Chapter 8.
Preferred CSO Control Alternative Selection

The alternatives for providing various levels of CSO control presented in Chapter 6 were evaluated, based on the following factors:

- Predicted system-wide control performance.
- Economic (capital, annual operation and maintenance, and present worth) costs.
- Technical aspects, such as constructibility, operability, and implementability.
- Environmental factors, such as recreational usage, fish and shellfish protection, water quality, and traffic.

This chapter summarizes the evaluation of the six principal alternatives to provide CSO control for the Denny Way / Lake Union Project area.

8.1. Evaluation of Control Performance

The CSO control performance for each alternative was examined with respect to the following parameters:

- Discharge frequency and volume.
- Total suspended solids removal.
- Effluent settleable solids.
- Fecal coliform levels at the edge of the chronic mixing zone boundary.

For comparison purposes, the predicted performance of each alternative for each of the parameters is shown in Table 8-1. The baseline condition is assumed to be the 1998 CSO condition as described in Section 4.3.1. The estimated baseline overflow volume is 550 million gallons (MG) per year and includes Dexter and Lake Union overflows.

8.1.1. Performance Evaluation Methodology

The King County hydraulic model was used to estimate the performance of each alternative. The model predicts the flow rate through the various system components based on seven King County design storms. The derivation of system flows based on these seven design storms is essentially the same methodology used to predict performance of the entire King County system in the *1988 Plan* and the *1995 CSO Update*.

Design Storms. King County has used seven selected design storms for design and analysis of CSO conditions and facilities since development of the *1988 CSO Control Plan*. These actual storms were selected from the years 1981, 1982, and 1983 (the baseline years for the *1988 Plan*) to represent the full spectrum of storms that occur. The overflows predicted from computer simulation of the system with these storms are multiplied by factors developed during 1988 CSO planning work and the result summed to estimate the annual average overflows from the system. The design storms, their frequency and date of occurrence, and multiplier for annual volume estimates, are shown in Table 8-2. These storms form the basis of the hydraulic analysis used to select a preferred Denny Way / Lake Union project.

Design Storm 6 is assumed to be the once-per-year storm and was chosen as the basis of design for the final Denny Way / Lake Union project to coincide with Ecology's one untreated discharge per year CSO control requirement. Treatment and pumping facilities within the project have been sized based to meet project goals during Design Storm 6. The west flow stream includes overflows from the Elliott Bay interceptor. Overflows from the Elliott Bay interceptor are subject to control at the Interbay pump station. The flow projections used are based on Interbay being operated at its 133 mgd capacity.

Simulated Project Inflows. King County has estimated flows over time for each pipeline within the system for each of the design storms. From this data, hydrographs were produced and analyzed for critical elements of the system. Flows have been aggregated for appropriate system elements to determine the east and west flow stream hydrographs resulting from each of the design storms. Table 8-3 presents the peak flow from each of these hydrographs. The total system discharge peak flow is the total flow that must be discharged via the Elliott West and Denny Way CSO outfall extension. It is equal to the sum of the east and west peak flows only when those peaks are coincident.

There are instances where system peak flow is not equal to the sum of the two peak flows because the peak flows for the east and the west flow streams occur at slightly different times.

King County has recently modified its computer hydraulic model to better maintain continuity in the Elliott Bay interceptor. As a result of this modification, predicted overflows from the Elliott Bay interceptor during the design storms have increased over those used during the initial development of the project (i.e., the February 1995 *Denny Regulator Accelerated CSO Control Program Report).* The analysis presented here includes these higher flows.

As described in Chapter 10, following selection of a preferred alternative, the Denny Way / West Point system was modeled again using six years of actual rainfall data rather than the seven design storms. That later modeling was done in order to verify performance predictions and to begin optimizing the preferred alternative. However, the selection of a preferred alternative from among the six alternatives considered was based entirely on modeling of the system using the seven design storms as input.

