated requirements for rock excavation, sheeting, or dewatering at a proposed site, these and other constructibility issues can also be considered on a more qualitative level. For example, an alternative involving deep tunnels will generally involve more specialized or complex construction techniques than a near-surface storage/sedimentation facility. Similarly, an alternative that requires a river crossing for a consolidation conduit will likely be more challenging in terms of constructibility than an alternative that does not require a river crossing. The overall size and location of a proposed alternative are also relevant to the constructibility analysis.

- **Reliability**—The operating history of similar installations is a good basis for predicting the reliability of a proposed facility. Contacting and/or visiting similar existing facilities can provide useful information on operations and reliability, especially since the availability of published information on operating facilities is limited. The evaluation of reliability should also include expected operating conditions, particularly for CSO facilities that are commonly unstaffed, rely on automatic activation, and operate only on an intermittent basis. Generally, alternatives that rely on simpler or less extensive mechanical equipment are more reliable than alternatives that rely on more complex equipment. The extent of reliance on existing facilities also affects reliability. For example, if the operation of a new CSO treatment facility relies on the operation of an aging upstream pumping station, the overall reliability of the alternative might be limited by the reliability of the pumping station. This aspect might be very important in areas where the existing collection system is known to be in poor condition.

- **Operability**—Issues of operability involve both process considerations and personnel-related considerations. Process considerations include the methods of solids handling and potential flexibility of response to various loading conditions; personnel-related considerations include the degree of automation and level of operator skill necessary to fully optimize use of available process features, as well as the need for confined space entry and for increased staff levels.

3.4.4.3 Implementation Issues

In addition to the cost, performance, environmental impacts, and technical issues, several other issues, which pertain to the political and institutional aspects of a project, affect the decision to implement a potential alternative. The following list discusses these implementation issues:

- **Adaptability to Phased Implementation**—The CSO Control Policy provides that "*...schedules for implementation of the CSO controls may be phased based on the relative importance of adverse impacts upon WQS and designated uses, priority projects identified in the long-term plan, and on a permittee's financial capability*" (II.C.8). Given the cost of CSO control facilities, municipalities might determine that projects that can be implemented in smaller parts over a period of time are more affordable than a single, large, one-time project. Phased implementation also allows time for evaluating completed portions of the overall project and the opportunity to modify later parts of the project due to unanticipated changes in conditions. The initial stages of phased projects often can be implemented sooner than a single, more massive project, bringing more immediate relief to a CSO problem.

- **Institutional Constraints**—Political and institutional forces can affect proposed CSO control programs in a number of ways. Because most CSO programs are funded by tax payers or sewer rate payers, elected officials generally must be able to convince the general public that the proposed CSO control program is cost-effective and for the public good. Public rejection of a proposed project can jeopardize the chances of raising the funds needed for project implementation. The best way to ensure public acceptance of a project is through an ongoing public participation program, as stressed throughout this guidance document.

  In addition to cost, siting issues are commonly the subject of most public debate on CSO control projects. Issues involving facility location, land takings, and easements in both public and private lands can lead to disagreements among Federal, State, and local officials, public utilities, private companies, and private citizens. Involvement, coordination, and negotiation among politicians, institutions, and other stakeholders and interested parties are necessary to ensure that a technically feasible project is also politically feasible.

Regional CSO controls call for coordination among the regional authority and the individual municipalities within the region, particularly where individual municipalities have already expended funds for planning and/or implementation of local projects. Intermunicipal agreements might be necessary if a CSO control project affects the collection systems of bordering municipalities.

The CSO Control Policy encourages permittees to "*...evaluate water pollution control needs on a watershed management basis and coordinate CSO control efforts with other point and nonpoint source control activities*" (I.B). The overall goals of a CSO control plan and the steps for achieving those goals can be affected or influenced by the goals of storm water or nonpoint source control programs. Therefore, these programs should be considered in evaluating CSO control program options.

- **Multiple Use Considerations**—One means for gaining public and institutional acceptance of CSO projects is through the development of multiple-use facilities. Locating parking facilities over storage/treatment tanks, constructing bike paths over the routes of consolidation conduits, and improving river access are possible enhancements to CSO control projects that have been shown to provide additional public benefit.

3.4.5 Rating and Ranking of Alternatives

Because most of the non-monetary factors described are qualitative in nature, evaluation of these factors necessarily entails a degree of subjectivity. To make reasonable comparisons among multiple alternatives, the qualitative judgments should be standardized to the extent possible. While cost and performance criteria are generally quantitative, judgment should still be made as to the relative importance of specific cost and performance data both with respect to the range of cost and performance criteria identified for each alternative and with respect to the non-monetary factors. For example, performance criteria can include predicted duration of exceedance of fecal coliform bacteria standards, reduction in fecal coliform loading during a given design storm, and reduction in overflow frequency during a typical year. Each of these performance criteria is quantitative; the municipality must determine whether they are equally important, whether any criteria are more important than the others, and their importance compared with siting or constructability issues. Developing a methodology to evaluate the data compiled for each alternative in such a way that the appropriate weight is given to the appropriate evaluation criterion is a difficult, yet important, step in the evaluation process.

