APPENDIX B, Economic Evaluation

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Additional Water Storage Project, Draft Feasibility Report & EIS

Howard Hanson Dam,
Green River, Washington
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prepared by
Seattle District
US Army Corps of Engineers

Tacoma Public Utilities

US Army Corps of Engineers®

APPENDIX B
ECONOMIC ANALYSIS AND COST SHARING

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SECTION 1 PROJECT AREA ASPECTS

1.1 PROJECT LOCATION AND DESCRIPTION

Howard Hanson Dam (HHD) is located on the Green River at river mile 64.5 in the south-central area of King County, Washington. The authorized project is currently operated for flood control and low flow augmentation. Other project purposes which were authorized but have never been implemented include municipal and industrial (M&I) water supply (up to 20,000 acre-feet), irrigation (agricultural) water supply and hydropower.

Approximately 3 miles downstream from HHD, the city of Tacoma, operates a 17-foot-high concrete M&I water supply diversion facility which can divert up to 113 cubic feet per second (cfs) from the Green River. Approximately 72 million gallons per day (mgd) is diverted 26 miles through a concrete and steel gravity pipeline (No. 1) to a water supply reservoir 8 miles northeast of Tacoma and then to the city. The existing diversion is from natural flows not from storage behind HHD. Tacoma's water supply is chlorinated. No other treatment of the water from this source is currently required since the watershed is closed to the general public. The majority of Tacoma's M&I water supply needs are met through this diversion facility.

Tacoma is in the process of constructing a second water supply pipeline known as Pipeline No. 5, which will carry water from the diversion structure westerly through several south King County communities and then south to Tacoma in Pierce County. In addition, a water supply intertie between Seattle and Tacoma is expected to be in place by project year one. In order to help meet the increasing summer M&I water needs of Pierce and South King Counties as well as Seattle, the proposed project will add up to 48 mgd of "summer/fall" (May/June-September/October) M&I water supply with a 95% reliability.

The proposed project will also provide ecosystem restoration with the intent of restoring "self sustaining" runs of anadromous fish runs in the upper Green River above HHD. Self sustaining runs are defined as fish runs which do not require supplementation of hatchery fish to maintain the run. Hatchery raised fish are considered by fish biologists to be substantially inferior to natural wild runs as they do not survive in the rivers and ocean nearly as well as wild fish. Juvenile hatchery fish are prone to disease, predation by birds and are over aggressive. With naturally produced fish runs, hatcheries will no longer be needed and cost to construct, operate and maintain new hatcheries will no longer be necessary. Restoration measures consist of providing: (1) a fish passage facility which will significantly improve the success of juvenile salmon and steelhead locating and passing from the reservoir to the river below the dam in their migration to the ocean, (2) an additional 9,600 acre-feet (ac-ft) of low flow augmentation storage, and (3) several fish habitat improvement measures.

1.2 POPULATION DATA

Most of the municipal and industrial water supplied by the proposed project will be used to meet future projected water demands in Pierce County. Pierce County, second largest of Washington's 39 counties, had a 1996 population of 665,200, about 12% of the state's population. The largest metropolitan area in the county is the city of Tacoma with a 1996 population of 185,000. Table B1-1 provides an overview of the state, Pierce County and Tacoma population data over the last 16 years.

1.3 HISTORICAL POPULATION GROWTH

Between the years 1980 and 1990, the average annual population growth rate for the state of Washington was 1.65% per year, while the period between 1990 and 1996 averaged 2.1%. Pierce County has also been experiencing an increasing rate of growth over the last 14 years. For example, between 1980 and 1990, the population growth rate in Pierce County average 1.9% per year while over the 1990-1996 period the growth rate has average 2.1%. This table also shows that most of the growth in Pierce County between 1990 and 1996 was outside the city limits of Tacoma. It also shows that the population of Pierce County over the same period has increased about 13,000 people per year on average and is growing at a rate equal to the state as a whole.

TABLE B1-1. POPULATION TRENDS OF WASHINGTON STATE PIERCE COUNTY AND TACOMA, 1980-1996

Year	Washington State (Beg. Of Year)	Pierce County	Tacoma
1980	4,130,163	485,667	158,501
1981	4,250,200	501,300	159,800
1982	4,264,000	504,500	160,100
1983	4,285,100	507,000	158,400
1984	4,328,100	514,600	159,400
1985	4,384,100	524,900	160,800
1986	4,419,700	530,800	158,900
1987	4,481,100	538,000	158,900
1988	4,565,000	547,700	161,400
1989	4,660,700	560,900	162,100
1990	4,866,692	586,203	176,664
1994	5,334,400	648,900	182,800
1996	5,516,800	665,200	185,000
Growth Rates			
1980-1990	1.65%	1.90%	1.09%
1990-1996	2.11	2.13%	.77%

Source: Washington State Office of Financial Management (1980-1996)

1.4 PROJECTED POPULATION GROWTH

Based on the 1995 population forecast prepared by the Forecasting Division of the Washington State Office of Financial Management, the population of Washington State is projected to grow at a rate of 1.5% per year between 1996 and year 2000; 1.47% between years 2000 and 2005 and 1.25% between 2005-2010. In absolute terms, the state population is forecast to be 5,850,000 by year 2000, 6,292,000 by 2005, and 6,693,000 by year 2010. Table B1-2 shows the projected population for Washington State and Pierce County for the above years.

TABLE B1-2. PROJECTED POPULATION* FOR WASHINGTON STATE AND PIERCE COUNTY, MEDIUM GROWTH SERIES, 2000-2010

Year	Washington State Population	Pierce County Population
2000	**5,850,000**	**722,000**
2005	**6,292,000**	**764,000**
2010	**6,693,000**	**812,000**

* Population has been rounded to the nearest thousand.

1.5 EMPLOYMENT DATA

Total non-farm employment growth in Pierce County, as forecast in 1997 by the Washington State Employment and Security Department Office of Labor Market and Economic Analysis Branch is expected to increased from 223,200 in 1996 to 252,100 in 2001 to 271,800 in year 2006. This represents an annual growth rate per year of 2.5% between 1996 and 2001 and a growth rate of 1.5% between 2001 and 2006. While significant growth is expected to occur in most employment sectors of Pierce County, the highest growth is forecast to occur in the service sector and wholesale and retail trade sector. As shown in Table B1-3, service sector employment is forecast to increase by 21.1% between 1996 and 2001 and by 12.5% between 2001 and 2006.
This represents an annual growth rate of 3.9% between 1996 and 2001 and 2.4% between 2001 and 2006. The wholesale and retail sector is forecast to increase by 2.5% per year between 1996 and 2001 and 1.5% between 2001 and 2006. See Table B1-3 for more detailed information on each employment sector.

TABLE B1-3. PROJECTED EMPLOYMENT GROWTH FOR PIERCE COUNTY BETWEEN 1996 AND 2006

				Annual Growth Rates (%)	
	1996	**2001**	**2006**	**1996-2001**	**2001-2006**
Total Non-Farm Employment	223,200	252,100	271,800	2.5	1.5
Manufacturing	22,200	23,300	24,100	1.0	.7
Construction and Mining	12,300	13,300	14,000	1.6	1.0
Transportation & Utilities	9,700	10,600	10,900	1.8	.6
Wholesale & Retail Trade	58,100	65,700	70,900	2.5	1.5
Finance, Ins. & Real Estate	11,000	12,000	12,600	1.8	1.0
Services	62,900	76,200	85,700	3.9	2.4
Government	47,000	51,000	53,600	1.6	1.0

SECTION 2 ECONOMIC EVALUATION

2.1 PROBLEMS AND NEEDS

2.1.1 Water Supply

Tacoma Water defines summer water demands as consisting of both an average demand per million gallons of water per day (mgd) over the May-September time frame (average summer) plus peak demands in mgd over a 4-day peak period during the summer. Based on the medium growth water demand forecast (discussed in Paragraph 2.6.5 of this appendix), compared to the without-project supply of M&I water, the average summer demand for M&I water in the greater Tacoma service area is expected to exceed the without-project summer supply of M&I water by 2003. The 4-day peak demand (discussed in Paragraph 2.6.5), which also occurs in the summer, is expected to exceed the without-project 4-day peak supply of water shortly after project year one. As a result, Tacoma Water Department is in need of a new source(s) of summer water supply sufficient to meet both the average summer and 4-day peak demands for future M&I water.

2.1.2 Ecosystem Restoration

From an ecosystem standpoint, construction of Howard Hanson Dam caused several significant impacts to anadromous fish in the Green River. One major impact was caused by disconnecting the headwaters of the Green River from the downstream Green River Basin. In an attempt to utilize the prime fish habitat in the upper watershed, salmon and steelhead have been reestablished (planted) above the dam. However, juvenile fish trying to pass from the reservoir to the river below the dam in their migration to the ocean, have difficulty finding the outlet works in the dam and when they do they must encounter trying to pass through the existing fish unfriendly by-pass system. Depending on the species, 80-95% of these juvenile fish either cannot find the fish outlet and perish in the reservoir as juveniles or if they do fine the outlet, do not survive the passage to the river below the dam.[1] Other significant impacts to the river as a result of HHD include: (1) reduced amount of fish habitat in both the Green River and its tributaries (2) reduced water quality and peak flows downstream of the dam and (3) elimination of sediment transport of gravel in the river below the dam which is needed for successful spawning of salmon and steelhead. All of these factors have contributed to declining salmon and steelhead runs in the Green River to the point where the runs are no longer self sustaining and must be supplemented with hatchery fish. In fact, chinook runs in rivers of Puget Sound have

[1] Based on a 5-year (season) study of monitoring juvenile fish passage through Howard Hanson Dam.

declined to the point where they are "likely to become endangered" based on a risk assessment of Washington salmonid stocks by the National Marine Fisheries Service as presented in their "Draft Ecosystem Impact Statement of the State of Washington Wild Salmon Policy", Table 11, page 62, dated April, 1997.