Table 8-2. Characteristics of King County Design Storms

Storm No.	Storm date	Total rainfall depth, inches	24-hour depth return frequency	Intensity[a] return frequency	Frequency of overflow[b]	Total storm duration (hours)	Annual volume multiplier[c]
1	1/4/83	2.86	10 year	2 years	4-5 years	30	1.16
2	3/10/83	0.09	25 per year	25 per year	52/year	1	13.3
3	9/10/83	0.37	5 per year	5 per year	21/year	2	7.89
4	10/6/82	0.62	10 per year	5 per year	14/year	10	8.33
5	10/28/82	1.10	5 per year	2 years	3-4/year	16	3.33
6	11/17/82	1.54	2 per year	2 years	1-2/year	22	2.31
7	12/3/82	2.29	25 years	25 years	4-5 years	12	0.95

[a] Intensity at 6-hour duration or longest duration of storm.

[b] CSO frequency associated with this class storm in the *1988 CSO Control Plan*.

[c] CSOs associated with each storm are multiplied by this factor and the result summed to estimate annual CSO volume.

Table 8-3. Peak Flows Projected for Each Design Storm

Design storm number	West end peak flow, mgd	East end peak flow, mgd	Total Denny discharge peak flow, mgd
1	103	80	172
2	34	21	0
3	128	92	0
4	65	43	49
5	97	49	135
6	132	84	197
7	179	125	331

8.1.2. Performance of Partial Separation Alternative

Partial separation involves removing a part of the stormwater inflow from the combined system and redirecting that flow to a stormwater outfall. That is a different approach from storage and treatment as used by the other five alternatives, and a direct comparison of treatment performance between Alternative 1 and the other five alternatives is therefore difficult. Overall CSO and stormwater discharge volume would decrease with Alternative 1, but stormwater discharges would increase. Urban stormwater contains pollutants, including oil, litter, and grime, that are washed down a storm drain not just during CSO events, but every time it rains. With Alternative 1, stormwater pollutant contributions to Lake Union and Elliott Bay would increase, as stormwater presently captured and treated at a secondary treatment plant with the combined sewer system would be released through storm drains with only minimum treatment. The amount of change in the overall pollutant load is difficult to quantify. However, analysis of a similar project at the Michigan regulator as part of King County's Water Quality Assessment Project indicated that partial separation would be expected to reduce total discharge (CSOs and stormwater) by only 11 percent annually. Because the heavy metals and TSS concentrations in stormwater are similar to CSOs, the reduction in these pollutants would also be about 11 percent on an annual basis.

The project team looked at the environmental and economic aspects of Alternative 1 before investing the effort required to develop a quantitative approach to evaluating the treatment performance of a partially separated system for Denny. As noted in subsequent sections of this chapter, the environmental and economic costs of partial separation are high. Sewer separation would result in widespread construction impacts to yards, streets, neighborhoods, traffic, and utilities within the area to be separated. In addition, partial separation has the second-highest capital cost of any of the alternatives (see Section 8.2). Alternative 1 has the highest unit cost for removing suspended solids of all the alternatives.

Partial separation has been rejected as a control option for the Denny basin because sewer separation is the second most expensive and most disruptive approach to CSO control and because partial separation would actually increase the volume of untreated stormwater being discharged to Elliott Bay and Lake Union. A full evaluation of the treatment performance of a partial separation project has not been made.

8.1.3. Discharge Frequency and Volume

The predicted discharge frequency and discharge volume to Elliott Bay for each alternative is shown on Figure 8-1 and Figure 8-2.

Alternative 1 would reduce untreated CSO discharges to Elliott Bay and Lake Union to not more than one per year. There would be no treated discharges at either location because Alternative 1 does not include any kind of treatment facility but relies on stormwater best management practices. The remaining CSO discharge would amount to approximately 20 MG per year. However, untreated stormwater discharges to Elliott Bay and Lake Union would increase with this alternative, as stormwater discharges would occur not only during the 51 storms per year that now produce overflow events at the Denny Way regulator station, but also during most smaller storms that do not produce Denny Way overflows.