One approach for evaluating the information developed for each alternative is to construct a matrix listing each factor or criterion on the vertical axis and each alternative on the horizontal axis. A rating system is then established for each factor, defining the relative magnitude of the factor, the degree of impact each alternative has on that factor, or vice versa, as appropriate. Rating systems can be descriptive (e.g., high, medium, low impact), symbolic (+, 0, -), or numeric (1 to 5, with 1 = low impact, 5 = high impact). Using a numerical scale facilitates summing the individual ratings to produce an overall rating. A numerical scale is also most amenable to weighting factors. For example, if the annual overflow frequency is determined to be more important than the TSS load during a specific design storm, then the rating for annual overflow frequency can be multiplied by a weighting factor. This weighting increases the relative impact of that specific rating when all of the ratings for a given alternative are summed.

To provide as much consistency as possible, criteria must be defined for each rating value. Exhibit 3-7 provides examples of criteria for rating values.

Exhibit 3-7. Example Criteria for Rating Values

Category	Rating	Criteria
Constructibility	1	Standard construction techniques
	2	Standard techniques, but with restraints (such as limited staging area, difficult site access)
	3	Special techniques or more severe restraints on construction
TSS Load	1	Substantial improvement over existing conditions
	2	Limited improvement or no change compared with existing conditions
	2	Load increases compared with existing conditions

In this exhibit, for constructibility, certain construction activities, such as tunneling with tunnel boring machines (TBMs), can be defined as being "special techniques." For TSS load, "substantial improvement over existing conditions" can be defined further as a minimum percent reduction in load. In general, the greater the degree of definition of the ratings, the less subjective the rating process.

Exhibit 3-8 presents an example of a matrix for evaluating CSO control alternatives. In this example, non-monetary factors, such as conformance with objectives, operability, and constructibility, have been rated qualitatively. As a next step, numerical values can be assigned to the ratings of "good," "fair," "poor," "medium," and "low," as well as to the relative values of the monetary factors. If appropriate, the numerical values can be weighted, then the values in each column can be summed to create an overall rating for each alternative.

Exhibit 3-8. Example Matrix for Evaluating CSO Control Alternatives

Selection Criteria	Sewer Separation	Storage	Screening and Disinfection
Monetary Factors:			
Capital Costs	$2,690,000	$3,450,000	$3,740,000
Annual O&M Cost	------	$35,000	$47,000
Present Worth	$2,470,000	$3,570,000	$3,920,000
P.W. $/Design Storm CSO Gallons Abated	$8.40	$12.15	$13.35
Conformance with Objectives:			
Control of Major Discharges	Good	Good	Good
Elimination of Identified Problem Areas	Fair	Poor	Poor
Impact on Priority Areas	N/A	N/A	N/A
Operability:			
Number of Facilities	0	2	2
Reliability	Good	Fair	Fair
Level of O&M	Low	Medium	Medium
Reliance on Existing Facilities	Low	Medium	Medium
Impacts on Downstream Facilities	Low	Medium	Medium
Constructibility:			
Site Requirements	Low	Medium	Medium
Extent of Disruption	Medium	Low	Low
Degree of Difficulty	Medium	Low	Low
Adaptability to Phased Implementation	Good	Fair	Fair
Conformance with Current Plans	Good	Poor	Poor

N/A - Not Applicable
Source: Metcalf & Eddy, 1988

Rating and ranking systems should be viewed as a tool in the evaluation process and not necessarily as the final determinant of a recommended plan. Once a series of alternatives has been rated and/or ranked, it is sometimes necessary to "step back" from the evaluation process to ensure that the recommendations make sense and that program goals are being met. Public input, through workshops, public meetings, and written comments, can also reshape the recommended plan. These and other issues associated with the final selection of the recommended plan are addressed in Chapter 4. Additional guidance on rating and ranking procedures is provided in (EPA, 1995d).

3.5 Financial Capability

As part of LTCP development, the ability of the municipality to finance the final recommendations should be considered. The CSO Control Policy "*...recognizes that financial considerations are a major factor affecting the implementation of CSO controls...*[and]*... allows consideration of a permittee's financial capability in connection with the long-term CSO control planning effort, WQS review, and negotiation of enforceable schedules*" (I.E). The CSO Control Policy also specifically states that "*...schedules for implementation of the CSO controls may be phased based on...a permittee's financial capability*" (II.C.8). In considering the implementation costs of CSO controls, the municipality should investigate both the total cost of the various alternatives and its ability to absorb the costs. To this end, EPA is developing guidance on financial capability assessment (EPA, 1995e).

EPA's assessment process to determine a municipality's financial capability is a two-step process involving an initial screening followed by an investigation of overall financial condition. In the initial screening step, financial parameters are identified and the financial implications of the proposed wastewater treatment and CSO controls evaluated. In this step, the municipality determines the total wastewater and CSO capital and operating cost per household (CPH) to implement the proposed control plan and the median household income (MHI) in the service area. With these two numbers, the municipality can assess the financial impact of each CSO control alternative on residential users.