The city of Tacoma has requested the Corps of Engineers to study: (1) the feasibility of providing additional summer storage at HHD for the purpose of supplying M&I water during the May-September time frame, and (2) the feasibility of adding ecosystem restoration measures on the Green River with a goal of re-establishing self sustaining runs of salmon (chinook and coho) and steelhead trout in the upper Green River above HHD.

2.2 PROPOSED PROJECT

Based on negotiations between the project sponsor, state and federal resource agencies, Muckleshoot Indian Tribe and Corps of Engineers, implementation of the proposed project will be in two separate phases. The major difference between the phases is a change in the source of water used for storage behind the dam during the March-May time frame but also involves a relatively small increase in construction costs. The increase in construction cost is primarily associated with providing low flow augmentation. A description and discussion of each phase is presented in Paragraph 2.8.3 of this appendix. The following discussion and presentations in this report assume both Phase I and Phase II are implemented.

The proposed water supply and ecosystem restoration project consists of raising the existing reservoir by 30 feet, from elevation 1147 (assumes the 1135 restoration project is in place) to 1177. The project as proposed will provide an additional 32,000 ac-ft of storage from May through September, of which 22,400 ac-ft will be used to provide up to an additional 48 mgd of M&I water at 95% reliability over a 153 day period during the summer and early fall. The other 9,600 ac-ft of storage is part of the ecosystem restoration portion of the project and will be used to increase in-stream flows during the summer by 39 cfs at 78% reliability over a 123 day period during the summer and early fall. The other ecosystem restoration features include: (1) the addition of a fish passage facility to significantly improve the ability of juvenile salmon to find and survive the passage from the reservoir to the river downstream of the dam in their migration to the ocean and (2) the addition/improvement of fish habitat above the dam and in the river downstream of the dam.

All costs and water supply benefits are in dollar values based on October 1997 prices. Ecosystem benefits (outputs) are measured either in returning adult salmon and steelhead or square feet of coverage (placement of gravel). Average annual costs and discounting were performed using the current authorized water resource interest/discount rate of 7 and 1/8 percent. Project year one is year 2003.

2.3 WITHOUT-PROJECT CONDITIONS

The without-project condition establishes the future "baseline" condition for comparison with the with-project condition in order to establish and quantify project related benefits and costs. The without-project condition is the most likely condition expected to exist in the future without the proposed project, including any known changes in law or public policy. Following are the expected without-project conditions assumed and expected to exist without the proposed HHD Additional Water Storage (AWS) Project. This condition assumes neither water supply or ecosystem restoration have been implemented at this project. Unless otherwise noted, the without-project conditions listed below will occur whether there is a project or not.

2.3.1 Water Supply

The without-project condition assumes the following conditions occur:

(1) Construction of Pipeline No. 5 will occur prior to project year one of 2003 and is not contingent on the construction of the HHD AWS Project. This condition is consistent with Tacoma's 404b permit application and Corps of Engineers approval for pipeline 5. Pipeline 5 is a water transmission line with a capacity of 100 cfs (65 mgd) that, under without-project conditions at 95% reliability, will carry winter/spring water from Tacoma's water diversion structure located just downstream of HHD through several communities in south King County and on to Tacoma. This winter water will initially be stored in an aquifer(s) and/or an existing reservoir for use in the summer and early fall and is included as part of the without- and with-project supply of summer/fall water shown in Table B2-7. When winter water demand grows sufficiently, this water will also be used to help meet winter supply needs. Without Howard Hanson Dam, the reliability of supplying an additional 48 mgd of water (the amount produced by the proposed project) from the Green River via Pipeline 5 during the summer and early fall months is basically zero percent. In the with-project condition, the proposed winter/spring storage at HHD for water supply increases the reliability of the additional 48 mgd of summer/fall water available to be transported through Pipeline 5 to 95%.

(2) Tacoma intends to supply Seattle up to 25 mgd of water with or without Howard Hanson Dam.[2] As a result, construction of a water supply intertie between Tacoma and Seattle water systems with a peak capacity of 40 mgd would occur under the without-project condition. Based on a water supply contract with Seattle, Tacoma will provide Seattle with 20 mgd of water at 95% reliability during the summer. As needed, the water supply alternatives defined in Table B2-

[2] Source: Tacoma Water Division. Supply without Howard Hanson Dam will require developing a currently undefined ground water or out of stream storage site.

10 would be implemented and used to provide future water to Seattle and over the intertie. Construction cost of the intertie is estimated at $34,000,000 and has a cost per million gallons per year of $933. The intertie is contingent upon construction of Pipeline 5, which provides a cost effective place to connect the intertie. Without Pipeline 5, the length of the intertie would need to be much longer and would not be cost effective. Without this intertie, Seattle would have to implement their next least cost water supply alternative which would be an addition to their current facility located on the North Fork of the Tolt River. The construction cost of this facility is estimated by Seattle at $135,000,000 and has an output which yields 36 mgd.[3] The cost per million gallons per year of this facility to produce summer/fall water is estimated at over $2,500.

As a result of these conditions outlined in Paragraphs 2.3.1(1) and (2) above, Tacoma's water supply service area is the same under both the without- and with-project conditions.

(3) Construction of new ground water wells.

(4) Implementation of a proposed artificial recharge project and,

(5) Implementation of cost effective water conservation and non-structural measures to include:

- plumbing code changes which required use of low-flush toilets and low-flow showerheads in new and remodeled residential construction;

- conservation pricing - seasonal water rate increases for residential and wholesale customers.

The above water supply without-project conditions will occur whether the proposed project is constructed or not. From a water supply alternative project standpoint, if the proposed project is not constructed, then additional water will have to be obtained by Tacoma using less cost efficient measures than the proposed project. These less cost efficient measures have been identified and include additional wells, industrial re-use, demand management measures plus a generic alternative and are described in the benefit analysis of this project in Paragraph 2.6.6.

2.3.2 Ecosystem Restoration

Following are the without-project conditions associated with ecosystem restoration:

(1) Currently, adult fish are trapped below Tacoma's diversion structure and trucked either around HHD for release in the reservoir or to a fish hatchery for hatchery

[3] Source: Seattle Water Department.

stock. Between now and project year one and as part of the mitigation settlement between Tacoma and the Muckleshoot Indian Tribe, Tacoma will be constructing a state-of-the-art fish ladder, providing a way for returning adults to navigate the diversion structure. The fish ladder will lead to a pond above the diversion structure where fish will be trapped and transported around HHD for release in the reservoir or tributary streams.

(2) When attempting to migrate downstream, juvenile salmon and steelhead experience difficulty in finding the existing crude fish passage system at HHD and those juvenile fish which do find the outlet would continue to suffer very high mortality. Approximately 75-95% of all juvenile salmon and steelhead either cannot find the outlet facility or are killed in the process of passing from the reservoir to the river below the dam.

(3) Flows in the river downstream of the dam assumes the proposed 1135 restoration project which provides 5,000 ac-ft of storage for low flow augmentation is implemented and continues without change.

(4) Available fish habitat in the river and tributaries, water quality and sediment transport of gravel used for anadromous fish spawning would remain inadequate.

(5) Existing anadromous fish runs would continue to have to be supplemented with lower quality hatchery fish. There is a high probability that Puget Sound chinook salmon (which would include Green River chinook) will be listed as an endangered species. If this species is listed, it could change how the existing project is operated and there could be fish management decisions impacting the planting and harvesting of chinook salmon (see Paragraph 2.1.2 above).

2.4 WITH-PROJECT CONDITIONS

This condition is the one expected to exist over the period of analysis if the project is undertaken. This condition is compared to the without-project condition in order to help quantify project related benefits and costs. Benefits attributed to the proposed additional storage at HHD are equal to the value of increased M&I water supply (i.e. avoided cost of having to implement other water supply measures) plus the incremental increase in the resource outputs achieved by implementing ecosystem restoration measures. The with-project water supply conditions are as follows:

(1) In addition to its winter time use in the without-project condition, pipeline 5 would also be used to carry summer/fall water from the diversion structure to Tacoma's water service areas to include south King County at a 95% reliability.

(2) Municipal and Industrial water demands in the greater Tacoma service area (including contracts with Seattle Water Department to supply up to 25 mgd during

summer months as well as up to 25 mgd to South King County) will be met over the next 35-40 years using the most cost effective water supply alternative - Howard Hanson Dam.

(3) Other assumptions associated with M&I water are the same as the without-project condition except most of the less cost efficient alternative water supply measures would not need to be constructed during the life of the proposed project.

The with-project ecosystem restoration assumptions are as follows:

1) Initially, anadromous fish (coho, chinook and steelhead) would be planted in the reservoir or rivers above the reservoir, with a goal of re-introducing self sustaining wild fish runs above HHD.

2) With the implementation of ecosystem restoration measures including a new fish passage facility at HHD, the number of juvenile fish actually finding the fish passage facility and successfully passing from the reservoir to the river below the dam in their migration would increase from the without-project condition of 5-25% to 85-95%.

3) The fish returning to the upper watershed would use the existing fish ladder at the Tacoma diversion structure which leads to the pool above the diversions structure. Here the fish would be trapped and trucked around Howard Hanson dam for release in either the reservoir above the dam or tributary streams above the reservoir. Since there would be more adult fish returning under this condition, the additional cost of transporting the fish around the dam is a project related cost and is included in the operation and maintenance cost estimate.

4) As part of Phase II, low flows in the river downstream of the dam would be increased by 39 cfs over a 123 day period at 78% reliability and several fish habitat projects would be in place.

5) Implementation of the recommended fish passage facility plus the recommended fish habitat improvements are expected to increase the number of returning adults to the point where the annual runs of chinook, coho and steelhead will have a high probability of reaching the goal of self sustaining runs and eventually will not have to be supplemented with hatchery produced fish.

6) The high probability of Puget Sound chinook salmon being listed an endangered is expected to remain in the with-project condition.

7) The existing project NED benefits consisting of flood control and low flow augmentation would not be impacted by the proposed project.