Alternative 2 would result in an average of 14 to 16 treated annual discharges and four to six untreated discharge events to Elliott Bay. The estimated CSO volume discharge would be reduced from 550 MG per year to about 159 MG, a reduction of 391 MG or about 71 percent. Alternatives 3 and 4 would likewise result in approximately 14 annual treated discharges per year, but the number of annual untreated discharge events would fall to one in accordance with Washington state regulations. The estimated annual CSO volume discharged would be reduced from 550 MG to 55 MG, a 90 percent reduction, with either Alternative 3 or 4.

Alternative 5 would result in approximately four to six untreated discharges per year. The estimated annual Elliott Bay CSO discharge volume reduction would be approximately 391 million gallons, a 71 percent reduction in overflows at Denny Way.

Alternative 6 would result in one untreated discharge per year. The estimated annual Elliott Bay CSO discharge volume reduction would be approximately 495 million gallons, a 90 percent reduction in discharge volume.

8.1.4. Total Suspended Solids Removal

The predicted system-wide annual total suspended solids (TSS) removal for Alternatives 1 through 6 is shown on Figure 8-3. The TSS removal was calculated based on the assumption that the CSO flows transferred to the West Point plant would receive 85 percent TSS removal. In addition, TSS removal would occur on site with Alternatives 2, 3, and 4. However, until more information concerning the settling velocity distribution in influent flows has been collected, on-site TSS removal efficiency cannot be reliably predicted. A CSO monitoring program has been implemented to develop the information needed to make reliable predictions.

With Alternatives 2 and 3, treated discharges to Elliott Bay would receive floatable material removal, solids removal, and disinfection prior to discharge through the new Elliott West outfall. Alternative 2 would meet the federal CSO control policy level of 35 percent annual TSS removal, calculated with a system-wide mass balance approach. Alternative 3 would meet the state CSO control requirement of 50 percent annual system-wide TSS removal. Alternative 4 would achieve approximately 61 percent annual system-wide TSS removal.

Alternatives 5 and 6 would provide system-wide TSS removal by storing sufficient quantities of combined sewage flow to control untreated discharges and diverting the stored flows to West Point for treatment and disinfection. Alternative 5 would achieve 66 percent annual TSS removal. Alternative 6 would achieve 78 percent TSS removal.

8.1.5. Treated Effluent Settleable Solids

The predicted treated effluent settleable solids discharge to Elliott Bay for each alternative is shown on Figure 8-4.

Alternatives 2 and 3 would remove floatable material and significantly reduce the aesthetic impacts associated with high settleable solids CSO discharges. Alternative 2 is designed to meet the requirements of the federal CSO policy, which has no settleable solids limit. Alternative 3 is predicted to have a settleable solids effluent long-term geometric mean of 0.3 mL/L/hr, with a maximum per event limit of 2.0 mL/L/hr. Alternative 3 would limit settleable solids discharge to only the larger rainstorm events. Alternative 4 would provide storage/treatment tanks, chemical addition, and dissolved air flotation to reduce settleable solids concentrations for each treated discharge to the Ecology settleable solids limit of 0.3 mL/L/hr.

Alternatives 5 and 6 would store flows until they could be treated at West Point and discharged through its outfall. The West Point plant consistently achieves settleable solids discharges of 0.1 mL/L/hr or less on a monthly basis.

8.1.6. Fecal Coliform Levels

The predicted treated fecal coliform discharge to Elliott Bay for Alternatives 2 through 6 is shown on Figure 8-5. The fecal coliform water quality requirement is a monthly geometric mean of 14 colonies per 100 mL at the edge of the chronic mixing zone, with no more than 10 percent of the samples exceeding 43 colonies per 100 mL. All combined storage and at-site CSO treatment alternatives would provide disinfection to meet state water quality standards for fecal coliform and dechlorination and water quality standards for residual chlorine. However, disinfection is not required for the storage and conveyance alternatives, as they would only discharge untreated flows to Elliott Bay within the discharge frequency limits imposed by the specific federal or state CSO control requirements.