The second step is an assessment of the following selected indicators to evaluate the municipality's financial capability:

- **Debt Indicators**—These give an indication of the debt burden on the municipality and include the bond rating and overall net debt as a percent of full market property value.
- **Socioeconomic Indicators**—These give an indication of the long-term trends in the municipality and include the unemployment rate and the median household income.
- **Financial Management Indicators**—These give an indication of the municipality's ability to manage financial operations and include the property tax revenue collection rate and property tax revenue as a percent of full market property value.

Although the financial analysis can influence the selection of a recommended plan, the financial capability assessment is primarily intended to serve as a guide for developing an implementation schedule for the recommended plan. For example, a municipality might not be able to implement multiple CSO controls simultaneously, but the financial capability analysis would provide guidance on an approach to phasing the implementation of the controls so that the financial impacts are attenuated over a period of years. Chapter 4 provides additional details on project financing and other implementation issues.

CASE STUDY: MASSACHUSETTS WATER RESOURCES AUTHORITY (MWRA) - CSO CONCEPTUAL PLAN AND SYSTEM MASTER PLAN

The Massachusetts Water Resources Authority (MWRA) provides wastewater services to 43 communities in the greater Boston area. Within this service area, four communities—Boston, Cambridge, Somerville, and Chelsea—have CSSs with a total of 80 CSO outfalls in Boston Harbor and six tributary rivers. The MWRA's CSO Conceptual Plan and System Master Plan (CCP/SMP), December 1994, presented an LTCP for CSO control, as well as an evaluation of the impacts of sizing and selection of CSO control alternatives of other aspects of the MWRA system, such as interceptor performance, secondary treatment at Deer Island, and system-wide I/I.

The MWRA's CSO program involved three major components:

- Reduction in the overall CSO volume and increase in the percentage of flow receiving treatment as results of recent improvements to the conveyance system, POTW, and CSO treatment capability
- Further reduction in CSO volumes through system optimization
- Development of long-term CSO control recommendations.

The demonstration approach was selected for the development of long-term CSO control facilities. This approach featured a combination of detailed modeling and a watershed approach to evaluate causes of current nonattainment of WQS, to define appropriate water quality goals and associated CSO control goals, and to develop cost-effective alternatives to meet the CSO control goals. For the purpose of this study, the receiving waters affected by CSOs were divided into 14 separate receiving water segments. The receiving water segment boundaries were generally defined by physical features, such as dams, river influences, and embayments. In many cases, these boundaries also correlated with changes in water uses, level uses, hydrology, and/or pollution sources. Solutions were developed for each receiving water segment, while considering the interrelationships among segments.

The MWRA invested in a detailed system characterization, which provided a solid foundation for developing a detailed system model (SWMM EXTRAN). The model then allowed for comprehensive engineering evaluations, through which a recommended plan was developed. This plan will lower expected project costs by approximately $900 million over a previous CSO control plan. The approximately $2 million spent on the system characterization not only substantially reduced the expected project costs, but also provided stakeholders with a high level of confidence in the results of the engineering evaluations.

Although the four communities, 80 outfalls, and multiple receiving waters included in the MWRA's CCP/SMP would clearly constitute a large and complex system, the approach taken by the MWRA would generally be applicable to smaller systems as well. In effect, the MWRA applied its methodology to 14 smaller systems representing the 14 receiving water segments. Much of the complexity in this project derived from the interrelationships among the segments. A smaller municipality could apply the same principles in its approach to the LTCP; however, with fewer outfalls and receiving waters, the scope of the work could be reduced appropriately.

PUBLIC PARTICIPATION

The MWRA established the following goals for its public participation program:

- Provide education on CSO issues
- Provide opportunities for public review and comment on the CSO program during development
- Respond to questions and comments in a timely fashion
- Ensure stakeholder input at key project milestones.

Specific aspects of the MWRA's public participation program included the following:

- Working with a citizens advisory committee, which included representatives of environmental, business, and neighborhood associations, citizen activists, and municipal and elected officials.
- Working with agency and regulatory representatives, including EPA and the State WQS authority.
- Publication of the *CSO Bulletin* to explain key CSO issues and planning decisions, notify municipal officials and working group members of upcoming events, and provide information on how CSOs fit into other MWRA planning efforts.
- Presenting two series of interactive workshops at key junctures in the development of the CCP/SMP: one series to present baseline receiving water data, initial water quality and CSO control goals, and initial alternatives for CSO control and another series to present the results of more detailed evaluations of CSO control alternatives. Attendees included MWRA and CSO community staff, representatives from regulatory agencies, environmental groups and other stakeholders. Each series consisted of a number of individual workshop sessions to present information pertaining to individual receiving water segments.
- Conducting two series of neighborhood meetings (one addressing water quality evaluations and one addressing control technology alternatives) to present the results from the above workshop series. Neighborhood meetings were arranged to generally correspond with groupings of receiving water segments.
- Conducting individual presentations upon request to groups having particular technical and/or local area interests.

LONG-TERM CONTROL PLAN APPROACH

As an initial step in developing its LTCP, the MWRA conducted an extensive system characterization program, followed by a receiving water quality evaluation program. Key features of the system characterization program included:

- Collecting flow data from approximately 250 metering locations, including CSO outfalls, interceptors, system headworks, and existing CSO treatment facilities
- Conducting numerous inspections of CSO regulators and other system features
- Developing detailed piping schematics for each regulator
- Developing a detailed hydraulic/hydrologic model (SWMM) for the four CSO communities.