2.5 BENEFIT METHODOLOGIES

Benefits produced from this multiple purpose project consist of M&I water supply and ecosystem restoration. Following is a discussion of benefit methodologies used to quantify water supply outputs and evaluate ecosystem restoration.

2.5.1 Water Supply

Economic evaluation of the proposed water supply storage project at HHD was conducted in accordance with Policy and Planning Guidance (ER1105-2-100), dated 28 December 1990.

Water supply benefits are based on: (1) the need for additional water supply, (2) the timing of that need and (3) society's willingness to pay for the increased output of water supply. Where the price of water reflects marginal cost pricing, that price is to be used to measure willingness to pay. Where marginal cost pricing is not used, willingness to pay is estimated based on the cost of the water supply alternative(s) most likely to be implemented in the absence of the proposed project. The most likely alternative(s) are usually the least cost alternative(s) available to the utility. In other words, using this methodology, the value of M&I water supplied by the proposed project is estimated based on the avoided costs of not needing to construct the least cost alternatives to the proposed project. Since Tacoma uses average cost pricing of water rather than marginal cost pricing, water supply benefits were estimated using the most likely alternative methodology or avoided costs.

2.5.2 Ecosystem Restoration

The evaluation of ecosystem restoration was performed in accordance with Engineering Circular 1105-2-210, dated 1 June 1995, "Ecosystem Restoration In The Civil Works Program". The economic evaluation of ecosystem restoration measures for fish passage and habitat improvements were performed using a cost effectiveness and incremental cost per incremental output analysis. The level of low flow augmentation to be provided was determined based on a negotiated[4] trade off analysis between low flows and M&I water supply which considered the benefits of low flow augmentation versus the benefits of water supply. From a project maximization standpoint, an increase in low flow augmentation in the project reduces the amount of available M&I water at 95% and vice versa. While the trade off analysis between each project purpose was negotiated, it should be noted that the amount of water supply negotiated to be provided is sufficient to just meet the expected average summer day deficit over the 50-year project life and is also sufficient to meet the 4-day peak supply deficit until project year 38. The amount of water provided for low flow augmentation (9,600 acre feet or 39 cfs at 78% reliability

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[4] Negotiated between project sponsor, federal and state resource agencies and Corps of Engineers.

over a 123 day summer/fall period) is considered the amount needed to begin to have a positive effect on the fishery resources downstream of the dam.

The number of expected returning adults in the with-project condition assume that the proposed low flow augmentation is implemented. Except for low flow augmentation and gravel placement in river, primary restoration benefits were quantified in terms of increases in fish survival rates as measured by the increased number of returning adult salmon and steelhead. Expected changes in survival rates are based on increases in fish passage through the dam. Secondary benefits also accrue to the project and are associated with both the fish passage measures and low flow augmentation. Secondary benefits associated with fish passage consist of an increase in the commercial and recreational harvest of chinook, coho and steelhead, while secondary benefits associated with low flow augmentation include: (1) water quality improvements related to better water temperature control downstream of the dam, (2) dilution of pollutants, (3) increased production of trout and wildlife species, (4) increased dissolved oxygen, (5) reduced salinity in the lower river, and (6) improved spring and summer flows for recreational boaters. Each of these benefits were considered in the analysis. Gravel placement was measured using square feet of gravel coverage.

2.6 WATER SUPPLY BENEFITS

Water supply benefits are quantified based on the need for additional M&I water, the timing of that need, and the consumer's willingness to pay for the increase in the value of goods and services attributed to increased supply. The quantity of additional M&I water needed and the timing of that need is determined by forecasting the future demand for water within the applicable service area and comparing it to the without-project supply of water. As stipulated in ER1105-2-100, the without-project supply of water is adjusted to include any expected reductions due to the age of the facilities and/or expected changed environmental requirements. For this project, no reductions to the without-project supply of water were made. The without-project condition excludes the proposed project but includes any water supply measure under construction or authorized measures expected to be implemented during the forecast period. See Paragraph 2.3.1 for additional information on the without-project water supply. Following is a discussion of the water demand forecast methodology used in this study as well as the results of the forecasts.

2.6.1 Water Demand Forecast Methodology

The water demand forecasts used in this analysis were developed and published by the Tacoma Water Division in June, 1995. This is the latest available forecast which has been approved by the Washington State Department of Ecology. The methodology employed by Tacoma Water Division in their forecast of future M&I water demand has also been approved by the Washington State Department of Ecology for use in planning future water supply need in the existing and future Tacoma service areas. Since the purpose of

HHD is to supply additional M&I water, primarily during the summer (i.e. May-September) months, the demand forecasts presented in this analysis consist of low and high summer day forecast as well as a low and high 4-day summer peak forecast. The low and high forecasts are expected to bracket the expected range of possible demand for M&I water Tacoma will encounter.

The state of Washington, through the Growth Management Act of 1990, requires Washington communities to establish urban growth areas (UGAs) and develop long range plans to provide urban services to areas within these boundaries. The urban growth areas that have been identified for Tacoma and Pierce County were used as the basis for identifying potential future service areas and potential summer water demands for those areas. In addition to the current Tacoma water service areas, future potential service areas for which forecasts were developed include the City of Tacoma UGA, a part of the Pierce County UGA plus an estimated contracted amount with South King County and the Seattle Water Department. Following is a geographical description of each service area.

Tacoma Water Service Area. Between 85-90% of the water demand Tacoma now serves and is expected to serve in the future is located in this service area. Generally, this area follows the City of Tacoma municipal boundary plus some abutting areas. In addition, there are areas outside the city limits, which are adjacent to existing transmission facilities which Tacoma provides service. Furthermore, there are several other water systems that purchase wholesale water from Tacoma. Even though these customers are located within the City of Tacoma or Pierce County UGA's the existing and future water demand from all existing wholesale and retail customers is included within the Tacoma Water Service Area forecast. Tacoma has also identified some potential new, large industrial, commercial, and residential customers who have expressed interest in water service. Some of these customers are outside the existing service area but since service to these customers is likely in the near future, demand for this group was included within the Tacoma Water Service Area - regardless of the location of the potential customer.

City of Tacoma Urban Growth Area. The City of Tacoma UGA water demand forecast includes demand for the entire geographic area of the City of Tacoma UGA minus the demand forecast for the portions of Tacoma Water Service Area which are geographically within the City of Tacoma UGA. The City of Tacoma UGA forecast was adjusted to avoid counting the demand within the Tacoma Water Service Area twice.

Pierce County Urban Growth Area. As part of the Growth Management Act, Pierce County has defined its urban areas, including those for each municipality within the County. Areas which can be serviced by Tacoma include those locations outside the current Tacoma Water Service Area that can be reasonably served by existing or proposed water transmission and distribution pipelines. The forecast demand for this service area does not include the demand for areas that are already served by Tacoma but are located within the Pierce County UGA. That demand is already included within the Tacoma Water Service Area forecast.

South King County and Seattle. The King County forecast area includes South King County purveyors and the Seattle Water Department – both of which are requesting a contract for water from Tacoma. Water supplied to South King County is contingent on construction of pipeline 5, while water to Seattle is contingent on construction of a water supply intertie between Tacoma and Seattle Based on current contract discussions between Tacoma and each of these demand entities, Tacoma will supply South King County with 15 mgd and Seattle with 20 mgd over the forecast period.

Separate demand forecasts for the Tacoma Water Service Area were developed for each of Tacoma's customer classes. Customer classes used in the demand forecast for this service area are: (1) inside and outside the city residential, (2) inside and outside the city commercial, (3) Simpson Paper Mill, (4) wholesale, and (5) municipal and other public buildings. Following is a description of these customer classes found in the Tacoma Water Service Area.

Residential Inside City. These are residential customers located within the City of Tacoma's municipal boundary. This customer class represents about 24% of Tacoma's annual consumption. Of this amount, 73% is single-family use, 26% is multifamily and 1% is separate outdoor irrigation accounts.

Residential Outside City. Residential customers served directly by Tacoma but located outside the current City of Tacoma boundary. This category consumes about 11% of annual consumption. Of this amount, 78% is single-family, 21% is multifamily and the remaining 1% is sprinkling accounts.

Commercial/Industrial Inside City. This category consists of commercial, industrial and irrigation accounts within the City of Tacoma's municipal boundary. Approximately, 23% of annual consumption is used by this class.

Commercial/Industrial Outside City. Commercial, industrial and irrigation accounts served by Tacoma but are outside the city boundary. Commercial outside represents 2% of total annual consumption.

Simpson Paper Mill. This industrial user is the largest single customer in the Tacoma Water Service Area and as such has its own customer class. Until 1991, Simpson used about 42% of the average consumption. Since implementing conservation measures in 1992, Simpson now represents about 34% of annual consumption.

Wholesale. This class represents other water utilities which purchase water from Tacoma for distribution to their customers within their own service area. Tacoma provides water to nine wholesale customers. This class represents about 2% annual consumption.

Municipal and Other Public Buildings. This class include irrigation for public parks and other public grounds as well as water used at municipal facilities such as schools, city offices, etc. Approximately 4% of annual consumption is attributed to these customers.

Short and Long Term Forecasts. Tacoma performs a short term forecast (2-5 year projections) every 2 to 3 years. This forecast is developed using 10 years of historical consumption by customer class. An econometric model that relates historical consumption to variables such as weather, price of water, real income, unemployment and other parameters that affect water consumption is used to perform the short term forecast. The short term forecast and its models (incorporating historical consumption, actual population estimates and employment estimates) is used to compute average water use per capita and average use per employee. These per capita and average use per employee values are then used to develop the long-range forecast. For example, the per capita usage from the short term forecast was multiplied by the forecasted population to determine the long term residential demand for the service area. Also, the forecast use per employee from the short term forecast was multiplied by the forecast number of employees to obtain commercial and industrial use within each service area over the long term.