Discharges from Alternatives 2 and 3 would not cause the monthly geometric mean of the receiving water to exceed the chronic fecal coliform standard of 14 colonies per 100 mL and would not exceed the maximum monthly chronic fecal coliform excursion limit of 43 colonies per 100 mL. Alternative 4 would meet the state receiving water chronic fecal coliform limit of 14 colonies per 100 mL for each treated discharge.

No disinfection would be provided for Alternatives 5 and 6 because both alternatives would store flows until they could be conveyed to West Point for treatment, disinfection, and discharge through the West Point outfall.

8.2. Economic Factors

Comparisons of economic factors involved development of capital and annual operation and maintenance costs for each CSO control alternative. The alternatives were then compared on the basis of present worth costs, including salvage values, to determine cost-effectiveness for CSO volume reduction and total suspended solids removal.

8.2.1. Capital Costs

Capital costs were developed by estimating the costs of constructing the components of the various alternatives, then adding cost factors such as contingency, sales tax, King County related costs (e.g., property acquisition, project management), and engineering design and construction management. All costs were prepared in first quarter 1996 dollars based on *Engineering News Record Construction Cost Index (ENR CCI)* of 5537. Contingency costs ranging from 20 to 35 percent were applied for each type of facility, including pipelines (20 percent), regulator and flow diversion structures (20 percent), marine outfalls (30 percent), tunnel (20 to 25 percent), and CSO treatment and pump stations (35 percent). Other capital costs items included 8.6 percent for sales tax, allowances for property and right-of-way acquisition, King County soft capital costs, and 23 percent for design and construction management.

Capital costs for the project are shown in Table 8-4. The highest cost alternative is Alternative 6, the twin-tunnel alternative. Alternative 6 has the most storage capacity and, therefore, the highest tunnel cost. The existing Denny Way CSO outfall would have to be extended, but no new outfall would be needed because all of Design Storm 6 is being stored and conveyed to West Point. Also, the Elliott West facility would be the least complex, as indicated by the relatively small cost for that facility. The second highest cost is for Alternative 1, partial sewer separation. A more detailed cost table is included as Appendix C.

Table 8-4. Total Project Capital Costs (in millions) for CSO Control Alternatives

	Alt. I	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Elliott West facility	$24.5	$29.3	$30.1	$50.3	$12.2	$15.0
Outfalls	$25.6	$6.6	$6.6	$12.3	$4.2	$4.2
South Lake Union conveyance facilities	$3.9	$7.8	$7.8	$7.8	$7.8	$7.8
Mercer Street tunnel	$0	$34.4	$41.8	$34.5	$96.0	$204.0
Denny CSO conveyance facilities	$10.7	$16.9	$16.9	$16.9	$8.4	$8.4
City of Seattle, Phase 2 conveyance	$0	$6.2	$6.2	$6.2	$6.2	$6.2
Storm sewer separation	$104.4	$0	$0	$0	$0	$0
South Lake Union CSO storage facility	$44.7	$0	$0	$0	$0	$0
Total project capital cost[a]	**$213.8**	**$101.2**	**$109.4**	**$128.0**	**$134.8**	**$245.6**

[a] All costs in first quarter 1996 dollars, *ENR CCI* = 5537

8.2.2. Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs were developed based on four major cost categories: labor, power, chemicals, and equipment repair and replacement. In addition, a 25 percent contingency was included for the annual O&M costs. O&M costs are directly dependent upon the number of overflow events. In addition, the West Point treatment costs associated with diverting additional CSO flows to the plant, calculated using a unit cost of $363 per million gallons of flow, were included in the total O&M costs. Those costs represent the increase in West Point's annual O&M costs to handle the Denny Way flows diverted to West Point for treatment and disposal. Table 8-5 shows the relative O&M cost for each alternative.