Key features of the receiving water quality evaluation program included:

- Defining existing water quality standards
- Defining existing water quality through wet and dry weather sampling
- Characterizing watersheds, waterbody hydrodynamics, CSO sources, and storm water sources
- Developing a receiving water quality model
- Defining causes of nonattainment of WQS.

Data from the MWRA's receiving water and combined sewer system characterization program indicated that non-CSO pollution sources contributed substantially to nonattainment of WQS in most receiving water segments. The MWRA considered both the presumption and demonstration approaches and determined that, for the impacted receiving water segments, the demonstration approach was necessary to fully evaluate attainment of WQS. Thus, the MWRA selected the demonstration approach for its LTCP. The demonstration approach allowed for the development of appropriate levels of CSO control for each receiving water segment and coordination of CSO control with appropriate water quality goals. Ranges of control were evaluated for each receiving water segment, with an emphasis on higher levels of control in critical use areas. Regulatory agency participation in the workshop series provided the opportunity for early coordination and presentation of the data, as well as the development of a mutual understanding of water quality issues.

DEVELOPMENT OF ALTERNATIVES FOR CSO CONTROL

Definition of CSO Control Goals

The MWRA developed a long-term conceptual plan for CSO control using a watershed-based approach, so that site-specific water quality conditions and impacts from CSOs relative to non-CSO sources of pollution could be determined. The process for selecting the recommended CSO control alternative for each receiving water segment integrated the concepts of watershed management and use attainability. A range of water quality goals was initially established for each receiving water segment, using information from an assessment of baseline receiving water conditions. The receiving water assessment included consideration of the major sources of pollutant loads in the watershed: CSOs, storm water discharges, and boundary or upstream sources. The flows and loads from these sources were estimated from modeled flows generated for various hydrologic conditions (design storm events and a design annual rainfall series) and from pollutant concentrations generated from statistical analyses of available site-specific data.

Receiving water models were used to assess the impacts of CSOs and storm water on selected riverine and coastal receiving water segments. These models were used to quantify the impacts of CSO sources only, storm water and upstream sources only, and a combination of CSO, storm water, and upstream sources on the attainment of bacteria standards for each segment.

In general terms, the range of water quality goals defined for each receiving water segment was as follows:

- Level I: Full attainment of designated uses
- Level II: Attainment of designated uses for most of the year (i.e., except for four or less overflows per year)
- Level III: Improvement over existing conditions (until other, more prominent sources of pollution are addressed).

A range of CSO control goals was then defined that would contribute to achievement of the water quality goals for each receiving water segment. The CSO control goals addressed only the CSO-related conditions that contributed to nonattainment of beneficial uses. In several receiving water segments, it was determined that pollution contributed by CSOs was only a small fraction of the total pollutant loads from other sources. In these segments, even complete elimination of CSO outfalls would not achieve the water quality goals because the other sources prevented the attainment of beneficial uses. The CSO control goals were developed with the assumption that if the other sources were remediated by the appropriate responsible parties, then the CSO controls would be stringent enough for water quality goals to be met.

Examples of a range of CSO control goals for a receiving water segment included the following:

- Level I: Eliminate all CSOs by sewer separation or relocation of the outfall(s)
- Level II: Reduce untreated CSOs to approximately four overflows per year by transport improvements, storage, or treatment
- Level III: Control floatables and meet other aesthetic criteria.

Initial Alternatives Development and Screening

Once CSO control goals were established to achieve the water quality goals in each receiving water segment, engineering and hydraulic analyses were conducted to develop and screen initial CSO control alternatives. The use of GIS and comprehensive system modeling allowed development and evaluation of alternatives where receiving water segment boundaries did not match collection and transport system hydraulic boundaries. While the impact of solutions focused on receiving water segments, hydraulic feasibility depended on the collection and transport system configuration. In some cases, structural modifications in one receiving water basin affected system performance in another receiving water basin. GIS maps provided an excellent backdrop for initial development of control alternatives, particularly with regard to identifying opportunities for consolidation of outfalls and geographic relationships among the most active outfalls and regulators.

The types of alternatives developed generally included elimination of CSOs through sewer separation or CSO relocation; near-surface storage, storage/sedimentation, or floatables control with disinfection; consolidation of outfalls to a regional storage or treatment facility, and use of consolidation conduits for storage; in-system storage; deep tunnel storage; interceptor or trunk sewer relief; upgrade of existing CSO control facilities; sewer separation upstream of selected regulators; and end-of-pipe floatables controls. Alternatives were generally sized for both a 3-month and 1-year design storms and were evaluated using continuous simulation for a 1-year period.