Residential and Commercial/Industrial Demand Forecast. The current short term forecast is based on normal weather conditions, a large rate increase of 40% in 1995 (reflects the anticipated impact of the cost of additional resources) and incorporating income and employment forecasts. This short-term model was used to project water use per customer for City of Tacoma inside and outside city residential and commercial/industrial classes for 1994 and 1995. Water use per customer values were multiplied by the forecast number of customers in each class to obtain total 1995 forecast water use by class.

To forecast future inside and outside city residential water usage, the 1995 Tacoma Water Service Area-Inside City Residential was divided by the Tacoma-Inside City residential population to develop Tacoma-Inside City per capita usage. A similar computation was performed to obtain Tacoma Water Service Area-Outside City Residential per capita usage.

To forecast inside and outside City Commercial/Industrial water usage, the Tacoma Water Service Area-Inside City Commercial/Industrial forecast consumption for 1995 was divided by the forecast number of employees inside the City of Tacoma in 1995 to obtain water use per employee. A similar computation was performed for outside the City of Tacoma commercial water use.

These 1995 use per capita (residential) and use per employee (commercial/industrial) were applied to the population and employment forecasts for each of the service areas to obtain future average annual residential and commercial usage. For service areas outside the existing Tacoma Water Service Area, planning studies performed by water utilities in those service areas were used in conjunction with Tacoma Water Service Area to develop use per customer and use per employee. Table B2-1 and B2-2, show water use per capita (residential) and water use per employee (commercial/industrial) that were used in this long term forecast.

TABLE B2-1. FORECAST OF RESIDENTIAL WATER USE (GALLONS PER CAPITA PER DAY)

Service Area	YEAR			
	1990	1995	2000	2001-2054
Tacoma Water Service Area - Inside City	88.6	87.5	87.5	87.5
Tacoma Water Service Area - Outside City	100.3	98.0	98.0	98.0
City of Tacoma - UGA	100.3	98.0	98.0	98.0
Pierce County - UGA	100.3	100.3	100.3	100.3

TABLE B2-2. FORECAST OF COMMERCIAL/INDUSTRIAL WATER USE (GALLONS PER EMPLOYEE PER DAY)

Service Area	YEAR			
	1990	1995	2000	2001-2054
Tacoma Water Service Area - Inside Comm.	145.2	110.7	110.7	110.7
Tacoma Water Service Area - Outside Comm.	86.9	74.1	74.1	74.1
City of Tacoma - UGA	86.9	74.1	74.1	74.1
Pierce County - UGA	86.9	74.1	74.1	74.1

2.6.2 Other Components Of M&I Water Demand

In addition to the demand components discussed above, there are other components which comprise total water demand within the Tacoma Water Service Area. These other water demand components consist of Simpson Paper Mill, wholesale customers, and municipal and public demand. System losses and unmetered uses, and conservation also affect total demand for water. A discussion of these other components is provided as follows.

a. Simpson Paper Mill. In 1991, Simpson Paper Mill implemented conservation measures which reduced the average water use at the plant from 30 mgd to 20 mgd. M&I water demand at Simpson was assumed to be 20 mgd over the study period.

b. Wholesale Customers. For current wholesale customers, which consists of other water utilities, use was assumed to be constant and equivalent of existing consumption. Growth in wholesale use is expected to occur within other service areas. The rate of growth is based on population and employment growth projected for those areas.

c. Municipal and Other Public Facilities. Water consumption of municipal and other public facilities was estimated as a fixed percentage of the forecast water consumption for the existing Tacoma Water Service Area (excluding Simpson Paper Mill and wholesale). Municipal and other public facilities demand was estimated to be 3.7%.

d. System Losses and Unmetered Uses. All M&I water systems incur losses from leaks in the system as well as needing to provide unmetered uses such as fire hydrant use, pipe flushing and reservoir cleaning. The amount of water associated with this category was computed by dividing the total volume of water consumed , as measured by customer meters, by the total volume of water produced, as measured by supply meters. Based on recent data, the average system losses and unmetered use range between 9 and 11%. The forecast assumed a 9% increase in demand to account for this category.

e. Conservation. In 1993, Tacoma Water Division completed a major indoor water conservation plumbing retrofit project. In the same year, the Washington State Uniform Plumbing Code was changed to require the use of low-flow toilets and showerheads in all new and remodeled residential construction. Forecast demand in the Tacoma Water Service Area was reduced by the combined savings from these plumbing code changes and retrofit program. The combined effect of these conservation measures was an estimated water savings in the Tacoma Water Service Area of .7 mgd in year 2000, 1.2 mgd in year 2010 and 2.9 mgd in year 2050.

Another conservation measure reflected in the demand evaluation is conservation pricing. This means higher seasonal (summer) water rates for residential and wholesale customers were used in estimating future water demand. Water savings as a result of these rate increases were not shown as a separate line item in the forecast but were included indirectly in the demand forecast numbers.

These conservation measures represent a baseline conservation plan and do not include other less cost efficient conservation measures evaluated as part of the alternative(s) analysis to HHD and discussed in Paragraph 2.6.6.

2.6.3 Demand Forecast Scenarios

As previously mentioned, both a high and low forecast scenario were developed for both the average summer day and 4-day peak forecast to account for the range of possible growth patterns the Tacoma Water will experience. Discussed below are the forecast scenarios:

a. Low Forecast. This forecast represents the estimate of future growth based on the following assumptions. This forecast assumes Tacoma would supply only 50% of the water demand increase within the City of Tacoma UGA and none of the Pierce County UGA demand. This forecast also uses a lower population growth forecast than that used in the high forecast. New customers within the Pierce County UGA would be met by new private water providers or would be absorbed by other water utilities. Potential new industrial, commercial, and residential customers who have expressed interest in water service are included as growth to the Tacoma Water Service Area. The expected 15 mgd demand for South King County and 20 mgd demand for the Seattle Water Department would still be served by Tacoma. This forecast also assumes conservation measures are implemented.

b. High Forecast. This forecast represents the demands that Tacoma would experience given the expected growth rates and anticipated changes in service territory. This forecast assumes Tacoma would provide supply for 100% of the water demand increase forecast for the City of Tacoma UGA and 50% of the water demand increase within the Pierce County UGA service area. This forecast also uses a higher population growth forecast than that used in the low growth forecast. The expected 15 mgd demand for South King County and 20 mgd demand for the Seattle Water Department would be served by Tacoma. Potential new industrial, commercial, and residential customers who have expressed interest in water service are included as growth to the Tacoma Water Service Area. Conservation measures are also assumed to be implemented under this forecast.

c. Average Summer Day and 4-Day Peak Demand Forecasts. Average summer day and 4-day peak demands were forecast for both a high and low scenario. These forecasts were determined using a summer use and 4-day peak factors developed from historical demand data that related water use during the period (summer and 4-day peak) to the average day water use for the whole year. This summer use and 4-day peak factors were then applied to the average day forecasts to obtain summer day and 4-day peak demand forecasts. These factors were assumed to be constant over the forecast period. A summary of the average summer day high and low forecasts are shown in Tables B2-3 and B2-4.

TABLE B2-3. WATER DEMAND FORECAST AVERAGE SUMMER DAY HIGH DEMAND FORECAST, 1995-2053 (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
City of Tacoma - Current Service Without Simpson Paper Mill	48.7	53.9	59.8	67.1	74.8	83.6	93.6
Simpson Paper Mill	20.0	21.0	21.0	21.0	21.0	21.0	21.0
Total - City of Tacoma - Current Service	68.7	74.9	80.8	88.1	95.8	104.6	114.6
City of Tacoma - New Service	7.7	16.7	22.9	22.9	22.9	22.9	22.9
Total - City of Tacoma - Current and New Service	76.4	91.6	103.7	111.0	118.7	127.5	137.5
City of Tacoma - UGA	0.0	1.3	2.7	4.6	6.6	8.9	11.4
Pierce County - UGA	0.0	0.0	0.0	0.0	0.8	3.0	5.5
South King County & Seattle	0.0	35.0	35.0	35.0	35.0	35.0	35.0
Total - M&I Water Demand	**76.4**	**127.9**	**141.4**	**150.6**	**161.1**	**174.4**	**189.4**

TABLE B2-4. WATER DEMAND FORECAST, AVERAGE SUMMER DAY LOW DEMAND FORECAST, 1995-2053 (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
City of Tacoma - Current Service Without Simpson Paper Mill	48.7	52.8	57.4	63.1	68.9	75.4	82.7
Simpson Paper Mill	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Total - City of Tacoma Current Service	**68.7**	**72.8**	**77.4**	**83.1**	**88.9**	**95.4**	**88.9**
City of Tacoma - New Service	7.0	14.2	19.5	19.6	19.6	19.6	19.6
Total - City of Tacoma Current and New Service	**75.7**	**87.0**	**96.9**	**102.7**	**108.5**	**115.0**	**122.2**
City of Tacoma - UGA	0.0	.4	.8	1.4	2.0	2.6	3.3
Pierce County - UGA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South King County & Seattle	0.0	35.0	35.0	35.0	35.0	35.0	35.0
Total - M&I Water Demand	**75.7**	**122.4**	**132.7**	**139.1**	**145.5**	**152.6**	**160.5**

A summary of the 4-day peak high and low forecasts are shown in Tables B2-5 and B2-6.

TABLE B2-5. WATER DEMAND FORECAST 4-DAY PEAK HIGH DEMAND FORECAST (1995-2053) (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
City of Tacoma - Current Service Without Simpson Paper Mill	76.9	85.2	94.9	106.4	119.0	133.3	149.5
Simpson Paper Mill	21.6	22.7	22.7	22.7	22.7	22.7	22.7
Total - City of Tacoma - Current Service	**98.5**	**107.9**	**117.6**	**129.1**	**141.7**	**156.0**	**172.2**
City of Tacoma - New Service	12.2	26.4	36.2	36.3	36.3	36.3	36.3
Total- City of Tacoma - Current and New Service	**110.7**	**134.3**	**153.8**	**165.4**	**178.0**	**192.3**	**208.5**
City of Tacoma - UGA	0.0	2.2	4.5	7.6	11.0	14.7	18.9
Pierce County - UGA 1/	0.0	0.0	0.0	0.0	2.4	6.5	11.4
South King County & Seattle	0.0	15.0	15.0	15.0	15.0	15.0	15.0
Total - M&I Water Demand	**110.7**	**151.5**	**173.3**	**188.0**	**206.4**	**228.5**	**253.8**

1/ Demand is forecast to begin in year 2030.