The table reveals that the alternatives involving treatment have the highest labor costs. Power costs are generally higher for the at-site CSO treatment alternatives, but power consumption is also directly related to the number of discharges, since discharge through the outfall requires effluent pumping. Labor, power, and repair and replacement of equipment would be lowest in the twin tunnel configuration because it is essentially a passive system with only a single pump station. The equipment costs for Alternatives 2 and 3 are lower because the submerged baffles for floatables control are considerably less expensive than the dissolved air flotation and sedimentation tank equipment included in Alternative 4.

Table 8-5. CSO Storage and Treatment Operation and Maintenance Costs

	Alt. I	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Annual operation and maintenance costs (thousands)						
Labor	$904	$29	$32	$59	$9	$10
Power	$21	$15	$31	$59	$7	$21
Chemicals	$0	$41	$29	$33	$0	$0
Equipment repair and replacement	$30	$79	$107	$135	$29	$43
Miscellaneous (25 percent)	$239	$41	$50	$72	$11	$19
Annual West Point O&M cost to treat diverted flows	$67	$72	$116	$116	$142	$180
O&M costs, total [a]	$1,261	$282	$366	$476	$202	$270
Present worth O&M cost (20 years at 7.625 percent)	**$12,730**	**$2,850**	**$3,700**	**$4,810**	**$2,040**	**$2,720**

[a] All costs in first quarter 1996 dollars, *ENR CCI* = 5537

8.2.3 Present Worth Costs

The bottom row of Table 8-5 shows the present worth value of the annual O&M costs. Present worth represents the investment required to provide a cash stream equal to the annual O&M costs over 20 years. The present worth is influenced by the cost of money or interest: higher interest rates produce a greater cash flow and therefore reduce the original investment. Table 8-5 reflects an USEPA interest rate of 7.625 percent, which produces a present worth factor of 10.10. The present worth factor multiplied by the annual O&M cost will give the present worth of annual O&M costs. No escalation of labor or energy costs was included in the present worth calculations.

An important element in determining the present worth costs for the project as a whole is salvage value. The depreciated value of structures and equipment at the end of the 20 year planning period was used as salvage value. To compute salvage value, structures and equipment were depreciated using straight-line depreciation and a 50-year useful life. The depreciated value after 20 years was then discounted to its present value. Structures included concrete structures such as pump station wet wells, floatable material control structures, regulators and diversion structures, and chemical storage and feed facilities. Conveyance pipelines and the CSO storage tunnel, including the drop structure, were assumed to have a 75 year useful life. Other items of equipment (including influent and effluent pumps, disinfection and dechlorination equipment, standby power generator, electrical and control equipment, and heating and ventilation equipment) were depreciated using a 20-year useful life. Land for the Elliott West site was not considered a depreciable asset and was therefore assumed to have 100 percent salvage value at the end of the 20-year planning period.

A 20-year present worth project cost, expressed in first quarter 1996 dollars, was estimated for each CSO control alternative using capital costs, present worth of O&M costs, and salvage value. No inflation or escalation of costs was used in calculating the present worth costs. Table 8-6 and Figure 8-6 show the present worth cost for each alternative.

Table 8-6. Present Worth Project Cost Comparisons (in millions)

	Alt. I	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Total project cost	$213.8	$101.2	$109.4	$128.0	$134.8	$245.6
Present worth of annual O&M cost	$12.7	$2.9	$3.7	$4.8	$2.0	$2.7
Less salvage value	($18.3)	($8.7)	($9.2)	($10.4)	($12.2)	($22.4)
Total present worth cost [a]	**$208.2**	**$95.4**	**$103.9**	**$122.4**	**$124.6**	**$225.9**

[a] All costs in first quarter 1996 dollars, *ENR CCI* = 5537

8.2.4. Cost-Effectiveness

The following cost/benefit relationships have been identified for the six CSO alternatives to facilitate selection of a preferred configuration for the Denny Way/Lake Union CSO Control Project:

- Relationship between present worth costs and reduction and discharge volume (i.e., volume of flows diverted to West Point Treatment Plant) for each alternative.
- Relationship between present worth costs and suspended solids removed for Alternatives 2 through 6.