Hydraulically feasible alternatives were initially screened based on a range of criteria, including hydraulic performance, water quality improvement, cost, construction risks, mitigation concerns, and short- and long-term environmental impacts. The screening was conducted in a matrix format, with alternatives organized by receiving water segment or subarea. For each alternative, the criteria were rated qualitatively, and the ratings for each alternative were summed to create a total score for each alternative. The performance, construction risks, and other criteria associated with each alternative were rated in a similar manner. Alternatives within a given receiving water segment that scored substantially lower than others within that segment were not evaluated further. Compatible alternatives for the receiving water segments were combined to form regional and system-wide CSO control strategies. The screening process was conducted during the first series of workshops, mentioned previously, which incorporated stakeholder viewpoints and concerns and served to educate all parties regarding the system and possible solutions. The result was a relatively short list of alternatives for each receiving water segment that then underwent a more detailed evaluation.

Evaluation of Alternatives for CSO Control

CSO control alternatives remaining after the initial screening process were evaluated in more detail using a variety of tools, including SWMM EXTRAN simulations using a design annual rainfall series and design storm evaluations using one- and two-dimensional receiving water quality models. More detailed evaluation criteria were established, organized into the following categories:

- **Cost**—Capital, O&M, and net present worth
- **Performance**—Reduction in CSO frequency/volume and percent reduction in pollutant loads
- **Cost/Performance Relationships**—Knee of the curve analyses based on pollutant load reductions for selected design storms
- **Water Quality**—Duration of WQS exceedances, number and frequency of untreated overflows remaining, and relative impact of non-CSO sources of pollution
- **Siting Constraints**—Qualitative evaluations of site availability and constraints.

A numerical rating system was established for these criteria to rate and rank the alternatives for each receiving water segment. For example, for performance and water quality impacts, receiving water-specific criteria were identified, based on an assessment of the current status of attainment of water quality criteria and designated uses. If a given water quality criterion, such as a fecal coliform standard to support primary contact recreation, was not currently attained during wet weather, then an evaluation criterion, such as predicted hours of exceedance of the fecal coliform standard for primary contact recreation, was defined for that receiving water segment. An alternative would be assigned a rating of one to three for that criterion, based on whether the alternative resulted in a reduction, no change, or increase in the predicted hours of exceedance as compared with the baseline condition. The ratings for each alternative would be summed, then the alternatives would be ranked on an overall scale of one to three, based on the ratings. Other examples of the water quality and performance criteria used to evaluate alternatives included fecal coliform bacteria load, BOD and TSS loads, volume of untreated overflows, and annual frequency of untreated overflows. A similar rating and ranking process was conducted for cost. Rating and ranking of alternatives based on the more detailed evaluation were conducted in the second series of workshops, referenced previously.

Various combinations of alternatives for the 14 receiving water segments were developed into system-wide control strategies to allow the evaluation of a range of control levels, in accordance with provisions in the CSO Control Policy. For example, one strategy included the most preferred control alternative for each of the individual segments, one strategy consisted of system-wide sewer separation, and one strategy consisted of system-wide control of overflows to a frequency of one overflow per year. By developing the system-wide strategies, it was possible to compare total CSO plan costs for different levels of control and review combinations of alternatives for consistency and compatibility. A summary matrix of the system-wide strategies was developed, which served as a useful tool in presenting the results of the evaluations to the various stakeholders. The preferred system-wide CSO control plan consisted of a mixed level of control alternatives. The range of control alternatives that comprised the recommended plan included sewer separation, CSO outfall relocation, interceptor relief, end-of-pipe screening and disinfection, in-line storage, detention/treatment, upgrading of existing CSO treatment facilities, and end-of-pipe floatables control (for relatively inactive outfalls). The plan will eliminate CSOs from critical use areas (beaches and shellfish beds), while providing cost-effective levels of control in other receiving water segments with consideration of existing uses and impacts of non-CSO sources of pollution.

CASE STUDY: PORTLAND, OREGON - CSO MANAGEMENT PLAN

Portland's existing CSS captures and treats approximately 96 percent of the sewage from homes and businesses. The remaining 4 percent becomes part of the untreated overflow discharged at 42 outfalls on the Willamette River and 13 outfalls on the Columbia Slough. During a typical year, there are approximately 150 days of rainfall in Portland. The magnitude and frequency of overflow varies from one outfall to another, however. Some outfalls overflow virtually every time it rains, whereas others overflow as few as 30 days in a typical year. During an average year, the city's CSS discharges an estimated total of 6 billion gallons of urban storm water mixed with sewage, representing approximately 1,600 hours when bacterial standards are exceeded because of CSOs.

In 1990, the city began an engineering study to evaluate CSO control alternatives. The following year, the State of Oregon established requirements for CSO abatement, based on currently available information, that were enumerated in an agreement called the Stipulation and Final Order (SFO). This agreement, between the city and the State, called for the virtual elimination of CSO outfalls. The Draft Facility Plan for the CSO Management Program (CH2MHILL, 1993) presented a CSO control alternative that satisfies the CSO Control Policy and evaluates two levels of CSO control between the CSO Control Policy and the SFO.

The SFO was amended in August 1994 to require that untreated overflows to the Willamette River be reduced to the 3-year return summer storm and the four in 1-year return winter storm, or a reduction of 94 percent of the CSO volume currently discharged to the Willamette River. The level of control for the CSOs to the Columbia Slough was kept at the original SFO control level of 1 in 10-year storm in the summer and the 1 in 5-year storm in the winter (AMSA, 1994).