TABLE B2-6. WATER DEMAND FORECAST, PEAK 4-DAY FORECAST LOW DEMAND FORECAST, 1995-2053 (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
City of Tacoma - Current Service Without Simpson Paper Mill	76.9	84.5	91.0	99.9	109.4	120.0	131.7
Simpson Paper Mill	21.6	21.6	21.6	21.6	21.6	21.6	21.6
Total - City of Tacoma - Current Service	**98.5**	**106.1**	**112.6**	**121.5**	**131.0**	**141.6**	**153.3**
City of Tacoma - New Service	11.1	23.7	30.9	31.0	31.0	31.0	31.0
Total - City of Tacoma - Current and New Service	**109.6**	**129.8**	**143.5**	**152.5**	**162.0**	**172.6**	**184.3**
City of Tacoma - UGA	0.0	.8	1.5	2.4	3.4	4.5	5.7
South King County & Seattle	0.0	15.0	15.0	15.0	15.0	15.0	15.0
Total - M&I Water Demand	109.6	145.6	160.0	169.9	180.4	192.1	205.0

2.6.4 Without-Project Supply of M&I Water

The without-project supply of water includes: (1) the existing supply of water adjusted to account for anticipated changes in water supply due to age of facilities or changed ecosystem conditions, (2) supply projects under construction or authorized and likely to be constructed during the forecast period, and (3) institutional arrangements such as water supply contracts. Shown in Table B2-7, is the expected without-project supply of average summer day as well as the 4-day peak supply of water, at 98percent reliability, available to Tacoma Water Division. Without-Project supply of M&I water remains the same after year 2010. Implemented conservation measures which are part of the without-project condition are considered demand management measures and are reflected in the demand forecasts. Following is a description of each without-project water supply measure.

- Green River First Diversion - This source of water is from Tacoma's first diversion water right on the green river which allows Tacoma to divert up to 72 mgd. This water flows through pipeline 1 to Tacoma and subsequently to their water distribution system.

- South Tacoma Well Field – This source of water consists of a series of wells located in south Tacoma which provide 45 mgd of summer and 4-day peak.

- Existing Other Wells – This is additional summer water which is expected to be provided from these wells via artificial recharge during the winter.

- Future Wells – This source represents the additional peak capacity that is gained from storing winter water from pipeline 5 in the South Tacoma Aquifer. Additional wells will be installed in order to provide the additional peaking capacity.

- Industrial Re-Use – This without-project source of supply is forecast to come on line in year 2010 and consists of using reclaimed water from the county-owned treatment plant to provide up to 5 mgd of water to a paper product company for use in their manufacturing processes. Construction costs were estimated at $7.0 million and consists of filtration, additional disinfection and storage facilities. The project costs also includes 4,000 feet of 18-inch diameter pipeline needed to deliver the water to the identified company.

TABLE B2-7. WITHOUT-PROJECT SUPPLY OF SUMMER DAY AND 4-DAY PEAK M&I WATER (1995-2053) (IN MGD AND 95% RELIABILITY)

Source Of M&I Water Supply - Avg. Summer Day & 4-Day Peak	Supply Category	1995	2003	2010-53
Green River First. Diversion	Avg. [5]	71	71	71
	4-Day	72	72	72
S. Tacoma Well Field	Avg.	45	45	45
	4-Day	45	45	45
Existing Other Wells	Avg.	9	9	9
	4-Day	13	13	13
Future Wells	Avg	0	0	0
	4-Day	0	20	29
Industrial Re-Use	Avg.	0.0	0.0	5
	4-Day	0.0	0.0	5
Total Without-Project Supply Of M&I Water	Avg.	125	125	130
	4-Day	130	150	164

2.6.5 Without-Project Supply Versus Forecast Demand

Water supply benefits are a function of the timing and level of need for additional water supply. The timing and level of need are determined by comparing the without-project supply of water to the forecast need for water. For this comparison, a medium growth demand forecast (half way between the low and high forecasts) was used as the likely forecast scenario for the future. As shown in Table B2-8, based on the medium growth summer day forecast and the without-project supply of summer day water, the average summer day need for additional water by project year one of 2003 is 1.5 mgd. This deficit

[5] Avg. = Average Summer Day.

is expected to increase to 14.9 mgd by year 2020 and reach 45 mgd by year 2050. Table B2-9 shows the 4-day peak forecast deficit of 2.7 in year 2010, increasing to 15 mgd by year 2020 and reaching 65.4 mgd by year 2050.

TABLE B2-8. SUMMARY OF M&I WATER DEMAND AND WITHOUT-PROJECT SUPPLY AVERAGE SUMMER DAY - MEDIUM DEMAND FORECAST, 1995-2053 (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
Medium - Avg. Summer Day Demand W/O S. King County or Seattle	76.0	91.5	102.1	109.9	118.3	128.5	140.0
Without-Project Summer Day Supply	125.0	125.0	130.0	130.0	130.0	130.0	130.0
M&I Water Surplus (Deficit) W/O S.King Co. and Seattle Contract Demand	49.0	33.5	27.9	20.1	11.7	1.5	(10.0)
S. King County and Seattle Contract Demand	0	35	35	35	35	35	35
Total M&I Water Surplus (Deficit)	49.0	(1.5)	(7.1)	(14.9)	(23.3)	(33.5)	(45.0)

TABLE B2-9. SUMMARY OF M&I WATER DEMAND AND WITHOUT-PROJECT SUPPLY PEAK 4-DAY - MEDIUM DEMAND FORECAS,T 1995-2053 (IN MGD)

	1995	2003	2010	2020	2030	2040	2050-2053
Forecast 4-Day Peak Demand	110.2	148.6	166.7	179.0	193.4	210.3	229.4
Without-Project 4-Day Peak Supply	1.0	150.0	164.0	164.0	164.0	164.0	164.0
M&I Water Surplus (Deficit)	19.8	1.4	(2.7)	(15.0)	(29.4)	(46.3)	(65.4)

2.6.6 Without-Project Water Supply Alternatives

As previously discussed, water supply benefits are based on the cost of obtaining the same quantity, quality, and reliability of M&I water from the most likely alternative source or combination of sources of water expected to be implemented in the absence of the proposed project. Alternative sources of water needed in the absence of the proposed project may consist of one source of water which would completely eliminate the projected water supply deficit over the proposed project life or the development of more than one source with increments phased to match anticipated deficits in future water supply. Cost of the alternative source(s) reflect providing the same water quality and reliability as the proposed project and also include the cost to transport the water from its source to the main transmission system. As presented in the Appendix H, Plan Formulation, the Tacoma Water Division has identified and evaluated all of their potential alternative sources of water available to them over the foreseeable future. Each of the potential measures were evaluated for: (1) acceptability, (2) completeness, (3) effectiveness, and (4) efficiency. The types of water supply measures that were evaluated consisted of seven new well projects, 24 different conservation and demand management items, four new dams/diversion structures on other rivers, two transfers from other water systems, two industrial re-use projects , and two separate artificial recharge projects. As part of the resource evaluation process, many of the above alternative measures were eliminated, as they either could not be implemented for environmental and/or cost reasons or they were included as part of the without-project condition. That is, Tacoma decided to go ahead and implement some of the measures (i.e. an industrial re-use and artificial recharge project) and they are included as part of the without-project supply of water.

Out of all the water supply measures that were evaluated, only four measures remained that reasonably met all of the above evaluation criteria and therefore were considered as viable alternatives to the HHD AWS. These alternatives consist of two well projects (Tide Flats and Lone Star), one industrial re-use project (separate from the re-use project implemented under without-project conditions), and a conservation/demand management project. The cost effective conservation/demand management measure consists of 12 different conservation components but is treated as one alternative since the different components would be implemented as a package. The costs and outputs for each of the measures were quantified and converted into average annual equivalents. Annual cost per unit of annual output were computed and used to rank each of the measures. The measures were listed in order of their per unit cost with the least cost measure assumed to be implemented first and the most expensive assumed to be implemented last.

Shown in Table B2-10 is the final list of alternative water supply projects available to Tacoma Water to provide average summer day and 4-day peak supply of M&I water. Summer time period is defined as a 149 day period from May-September, excluding the 4-day peak. The 4-day peak occurs during a 4-day period in the summer. These alternative projects are ranked in order of annual cost per million of gallons of water provided over the May-September demand season (MGS). Cost per MGS was determined by computing the total construction cost, in October 1997 prices, of each alternative project and annualizing it at 7 1/8 percent over the alternatives expected life, adding annual operating and maintenance costs and dividing the sum of the annual costs by the expected May-September water output for that alternative.