Cost per Gallon of CSO Volume Reduced. Each of the alternatives would store some of the CSO that would otherwise overflow at Denny Way (or Lake Union or the Dexter regulator) without the project. Table 8-7 shows the actual CSO volume in million gallons that would be diverted to West Point. Without this project, 550 MG of CSO would overflow at Denny Way. The second row of the table shows number of million gallons being diverted.

By comparing the number of gallons diverted to West Point with the present worth project cost, the cost per million gallons of CSO diverted to West Point can be computed (See Figure 8-7). The bottom line in Table 8-7 indicates Alternative 3 has the lowest unit cost for flow diverted to West Point. Alternatives 1 and 6 have the highest unit cost.

Table 8-7. Cost of Annual CSO Volume Discharge Reduction (in millions)

	Alt. I	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Present worth cost of alternative[a]	$208.2	$95.4	$103.9	$122.4	$124.6	$225.9
Volume diverted to West Point (MG/yr)	185	198	319	319	391	495
Volume treated and discharged at Denny	0	193	186	186	0	0
Total volume reduction	185[b]	391	495	495	391	495
Cost per gallon of CSO reduction	**$1.13**	**$0.24**	**$0.21**	**$0.25**	**$0.32**	**$0.46**

[a] All costs in first quarter 1996 dollars, *ENR CCI* = 5537.

[b] Does not include CSO reduction resulting from removal of stormwater inflow from system.

Cost per Pound of Suspended Solids Removed. Total influent suspended solids at Denny Way generated by CSOs is estimated to be approximately 365,000 pounds per year. Solids reduction in the Denny Way system is a combination of the solids reduction that takes place at the site (for those alternatives that include a CSO treatment tank) and the solids removal that occurs at West Point for the flows diverted there. Table 8-8 shows the total number of pounds of solids predicted to be removed from the influent CSO flows, without regard to whether the solids removal would take place at Denny Way or West Point. Figure 8-8 shows the cost per pound of TSS removed.

Table 8-8. Cost of Suspended Solids Removal

	Alt. I	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Present worth cost of alternative (in millions) [a]	$208.2	$95.4	$103.9	$122.4	$124.6	$225.9
Annual pounds of suspended solids removed	104,500	128,000	205,000	223,000	241,000	289,000
Cost per pound of solids removed [a]	**$1,992**	**$745**	**$507**	**$549**	**$517**	**$782**

[a] All costs in first quarter 1996 dollars, *ENR CCI* = 557

Note that all solids removal for Alternatives 2 through 6 is predicted to take place at West Point. In fact, however, the tunnels included in these alternatives are essentially quiescent, and the contents of the tunnels would discharge over weirs. It is certain that some solids would settle out in the tunnel, and some removal would therefore occur.

The amount of settling is very difficult to predict at this stage of project design, however. Therefore, the calculations on which Table 8-8 are based do not include any pounds of TSS that might be removed in the storage tunnels. Once additional CSO sampling has been completed and a distribution of settling velocities in the influent is known, then a prediction about solids removal in the various tunnels can be made. Because in-tunnel TSS reduction would occur with each of Alternatives 2 through 6, it is not expected that inclusion of solids removed in the tunnel is likely to change the cost effectiveness of any one alternative relative to the others.

8.3. Technical Factors

The alternatives were evaluated according to several technical factors, including construction risk and difficulty, operability, and implementability. This evaluation rated the alternatives as above average, average, or below average. This rating system is somewhat subjective, but it does identify alternatives with clear advantages or disadvantages compared to others. The comparison factors are described below, and technical evaluation is summarized in Table 8-9.