PUBLIC PARTICIPATION

The objective of the public education and involvement process was to reach as many residents as possible during LTCP development. The components of the public participation process for the Portland CSO management program are summarized in Chapter 4 (Exhibit 4-1). The key components included the River Alert Program, public education, and public involvement.

LONG-TERM CONTROL PLAN APPROACH

The objective of the CSO Management Study was to develop a planning approach to establish water quality goals and associated system performance criteria, in addition to integrating with other collection and treatment system needs. To examine the wide range of possible solutions to CSOs, the city adopted three simultaneous planning approaches: (1) results-based, (2) statistics-based, and (3) technology-based:

- **Results-Based Approach**—This begins with the reduction of storm water flow and pollutants at the source through inflow reduction and urban BMPs. Next, CSO control is reviewed as part of meeting larger water quality goals, including strengthened watershed protection elements.

- **Statistics-Based Approach**—This approach focuses on identifying a specific frequency of CSOs and developing control strategies to achieve that frequency. For example, the SFO designated the statistical frequency of CSOs to the Columbia Slough as once in 10 summers and once in 5 winters. This approach provided a clear, numerical goal that can be achieved without correlating that statistical yardstick with the benefit achieved.

- **Technology-Based Approach**—This approach generates the sewer separation alternative. A second sewer system would be constructed throughout the combined area to convey storm water, and the existing system would be rededicated to transporting only sanitary wastewater.

A single alternative was evaluated in which a completely new system was assumed and costs developed.

DEVELOPMENT OF ALTERNATIVES FOR CSO CONTROL

To lay the foundation for the development of the CSO Management Plan, control options or technologies were examined for their applicability in the city's sewer service area. These technologies represent the "building blocks" for the development of comprehensive alternatives that meet target levels of CSO control. Once a list of control alternatives to be considered for the program was compiled, each of the individual alternatives was evaluated for its ability to meet the needs of the program. This process began with a comprehensive list of CSO control alternatives. Then the list was narrowed to include only control alternatives that were appropriate or desirable to be considered further. Typically, a number of control alternatives will be inappropriate for the circumstances encountered in a given community, such as siting restrictions, financial constraints, nonconformance with WQS, or public or institutional opposition. These control alternatives can be eliminated from the list of potential controls by using an initial screening process. This initial screening makes it easier to develop realistic and appropriate control alternatives by reducing the number of possible controls to be considered, thus focusing effort on more viable alternatives.

A set of performance, implementation, and environmental criteria were developed (in conjunction with Bureau of Environmental Services staff) to evaluate the various CSO control technologies available for use in Portland.

PERFORMANCE FACTORS

The criteria grouped under the category of performance factors are related to pollutant removal, as well as overflow frequency and volume control. These criteria described the ability of the control alternative to meet an acceptable level of pollutant control and included the following:

- **CSO Volume/Frequency**—The control alternatives should be screened based on their ability to reduce the frequency of overflows and the overall volume discharged.

- **Pollutant Control**—Control alternatives more effective at controlling the primary pollutants of concern (e.g., bacteria, floatables, or suspended solids) in the municipality will generally be favored over measures that control other pollutants of lesser concern.

Implementation and Operation Factors

In addition to the performance factors, control measures are often assessed for their relative ease of implementation and operation according to the following criteria:

- **Complexity**—The more complex a control measure, the more likely there is to be a problem during implementation or operation.

- **Reliability**—Some control measures might be difficult to maintain and, therefore, should be eliminated from further consideration.

- **Flexibility**—Control measures that can be implemented in a number of configurations and across a wide range of circumstances will be preferred over more restrictive controls.

- **Land Required**—If a control technology has large land requirements, it might not be possible to implement in a highly developed watershed.

- **Public Acceptance**—In order for some control measures to be implemented, a high degree of public involvement is required. Public acceptance, therefore, can be important to the success of the control.

- **Development Time**—Controls that can be implemented immediately will generally be preferred over controls that must be developed over a number of years.

- **Cost**—The use of cost as a screening criterion at this early stage in the development of alternatives is not always appropriate, because the proposed control measures have not yet been sized. In certain cases, however, such as for treatment technologies that would provide a greater level of control than required to meet WQS, the higher level of control might not be justified by the cost of these technologies, allowing them to be eliminated from further consideration. More detailed cost evaluation is described under the Evaluation of Alternatives for CSO Control section of this case study.

Environmental Impacts

The following criteria are generally related to the potential negative side-effects resulting from constructing structural controls:

- **Construction Period**—Some control technologies require extensive construction activities that could adversely affect the surrounding environment. These would be ranked lower than corresponding controls that are less intrusive.

- **Operating Considerations**—The operation of some major structural controls can cause environmental impacts, such as noise or odor problems.

- **Siting Restrictions**—The implementation of some control technologies can be discouraged because of surrounding land use impacts that are more significant than the improvements provided by the control of CSOs.

The technologies were evaluated during meetings and workshops held in 1991 and 1992. Exhibit 3-9 summarizes the results of the evaluation, listing the range of rankings from excellent to adverse for each technology considered. The technologies were evaluated further in later phases of the project when additional information was obtained and during the development of the CSO Management Plan. The basic tenets of the screening methodology, including the basis of evaluation given above, were retained throughout plan development.