Following is a description of each of the final water supply alternatives. Costs and outputs for each alternative was taken from Tacoma's Integrated Resource Plan report. Costs were updated to October 1997 prices.

a. Tide Flats. Based on a recent study (Hart Crowser, 1995) it is estimated that the aquifer below the Tide Flats area of Tacoma is capable of producing an additional 5 mgd. Construction would consist of two additional wells each capable of producing 2.5 mgd. With approximately 2,000 feet of transmission pipeline, the water could be conveyed to Tacoma Water's distribution system. The estimated construction cost for developing this resource in October, 1997 prices including the transmission line is $2,920,000. Interest and amortization of the construction costs over the expected service life of 25 years totals $259,000. Operation and maintenance costs are estimated at $54,000 per year and annual costs total $313,000. Output is estimated at 5.0 mgd during the 149 day average summer day period and 5.0 mgd for the 4-day peak period. The cost per million gallons is estimated at $409.

b. Demand Side Management. This measure consists of implementing the 12 most cost effective conservation measures from a list of all practical and available conservation measures. To determine the most cost effective measures to add to their existing conservation program, Tacoma Water analyzed numerous conservation measures based on estimated water savings and cost to implement. The measures were divided into four user classes: single family, multi-family, commercial/industrial, and public facilities. Three methods of delivery were evaluated for the single family and multi-family users classes - direct installation, hang bag delivery, and direct mail. Each conservation measure was evaluated based on product useful life, cost per device, administrative cost, installation cost, number of units per customer, average water savings, and penetration and retention rates. The screening results were tabulated in order of increasing cost per mgd of water saved. An additional screening criterion which consisted of measures which were difficult or unnecessary to implement, because of legal issues or duplication in existing programs were eliminated. The measures which are included as this measure consist of: (1) Indoor industrial audit - no devices; (2) Commercial/industrial ultra low flow toilet rebate; (3) Remote irrigation facilities for parks; (4) remote irrigation of schools; (5) single-family self-closing hose nozzle- direct mail; (6) ultra low flow toilets in schools; (7) single-family ultra low flow toilet rebate - direct mail; (8) single-family horizontal axis washing machine rebate - direct mail; (9) public building outdoor water audits - direct install; (10) public schools outdoor water audits - direct install; (11) commercial/industrial low flow showerhead - direct install; (12) public facilities electronic faucets - direct install; (13) single-family outdoor faucet auto shutoff - direct mail. Cost to install these measures is estimated at $1,725,000. Average annual costs consist of interest and amortization of the implementation cost over a project life of 25 years and total $153,000. There are no operation and maintenance costs associated with these components. Output totals 1.3 mgd during the average summer day and 1.8 mgd during the 4-day peak. The cost per million gallons is estimated at $761.

c. Lone Star Sand and Gravel. The Lone Star Sand and Gravel property contains water rights for developing an additional 9.3 mgd for use during the summer and 4-day peak periods. In addition to the cost of the well, approximately 15,000 feet of transmission line needed to connect this supply to Tacoma's distribution system and a retrofitted pump station needed to achieve a hydraulic grade line of 576 feet would be required.

Construction costs in October, 1997 prices are estimated at $8,287,000. Interest and amortization of the construction costs over the expected service life of 50 years totals $629,000. Annual operation and maintenance costs are estimated at $580,000 per year resulting in annual costs totaling $1,209,000. The cost per million gallons is estimated at $838.

d. Industrial Reuse. This project consists of providing 10 mgd from a city-owned wastewater treatment plant to a paper product industry. The construction cost of this resource is estimated at $16,579,000. Interest and amortization of the construction costs total $1,386,000. Annual operation and maintenance costs are estimated at $227,000 per year. Annual costs total $1,613,000. Cost of this measure assume that filtration, additional disinfection, and storage facilities will be installed and located at the treatment plant. In addition, 4,000 feet of 30-inch pipeline will be needed to deliver the reclaimed water to the identified industry and is included in the above cost. The cost per million gallons is estimated at $1,054.

e. Generic Alternative. Implementation of the above measures (in lieu of HHD AWS) would provide a sufficient supply of water to meet the projected average summer water deficits until year 2033 or project year 30 and is sufficient to meet the projected 4-day peak deficits until year 2028 or project year 25. Because Tacoma has not evaluated any other alternatives available to them in sufficient cost and output detail and because the remaining alternatives potentially available to them are highly speculative at this point in time, a "generic" alternative was used to quantify the value of water from HHD AWS after project years 25 and 30. A cost per million gallons per year of $1,265 was used. The cost of this alternative is 20% higher than the next least costly alternative (i.e. industrial re-use) and over 300% higher than the least cost alternative implemented first (i.e. Tide Flats Wells). More importantly, this cost compares to a newly proposed artificial recharge project in the City of Federal Way (city in South King County adjacent to Tacoma) in which the feasibility report roughly estimates construction costs to range from $45 to $68 million dollars and the costs per million gallons per year, including expected treatment costs, to range from $850 to $1,400 per mgd per year [6] depending on the assumptions made.[7] So the proxy value of $1,265 used for the "generic" alternative is considered to represent a close approximation of the cost of the next water supply alternatives available to Tacoma.

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[6] Adjusted to 1997 prices.

[7] Source: Oasis Feasibility Study - An Aquifer Storage and Recovery Project in Federal Way, dated August, 1994.

TABLE B2-10. ALTERNATIVE WATER SUPPLY PROJECTS SUMMER DAY (OCTOBER, 1997 PRICES; 7 1/8%)

Resource & Daily Output Per Season	Const. Cost ($1,000)	I & A ($1,000	O & M ($1,000)	Total Annual ($1,000)	Total Output/Yr. (Mgs) [8]	Annual Cost Per Mgy
TIDE FLATS 5.0 mgd Summer 5.0 mgd 4-Day Pk.	$2,920	$259	$54	$313	745 (Summer) 20 (4-day pk) 765.0 Total	$409
DSM 1.3 mgd Summer 1.8 mgd 4-Day Pk.	$1,725	$153.0	$0.0	$153.0	194 (Summer)[9] 7 (4-daypeak)[10] 201 Total	$761
LONE STAR 9.3 mgd Summer 9.3 mgd 4-Day Pk.	$8,287	$629	$580	$1,209	1,386(Summer) 37(4-Day Pk.) 1,423 Total	$838
INDUST. RE-USE 10 mgd Summer 10 mgd 4-Day Pk.	$16,579	$1,386	$227	$1,613	1,490(Summer) 40(4-Day Pk.) 1,530 Total	$1,054

2.6.7 Quantification of Water Supply Benefits

As previously mentioned, water supply benefits are based on the cost of implementing the most likely alternative(s) in the absence of the proposed water supply project, which could be used to provide the same quantity of water in demand at the same reliability and quality as the proposed project. The proposed water supply project consists of two phases. The first phase is between years 2003 and 2008. During this time period the proposed project will have the capability of producing 42 mgd over the May-Sept. time frame at 95% reliability. Phase II is assumed to begin in year 2008 and extends to the end of the project life or 2053. During this phase the proposed project will have the capability of producing 48 mgd at 95% reliability over the same time period.

Water supply benefits over time are limited to the amount of water deficit in a given year or water supplied by the proposed project, whichever is less. That is, if the forecasted water supply deficits are projected to be 10 mgd in year 2005, 20 mgd in year 2010 and 30 mgd in year 2020, but the proposed project can supply a maximum of 30 mgd, then water supply benefits in year 2005 and 2010 would be limited to 10 mgd and 20 mgd

8 MGS = Million Gallons Per Season (May-Sept.)
9 Summer is a 149 day period.
10 Peak Demand is based on peak 4 days during summer.

respectively. Benefits for the full 30 mgd supplied by the project, can not be claimed until year 2020, the year the deficits reach 30 mgd. If, however, supply deficits exceed 30 mgd, the value of water supply benefits could not exceed the project output of 30 mgd.

The value of M&I water supplied by the proposed project is computed by identifying those least cost water supply alternatives which would be implemented if the proposed project is not constructed. The city of Tacoma Water Division has identified all of their without-project water supply alternatives which are realistically available to them over the foreseeable future. These alternatives are shown in Table B2-10. This table shows that the least cost alternatives identified as available to Tacoma will provide, at 95% reliability, a combined total of 25.6 mgd during the average summer demand period of May-September and a combined total of 26.1 during the 4-day peak period. These identified water supply alternatives will provide enough water to meet the average summer day demand deficit until year 2032 and, at the same time, these same alternatives will also provide sufficient water to meet the 4-day peak until year 2027. The value of water per million of gallons supplied during the average summer demand and 4-day peak periods ranges from a low of $409 to $1,265.

All water supply values were computed by dividing the average annual cost of the alternative by the million gallons of water produced by that alternative during the May-September time period and are shown in column 7 of Table B2-10. Benefits are based on implementing each alternative measure in a cost efficient manner starting with the lowest cost alternative per million gallons first and then, once the projected deficit is greater than that alternative's output, the next most cost effective measure is assumed to be implemented. The overall value of water is therefore a weighted average of the alternative(s) implemented as they are needed, based on the projected water supply deficits. For example, in Table B2-11, the value of water shown in the fifth column is $409 per million gallons. This is cost of implementing the least cost alternative or the Tide Flat Wells shown in Table B2-10. This alternative has a summer day output of 5.0 mgd. Therefore, the value of water is $409 per million gallons for the first 5.0 mgd of water deficit as shown in Table B2-11. Once the deficit exceeds 5.0 mgd, the next least cost alternative would be implemented, or DSM, at a cost of $761 per million gallons (see Table B2-10). In Table B2-11, the water deficits exceed 5.0 mgd in year 2008 (i.e. year 2008 = 5.5 mgd deficit). Therefore, the first 5.0 mgd of deficit has a value of $409 per million gallons and .5 mgd has a value of $761. The weighted average value using these two alternatives is $441 per million gallons and is the value used for water in year 2008 as shown in Table B2-11. These values, together with the projected water supply deficits in mgd were multiplied together to compute the stream of water supply benefits over the project life. This benefit stream was converted to a present-worth value by discounting the benefit stream back to project year one (2003) using the current federal discount rate of 7.125%. The sum of the present-worth values were levelized over the 50-year project life using a 7.125% interest rate to obtain average annual benefits. Water supply benefits were computed for both the average summer day and 4-day peak demand periods and were limited to the output provided by the proposed project or the projected deficit, whichever is lower. That is, based on a 95% reliability, Howard Hanson Dam, in Phase II, will provide 48 mgd during the May-September time frame. Therefore, water supply benefits for the average summer day and 4-day peak are limited to the project output of 48 mgd or the projected deficit, whichever is lower. Computation of the water supply benefits associated with average summer day and 4-day peak demand periods are shown below in Tables B2-11 and B2-12 respectively. As shown in these tables, cumulative present worth water supply benefits total approximately **$19,267,000** ($18,729,000 for the average summer day + $538,000 for the 4-day peak) which when levelized over the 50-year project life at 7 and 1/8 percent interest represents an average annual benefit of **$1,418,000**.