8.3.1. Construction Risk and Difficulty

The degree of difficulty of constructing specific components was considered quantitatively through additional cost requirements, such as imported backfill material and increased construction contingency, different tunnel production rates for different tunnel diameters, and pipe installation rates for marine versus land pipeline construction.

The construction risk was determined through a qualitative evaluation of the complexity of the type of construction. For example, it was assumed that constructing facilities on the County-owned Elliott West site is less difficult and has less risk of damaging adjacent property than constructing a large-diameter, underground tunnel beneath multiple property owners and facilities.

8.3.2. Operability

The operation of the CSO control alternatives was determined quantitatively by estimating annual O&M costs, and qualitatively by considering several operational factors, such as level of operational control required, periodic cleaning required for floatable material control structures and storage tanks, seasonal and intermittent operation, operational flexibility to respond to different storm intensities and durations, and the ability to meet discharge limits. For example, tunnel storage was assumed to be more reliable than at-site CSO treatment because of the less complex operational control system required for a passive tunnel storage system.

8.3.3. Implementability

An opinion of possible public acceptance of, or opposition to, the implementation of the alternatives (or to specific components of the alternatives) was developed. For example, it was assumed that construction of large, open-air CSO storage tanks at the Elliott West site would be less acceptable to the general public than constructing a pump station that would resemble an industrial building.

8.4. Environmental Factors

Possible environmental impacts associated with each alternative are described in Chapter 7. The major environmental factors used to evaluate the CSO control alternatives are recreational impacts, impacts to fish and shellfish resources, water quality impacts, traffic impacts, and construction impacts to treaty tribes' commercial fishing activities and to possible cultural resources along pipeline alignments and other excavations associated with the project. The separate project supplemental EIS and NEPA environmental assessment documents address the environmental impacts in detail. The environmental evaluation is summarized on Table 8-10, and the comparison factors are described below.

8.4.1. Recreational Impacts

Public recreational use was divided into the following categories: primary contact recreation (e.g., swimming), sport fishing, boating, and aesthetic enjoyment. An estimate of the discharge frequency for each month of the year was developed, in order to determine the impact. It was assumed that discharges during the summer season, when recreational use is high, are less desirable than discharges during the low recreational winter months.

8.4.2. Impacts to Fish and Shellfish

Potential impacts upon existing shellfish and fisheries resources were evaluated. There are existing fish rearing pens near the proposed treated discharge outfall location, as well as established migratory fish patterns.

8.4.3. Water Quality Impacts

Depending on the alternative selected, the project would discharge untreated CSOs and treated effluent into Elliott Bay. WAC 173-201A-140 classifies Elliott Bay as Class A marine waters. WAC 173-201A-030(2) defines the applicable water criteria for Elliott Bay. Fecal coliform and residual chlorine are assumed to cause the greatest concern. An estimate was made for each alternative for the fecal coliform and chlorine residual concentrations at the edge of the chronic mixing zone, and compliance with the water quality requirements was also predicted for each alternative. Alternatives that would not discharge treated effluent (Alternatives 5 and 6) were considered to have a lower adverse impact than Alternatives 2, 3, and 4, which discharge treated effluent many times per year.

8.4.4. Traffic Impacts

Areas of railroad, streets, and marine traffic may be disturbed as a result of the construction of all alternatives. Street traffic would be impacted by the short-term street closures during construction of pipelines, storm sewers, and underground storage facilities buried beneath streets. Railroad traffic may be impacted by temporary disruption of side railing access during construction. Marine traffic may be impacted during construction of new outfall structures.