The selection of system components for inclusion in control alternatives was based on the screening results and input from BES staff. Technologies were either eliminated from further consideration or selected for one or more applications: widespread use throughout the system, localized use, or interim use. Exhibit 3-10 summarizes the selected components. Through this initial screening process, 12 of the original 31 potential control measures were eliminated from further consideration. Control technologies considered appropriate for widespread use were incorporated into the program elements for the alternatives development. Local solutions were included in specific applications when appropriate.

Exhibit 3-9. Ranking CSO Technologies

		Performance Factors				Implementation and Operation Factors							Environmental Impacts	
	CSO Control Technology	CSO Volume/Frequency	Bacteria	Floatables	Suspended Solids	Complexity	Reliability	Flexibility	Land Required	Public Acceptance	Development Time	Construction Period	Operating	Siting
Source Controls	Street Sweeping				●	●	◓	◒	●	●	●	●	◓	●
	Construction Site Erosion Control					●	◓	⊙	●	●	●	●	◓	●
	Catch Basin Cleaning			◓	●	◓	◓	◒	●	◓	●	◒	◓	◓
	Industrial Pretreatment					◓	◓	◒	●	●	●	◓	◓	●
	Garbage Disposal Ban			⊗	●	◓	◒	⊙	●	⊗	●	●	◓	●
	Onsite Domestic WW Storage		⊙	⊙	⊙	◒	⊙	⊙	◓	⊙	◓	◒	◓	⊙
	Combined Sewer Flushing		⊙		◒	◒	◓	◒	●	◓	●	◓	◒	◓
Sewer System Optimization	Static Flow Control	●	●	●	●	●	●	◒	●	●	●	●	●	●
	Variable Flow Control	◓	◓	●	●	◒	◓	◓	●	●	●	◓	●	◓
	Real-Time Flow Control	◒	◓	●	●	⊙	◒	◓	●	●	◓	◓	●	◓
Inflow Reduction	Upland Storm Water Storage	●	●	●	●	◒	◓	⊙	⊙	◒	◓	⊙	◓	⊙
	Storm Water Sumps	◓	◓	●	●	◒	◒	⊙	◓	◒	●	◒	◓	◒
	Sewer Separation	⊙	◒	◓	◓	⊙	●	⊙	●	⊗	⊙	⊗	●	⊗
	Stream Diversion					◒	●	⊙	●	◒	●	⊙	●	⊙
Storage	Earthen Basins	◓	◓	●	●	◓	◓	◒	⊙	⊙	◒	◒	⊙	⊗
	Open Concrete Tanks	⊙	◒	◒	◒	◓	◓	◒	⊙	⊙	◒	◒	⊙	⊗
	Closed Concrete Tanks	⊙	◒	◒	◒	◓	◒	◒	◒	◒	◒	◒	◒	◒
	Storage Conduits	⊙	◒	◒	◒	◓	◒	◒	◒	◒	◒	◒	◒	◒
	Storage Tunnels	⊙	◒	◒	◒	◒	◒	◒	◒	◒	◒	⊙	◒	◒
Physical/Chemical Treatment (all options include chlorination/dechlorination)	Swirl Concentrator	◒	◓	◓	◒	◓	◓	⊙	◒	◒	◓	◒	◒	◒
	Vortex Separator	◒	◓	◓	◓	◓	◓	⊙	◒	◒	◓	◒	◒	◒
	Coarse Screening	◒	◓	◓	◓	⊙	⊙	⊙	◒	◒	◓	◒	◒	◒
	Primary Sedimentation	◒	◓	◓	◓	◓	◓	⊙	⊙	◒	◒	◒	◒	⊙
	Flocculation/Sedimentation	◒	◓	◓	◓	◒	◒	⊙	⊙	◒	◒	◒	◒	⊙
	Dissolved Air Flotation (DAF)	◒	◓	◓	◒	⊗	⊙	⊙	◒	◒	◒	◒	◒	⊙
	DAF with Polymer Addition	◒	◓	◓	◒	⊗	⊙	⊙	◒	◒	◒	◒	◒	◒
	High Rate Filtration (HRF)	◒	◓	◓	◒	⊙	⊙	⊙	◒	◒	◒	◒	◒	◒
	Flocculation/HRF	◒	◓	◓	◓	⊙	◒	⊙	◒	◒	◒	◒	◒	◒
Biological Treatment	Columbia Boulevard WWTP					◓	●	◓	●	◓	◓	◒	◓	●
	Wetlands Treatment					◓	◓	⊙	◒	◓	◒	◒	●	◒