TABLE B2-11. WATER SUPPLY BENEFIT COMPUTATION, MEDIUM DEMAND FORECAST—AVG. SUMMER DAY

Year	Deficit	Days Of Water (Summer)	Millions Of Gallons	Cost Per Mill. Gal	Value	P.W. Factor 7.125%	P.W. Amount
2003	1.5	149	223.5	$409 [11]	91411.5	1	$91,411
2004	2.3	149	342.7	409	140164.3	0.9335	130,843
2005	3.1	149	461.9	409	188917.1	0.8714	164,622
2006	3.9	149	581.1	409	237669.9	0.8134	193,321
2007	4.7	149	700.3	409	286422.7	0.7593	217,481
2008	5.5	149	819.5	441	361399.5	0.7088	256,118
2009	6.3	149	938.7	482	452453.4	0.6617	299,388
2010	7.1	149	1057.9	522	552223.8	0.6177	341,108
2011	7.9	149	1177.1	554	652113.4	0.5766.	376,008
2012	8.7	149	1296.3	580	751854	0.5382	404,648
2013	9.5	149	1415.5	608	860624	0.5024	432,377
2014	10.3	149	1534.7	626	960722.2	0.4690	450,579
2015	11.1	149	1653.9	641	1060150	0.4378	464,134
2016	11.9	149	1773.1	654	1159607	0.4087	473,931
2017	12.6	149	1877.4	665	1248471	0.3815	476,292
2018	13.4	149	1996.6	675	1347705	0.3561	479,918
2019	14.2	149	2115.8	684	1447207	0.3325	481,196
2020	14.9	149	2220.1	691	1534089	0.3104	476,181
2021	15.7	149	2339.3	700	1637510	0.2897	474,386
2022	16.6	149	2473.4	729	1803109	0.2704	487,561
2023	17.4	149	2592.6	743	1926302	0.2525	486,391
2024	18.2	149	2711.8	756	2050121	0.2357	483,213
2025	19	149	2831	760	2151560	0.2200	473,343
2026	19.8	149	2950.2	772	2277554	0.2054	467,810
2027	20.7	149	3084.3	784	2418091	0.1917	463,548
2028	21.6	149	3218.4	795	2558628	0.1789	457,739
2029	22.5	149	3352.5	805	2698763	0.1671	450,963
2030	23.3	149	3471.7	813	2822492	0.1559	440,026

[11] From Table B2-10.

Year	Deficit	Days Of Water (Summer)	Millions Of Gallons	Cost Per Mill. Gal	Value	P.W. Factor 7.125%	P.W. Amount
2031	24.3	149	3620.7	823	2979836	0.1456	433,864
2032	25.3	149	3769.7	832	3136390	0.1359	426,235
2033	26.3	149	3918.7	846	3315220	0.1268	420,370
2034	27.3	149	4067.7	861	3502290	0.1184	414,671
2035	28.4	149	4231.6	877	3711113	0.1105	410,078
2036	29.4	149	4380.6	890	3898734	0.1032	402,349
2037	30.4	149	4529.6	902	4085699	0.0963	393,453
2038	31.5	149	4693.5	914	4289859	0.0899	385,658
2039	32.5	149	4842.5	925	4479313	0.0839	375,814
2040	33.5	149	4991.5	935	4667053	0.0784	365,896
2041	34.6	149	5155.4	945	4871853	0.0731	356,132
2042	35.7	149	5319.3	955	5079932	0.0683	346,959
2043	36.8	149	5483.2	964	5285805	0.0637	336,705
2044	37.9	149	5647.1	973	5494628	0.0595	326,930
2045	39	149	5811	981	5700591	0.0555	316,382
2046	40.1	149	5974.9	989	5909176	0.0518	306,195
2047	41.2	149	6138.8	997	6120384	0.0484	296,226
2048	42.3	149	6302.7	1004	6327911	0.0452	286,021
2049	43.4	149	6466.6	1010	6531266	0.0422	275,619
2050	44.5	149	6630.5	1016	6736588	0.0394	265,421
2051	44.5	149	6630.5	1016	6736588	0.0367	247,233
2052	44.5	149	6630.5	1016	6736588	0.0343	231,064
2053	44.5	149	6630.5	1016	6736588	0.0320	215,571
						SUM OF PRESENT WORTH	= $18,729,382

TABLE B2-12. WATER SUPPLY BENEFIT COMPUTATION MEDIUM GROWTH FORECAST—4-DAY

Year	Deficit	Available To Use	Days Of Water	Millions Of Gallons	Cost Per Mill. Gal. (Oct 97 Prices)	Value	P.W. Factor 7.125%	P.W. Amount
2003	0	N.A.	4	0	N/A	N/A	N/A	0
2004	0	N.A.	4	0	N/A	N/A	N/A	0
2005	0.1	N.A.	4	0.4	409	163.6	0.8714	$143
2006	0.6	N.A.	4	2.4	409	981.6	0.8134	798
2007	1.1	N.A.	4	4.4	409	1799.6	0.7593	1,366
2008	1.6	N.A.	4	6.4	409	2617.6	0.7088	1,855
2009	2.1	N.A.	4	8.4	409	3435.6	0.6617	2,273
2010	2.7	N.A.	4	10.8	409	4417.2	0.6177	2,728
2011	3.9	N.A.	4	15.6	409	6380.4	0.5766	3,679
2012	5.1	N.A.	4	20.4	416	8486.4	0.5382	4,567
2013	6.3	N.A.	4	25.2	482	12146.4	0.5024	6,102
2014	7.5	N.A.	4	30	534	16020	0.469	7,513

Year	Deficit	Available To Use	Days Of Water	Millions Of Gallons	Cost Per Mill. Gal. (Oct 97 Prices)	Value	P.W. Factor 7.125%	P.W. Amount
2015	8.8	N.A.	4	35.2	579	20380.8	0.4378	8,923
2016	10	N.A.	4	40	611	24440	0.4087	9,989
2017	11.2	N.A.	4	44.8	636	28492.8	0.3815	10,807
2018	12.4	N.A.	4	49.6	655	32488	0.3562	11,572
2019	13.7	N.A.	4	54.8	672	36825.6	0.3325	12,245
2020	15	N.A.	4	60	687	41220	0.3104	12,795
2021	16.4	N.A.	4	65.6	703	46116.8	0.2897	13,360
2022	17.9	N.A.	4	71.6	732	52411.2	0.2704	14,172
2023	19.3	N.A.	4	77.2	755	58286	0.2524	14,711
2024	20.7	N.A.	4	82.8	775	64170	0.2357	15,125
2025	22.2	N.A.	4	88.8	794	70507.2	0.2200	15,512
2026	23.6	N.A.	4	94.4	810	76464	0.2054	15,706
2027	25	N.A.	4	100	824	82400	0.1917	15,796
2028	26.5	N.A	4	106	840	89040	0.1789	15,929
2029	27.9	N.A	4	111.6	861	96087.6	0.167	16,046
2030	29.4	N.A	4	117.6	882	103723.2	0.1559	16,170
2031	31.1	N.A	4	124.4	903	112333.2	0.1456	16,356
2032	32.8	N.A	4	131.2	922	120966.4	0.1359	16,439
2033	34.5	N.A	4	138	939	129582	0.1268	16,431
2034	36.2	N.A	4	144.8	954	138139.2	0.1184	16,356
2035	37.9	N.A	4	151.6	968	146748.8	0.1105	16,216
2036	39.6	N.A	4	158.4	980	155232	0.1032	16,020
2037	41.3	N.A	4	165.2	992	163878.4	0.0963	15,781
2038	43	N.A	4	172	1003	172516	0.0899	15,509
2039	44.7	N.A	4	178.8	1013	181124.4	0.0839	15,196
2040	46.3	N.A	4	185.2	1022	189274.4	0.0784	14,839
2041	48.2	48	4	192	1032	198144	0.0731	14,484
2042	50.1	48	4	192	1032	198144	0.0683	13,533
2043	52	48	4	192	1032	198144	0.0637	12,622
2044	53.9	48	4	192	1032	198144	0.0595	11,790
2045	55.8	48	4	192	1032	198144	0.0555	10,997
2046	57.7	48	4	192	1032	198144	0.0518	10,263
2047	59.6	48	4	192	1032	198144	0.0484	9,590
2048	61.5	48	4	192	1032	198144	0.0452	8,956
2049	63.4	48	4	192	1032	198144	0.0422	8,362
2050	65.4	48	4	192	1032	198144	0.0394	7,807
2051	65.4	48	4	192	1032	198144	0.0367	7,272
2052	65.4	48	4	192	1032	198144	0.0343	6,796
2053	65.4	48	4	192	1032	198144	0.032	6,341
								SUM OF PRESENT WORTH = $537,904

2.7 ECOSYSTEM RESTORATION

The economic evaluation of ecosystem restoration is performed by comparing the economic cost to implement, operate and maintain ecosystem measures to the outputs gaining as a result of the ecosystem measures. While the cost of these measures can be measured like the cost of any other project purpose, there is currently no acceptable way to measure the value of the outputs in monetary terms (except for those fish which are produced by the project and subsequently harvested). Therefore, a traditional benefit-cost ratio for this part of the project cannot be determined. When benefits are not measured in dollars, a cost effectiveness and incremental cost analysis offers the next best approach to evaluate plan alternatives. While this analysis will not necessarily identify a unique or optimal solution, it will provide a mechanism to help decision makers allocate financial resources more efficiently and avoid the selection of economically irrational restoration measures. The results of the analysis allows decision makers to progressively compare alternative levels of ecosystem outputs and be able to ask if the next level of ecosystem output is worth its monetary cost.