8.5. Selection of Preferred Project Configuration

Alternative 3 was selected as the preferred alternative based primarily on the cost-effectiveness evaluation. On a cost per pound of solids removed and a cost per gallon of discharge reduced, Alternative 3 provides the greatest water quality benefit per dollar invested. In addition, Alternative 3 will also provide floatables removal and disinfection/ dechlorination to meet water quality standards. Other alternatives provides greater total solids removal and/or volume reduction than the preferred alternative, but the cost of removing each additional pound of solids or million gallons of overflow volume is higher with the other alternatives than with the preferred system. The preferred alternative satisfies the state requirement of one untreated discharge event per year, 50 percent suspended solids removal, disinfection/dechlorination to meet water quality standards, and effluent settleable solids limits based on a long-term geometric mean. The preferred alternative would satisfy all these requirements for nearly $20 million less in present worth cost than the next lowest-cost alternative.

The federal CSO control policy alternatives (Alternatives 2 and 5) would not comply with the more stringent Washington State regulations. Therefore Alternatives 2 and 5 were not considered viable.

Alternative 1 involves removing a portion of the stormwater inflow to the combined system and redirecting that flow to a stormwater outfall. This is a different approach from the approaches used for the other five alternatives, making a direct comparison difficult. Overall CSO discharge volume would decrease with Alternative 1, but stormwater pollutant contributions to Lake Union and Elliott Bay would increase. Partial separation has been rejected as a control option because it has the highest unit costs for volume and solids removal and is the most disruptive approach to CSO control.

Alternatives 4 and 6 were not selected because they were not cost-effective. Although these alternatives have the highest water quality benefits in terms of volume and/or solids reduction, they have higher capital and present worth costs than the preferred alternative.

Alternative 3 would satisfy current state requirements for CSO control as described below.

Number of Annual Untreated Discharge Events. This alternative will provide a combination of storage and at-site CSO treatment to control untreated discharges to one per year at the Denny Way and Lake Union CSOs (i.e., to control King County's Design Storm 6). A CSO control project that controls Design Storm 6 by either storing the combined sewer flows and conveying them to a treatment plant (West Point) for treatment and disposal, or by storing flows and providing at-site CSO treatment before discharge, meets state CSO control requirements. Flows diverted to West Point would receive either secondary treatment or blended primary/secondary treatment and disinfection.

Suspended Solids Removal. Alternative 3 would, by combining on-site treatment at the Elliott West site and treatment of flows stored at and conveyed to West Point, achieve 50 percent TSS reduction system-wide and satisfy the state requirements. It is estimated that approximately 310 million gallons diverted to West Point per year will result in about 56 percent TSS reduction for the Denny Way system. Additional TSS reduction will undoubtedly occur in the new facilities, although insufficient data exists to reliably predict the on-site TSS removal efficiency.

Disinfection. Flows in excess of storage capacity of the tunnel and the conveyance capacity of the Elliott Bay interceptor would receive floatable material removal and disinfection prior to discharge through the new Elliott West outfall. Flows from storms greater than King County Design Storm 6 would produce untreated discharges at the new Denny Way CSO outfall extension. The volume of untreated CSO discharges would decline by 90 percent at the Denny Way CSO outfall, however.

Water Quality Standards. In addition, the preferred alternative will satisfy the state water quality standard for chronic fecal coliform levels by not exceeding the fecal excursion limit of 43 colonies per 100 mL, based on a predicted maximum daily treated discharge flow of 80 mgd and an "end of pipe" fecal coliform concentration of 400 colonies per 100 mL. In addition, flows would be dechlorinated to meet chlorine residual water quality limits.

Settleable Solids. Even though effluent settleable solids discharge from the Elliott West outfall would exceed 0.3 mL/L/hr on occasion, the settleable solids discharge would meet Ecology's 0.3 mL/L/hr limit on a long-term, geometric mean basis. A settleable solids discharge limit per event is proposed at 2.0 mL/L/hr as a means of determining compliance with the long-term limit.

Following selection of Alternative 3 as the preferred alternative, the project team looked at a number of changes or refinements to Alternative 3 in hopes of improving system performance and/or reducing costs. The results of that refinement process are discussed in Chapter 9.