● Excellent ◓ Very Good ◒ Good ⊙ Poor ⊗ Adverse

SOURCE: CH2MHILL, 1993

Exhibit 3-10. Control Technologies Screening Summary

CSO Control Technology	Consider for Widespread Use	Consider for Localized Use	Consider for Interim Use	Eliminate from Further Consideration
Source Controls				
Street Sweeping			X	
Construction Site Erosion			X	
Catch Basin Cleaning			X	
Industrial Pretreatment		X	X	
Garbage Disposal Ban				X
Onsite Domestic Wastewater				X
Combined Sewer Flushing			X	
Sewer System Optimization				
Static Flow Control	X		X	
Variable Flow Control	X			
Real-Time Flow Control	X			
Inflow Reduction Techniques				
Upland Storm Water Storage		X		
Storm Water Sumps		X		
Sewer Separation	X	X		
Stream Diversion		X		
Storage				
Earthen Basins				X
Open Concrete Tanks				X
Closed Concrete Tanks	X			
Storage Conduits	X			
Storage Tunnels	X			
Physical/Chemical				
Swirl Concentrator				X
Vortex Separator		X	X	
Coarse Screening				X
Primary Sedimentation	X			
Flocculation/Sedimentation				X
Dissolved Air Flotation (DAF)				X
DAF with Polymer Addition				X
High Rate Filtration (HRF)				X
Flocculation/HRF				X
Chlorination/Dechlorination	X			
Biological Treatment				
Columbia Boulevard WWTP				X
Wetlands		X		

Source: CH2MHILL, 1993

EVALUATION OF ALTERNATIVES FOR CSO CONTROL

SWMMs were developed for each of the 43 combined sewer basins and for the major interceptors, and calibrated and verified based on extensive rainfall and flow data. Both long-term (15 years) and single-storm simulations were performed using the calibrated models. In addition to the CSS hydraulic modeling, CSS pollutant and receiving water quality models were developed to assess CSO impacts to the Willamette River.

The first step in the CSO control approach for Portland was to focus on technically simpler and lower cost methods that could be implemented on a neighborhood scale to reduce the size of the CSO problem. It is anticipated that the following projects, called Cornerstone Projects, will reduce the annual average volume of overflow by 47 percent (AMSA, 1994):

- **Storm Water Sump Construction**—Much of the combined sewer area has highly permeable soils with a high hydraulic capacity. Street inlets are currently being disconnected from the CSS and connected to sumps, which are designed to infiltrate the storm water into the ground. The sumps are designed to settle suspended solids and reduce pollutant loads.

- **Roof Drain Disconnections**—Most of the roof drains in the combined sewer service area are connected to the CSS. A program is currently underway to disconnect these roof drains from the CSS and dispose of the drainage on site. Roof drain disconnection is particularly effective in areas to be sumped, because any roof drainage leaving the property would be kept out of the CSS.

- **Street Diversion**—As Portland grew, several streams in Portland were channelized and routed into pipes to allow property development in the downtown area. These streams discharge into the CSS and reduce the collection system capacity available for sewage. The city will be disconnecting these streams from the CSS.

- **Local Sewer Separation Projects**—Sewer separation is planned in areas where the CSS is undersized, in remote basins where conveyance costs are high, and where the outfalls discharge to sensitive areas, such as parks. Several of these separation projects are being designed and built.

The next step was to analyze the amount of remaining overflow that would occur in the Columbia Slough. The Slough is shallow and slow moving and can be dominated by CSOs during large storm events. It has been identified as water quality limited for bacteria, pH, aesthetics, and some toxics. The facility plan concluded that the presumption approach identified in the CSO Control Policy would not provide adequate treatment for the Slough. The recommended control plan is to capture overflows to the Slough to the once in 10-year summer storm and the once in 5-year winter storm. All combined sewage flow resulting from storms smaller than these design storms will be conveyed to a wet weather treatment facility at the Columbia Boulevard Treatment Plant Site. It is anticipated that CSOs from storms larger than these design storms will continue to overflow without treatment. This represents a 99.6-percent capture of the existing CSO volume to the Columbia Slough.

The final step was to analyze the amount of remaining overflow that would occur in the Willamette River. Because of the swifter-flowing nature of the river, the large volume of water it contains, and the river's own ecology, the facility plan examined options to protect the beneficial uses of the Willamette River with facilities that capture and treat less CSO volume than required by the SFO. The approach was to compare the methods, benefits, and costs of alternative levels of control ranging between the two key benchmarks—the SFO and the CSO Control Policy. The resulting recommended plan is to capture overflows to the Willamette to the one in 3-year summer storm and the three in 1-year winter storm. All combined sewage overflow resulting from storms smaller than these design storms will be conveyed to a wet weather facility located on the Willamette River. A fallback option determined to be technically feasible but more costly is to convey the Willamette River overflows to the Columbia Boulevard Wastewater Treatment Plant. Overflows from storms larger than these design storms will continue to overflow without treatment. This represents a 94-percent capture of the existing overflow volume to the Willamette River.

To capture and treat the overflow, the city will rely on a combination of storage and wet weather treatment. A number of storage and treatment options were considered in the facilities plan for their ability to cost effectively store and treat overflows, for their operational simplicity, for their implementability within Portland, and for their ability to protect water quality and beneficial uses. Wet weather storage will be provided by oversizing the tunnels that convey overflows to the new wet weather treatment plants. This will provide in-line storage. Off-line storage will not be a major component of the CSO solution for Portland. Wet weather treatment will include screening, sedimentation basins, and disinfection. The planning assumption was that disinfection will be accomplished with hypochlorite injection followed by dechlorination. It is anticipated that the discharges from the treatment plants will allow in-stream WQS to be met at the edge of the mixing zone.