2.7.1 Cost Effective and Incremental Cost Analysis

The purpose of the cost effective part of the analysis is to filter out measures that produce the same output level as another plan but costs more; or costs either the same or more than another plan, but produces less output. This part of the analysis ensures that the least cost plan is identified for each level of ecosystem output. The subsequent incremental cost analysis of the least cost plans is performed to show the incremental increases in cost as ecosystem outputs are increased. While these tools will not lead, nor are they intended to lead to a single best solution, they will improve the quality of the decision making by ensuring a rational, supportable, focused and traceable approach is used for considering and selecting alternative methods to produced ecosystem restoration outputs. Together, these tools will assist when selecting the recommended federal restoration (and mitigation) plan.

2.7.2 Ecosystem Restoration Goal

The ecosystem problems on the Green River have resulted in steady declining runs of anadromous salmon and steelhead fish coupled with a severe inability to attract and successfully pass juvenile salmon and steelhead from the HHD reservoir to the river downstream. The goal of the restoration project is of paramount importance in determining the various measures available to help solve identified problems. ER1105-2-210, dated June, 1995 states that "the goal of restoration is to return the environmental study area to as near a natural condition as is justified and technically feasible." For this project, the restoration goal is: to restore and maintain naturally reproducing and self sustaining runs of historical species of anadromous fish found in the upper Green River above HHD. Self sustaining runs are those which do not have to be supplemented with hatchery fish to maintain the run. While the output of the proposed project will not return the Green River to its "natural condition", or pre-dam condition, it does attempt to develop fish runs which maintain themselves naturally (i.e. without the use of hatchery produced fish).

2.7.3 Ecosystem Restoration Measures

Restoration measures available to help meet or partially meet the restoration goal were identified by a study team consisting of the project sponsor, state and federal agencies, tribal representatives, Trout Unlimited and representative from the Seattle District. This team of people identified nine separate fish passage measures, and five habitat improvement measures for evaluation. The low flow portion of the restoration project was previously established through negotiations between the project sponsor, state and federal resource agencies, Muckleshoot Indian Tribe and Corps of Engineers. Below is a short description of each of the fish passage measures (referred to in the plan formulation appendix as alternative 9), habitat improvements (referred to in the plan formulation appendix as alternative 10) and low flow augmentation measures (referred to in plan formulation appendix as alternative 7). It should be noted that the fish passage measures were a preliminary list which represent different levels of restoration output and do not necessarily meet all planning/engineering and biological criteria needed to reach the restoration goal. The construction costs of each measure are based on a 10% level of design and were provided by the Corps' Cost Engineering Section . Outputs used in this analysis were provided by the fish biologist and indirectly from the fish passage committee. Outputs are based on the estimated number of returning adults for three stocks (chinook, coho, and steelhead) and assume: (1) median reservoir survival, (2) median fish passage survival and (3) normal ocean survival. Outputs used in the incremental cost and cost effectiveness analysis also assumed no commercial harvest of the adult fish. Outputs used in selecting the recommended fish passage measure did, however, include an estimated long term harvest rate of chinook, coho and steelhead. A sensitivity analysis was performed using different parameters on reservoir, fish passage and ocean survival variables. While a change in the parameters of the variables resulted in a change in the incremental cost per incremental output, the cost break points among the final list of measures did not change. This was because a change in the parameters affected each of the fish passage measures in the same manner. See Appendix F for detailed information on how the number of returning adult fish were determined. The following section briefly describes each of the fish passage measures which were evaluated in the initial incremental cost and cost effectiveness analysis. A more detailed description of each measure can be found in the Environmental Appendix F, Part 1, Section 8, Paragraph 5.B.1.

a. Fish Passage Measures

(1) Fish Passage 1 (A1) – Currently, juvenile anadromous fish pass from the reservoir to the river downstream of the project through an intake structure; a 48 inch bypass pipeline and exit to the river below the dam. Because of the configuration of the intake, bypass pipeline and exit system of this existing structure, these fish experience a very high mortality by the time they enter the river below the dam. This alternative consists of modifying the 48 inch bypass exit by adding a 48 inch diameter pinch valve.

(2) Fish Passage 2 (A2) – This measure consists of a combination of fish passage 1 plus smoothing three downstream bends in the existing 48 inch bypass line.

(3) Fish Passage 3 (A3) – This measure consists of a combination of fish passage 1 and 2 plus the excavation of a wet well chamber within the existing intake tower. This would consist of an extension of the existing bypass intake port from elevation 1068 to elevation 1140 providing near surface fish collection. There would be a sliding trash rack with gate guide slots.

(4) Fish Passage 4 (A4) – Consists of a combination of 1 and 2 above in addition to an upstream "gulper" collector similar to that used at Green Peter Dam on Santiam River in Oregon. It would be mounted on the existing intake tower and gate lift hoist structure.

(5) Fish Passage 5 (A5) – This measure consists of a new intake tower with a single modular incline screen (MIS) and single lock facility. A live box would capture fish within the lock when the lock is being evacuated. Separate open channels would carry flow from the fish bypass and lock evacuation. Flow from the lock eventually combines with the existing flood control tower. Maximum discharge capacity of 560 cfs.

(6) Fish Passage 6 (A6) – This measure consists of a new intake tower the same as fish passage A5 with a single MIS and fish lock, except outflow conduits will be routed through a new 2000 foot long tunnel to a portal area located downstream of the existing spillway discharge point. Maximum discharge capacity of 625 cfs within screen criteria.

(7) Fish Passage 7 (A7) – This measure consists of a new intake tower the same as fish passage A5 and A6 except that two intake horns, two MIS screens, and two fish locks will be used. Like measure A6, the outflow would pass through a new tunnel to the downstream portal and stilling basin. Maximum discharge capacity is 1,250 cfs.

(8) Fish Passage 8 (B1) – Is comprised of a fish collector located on the mainstem Green River above the reservoir at elevation 1181 feet. The collector consists of a bank of 4 MIS, a permanent spillway, a seasonal rubber dam (March 15 – September 30). Transport would be by truck around the dam to a release site below HHD.

(9) Fish Passage 9 (B2) – Same as fish passage 8 except transport of fish to the river below the dam would be via an open channel using the railroad grade (approximately 5.5 miles to Bear Creek.

When performing the cost effectiveness and incremental cost analysis, the costs and outputs of fish passage measures at the dam (fish passage 1-7) as well as fish passage measures above the reservoir (fish passage 8 and 9) were evaluated individually and in combination with each other. Since implementation of either fish passage 8 or 9 would capture many of the juvenile salmon and steelhead before they reach the fish passage measures at the dam, the number of juvenile fish expected to pass through fish passage measures at the dam (measures 1-7), when combined with fish passage measures 8 or 9, were reduced accordingly. Fish passage measures at the dam with reduced outputs were considered to be fish passage measures "C1-C7" and are dependent on implementation of fish passage measures 8 (B1) or 9 (B2). For clarification, outside of this appendix, fish passage measures C1-C7 are referred to as fish passage measures A1-A7 with reduced output when they are combined with either fish passage measures B1 or B2.

Since the bulk of the implementation costs and outputs are associated with the nine fish passage measures, the cost effectiveness and incremental cost analysis was first performed incorporating the individual and combination of fish passage measures. The recommended federal fish passage measure was then selected from the final list of remaining fish passage measures. A second cost effectiveness and incremental cost analysis was performed for the proposed habitat improvements, except gravel placement. Gravel placement in the river downstream of the project was excluded from this analysis since the outputs of these measures were measured in output units different than the other habitat improvement measures. The habitat improvement analysis is presented in Paragraph 2.7.3b.

Shown in Table B2-13 are the construction costs, average annual costs, and restoration outputs, (measured in returning adult chinook, coho, and steelhead trout). The outputs are based on the following assumptions: (1) median reservoir survival, (2) median fish passage survival, (3) long term ocean survival rates and (4) no harvest. Since expected harvest rates affect each of the fish passage and habitat improvement measures in like proportion, they do not affect where the cost break points occur between measures. Harvest rates do however play a major role in helping to determine whether a particular measure or combination of measures will likely meet the ecosystem restoration goal of achieving self sustaining runs and were therefore included in selection of the recommended measure.

Shown in Tables B2-14 through B2-18 are the analytical steps used to perform the cost effectiveness and incremental cost analysis of the fish passage measures.

As previously mentioned, the alpha-numeric codes for each management measure are as follows:

"A" 1-7 represents fish passage measures one through seven. Because of the outputs of this measure, which are based on fish passage at the dam only, this measure cannot be combined with either measure B or C.

"B" 1 and 2 represents fish passage measures eight and nine;

"C" 1-7 represents fish passage A 1-7 above but with modified output which occur when combined with management measure B. This measure is dependent on fish passage B 1 or 2 being implemented.

A "0" code means that measure or scale is <u>not</u> included.

TABLE B2-13. ECOSYSTEM RESTORATION, ANALYSIS OF FISH PASSAGE COST AND OUTPUT

Scales	Const. Costs [12]	I & A	O & M	Repl.	Total Annual Cost	HABITAT OUTPUTS*
			MANAGEMENT MEASURE A - FISH PASSAGE AT THE DAM			
A1	$189,000	$14,000	$45,000	N.A.	$59,000	2,120
A2	$756,000	$57,000	$45,000	N.A.	$102,000	2,395
A3	$3,150,000	$239,000	$45,000	N.A.	$284,000	9,096
A4	$11,214,000	$851,000	$104,000	N.A.	$955,000	18,851
A5	$37,800,000	$2,870,000	$205,000	$5,000	$3,080,000	22,936
A6	$56,700,000	$4,304,000	$205,000	$5,000	$4,514,000	22,936
A7	$73,080,000	$5,548,000	$205,000	$8,000	$5,761,000	24,933
			MANAGEMENT MEASURE B - FISH PASSAGE ABOVE THE DAM			
B1	$31,777,000	$2,412,000	$150,000	$29,000	$2,591,000	24,957
B2	$56,700,000	$4,304,000	$150,000	$23,000	$4,477,000	25,787
			MANAGEMENT MEASURE C FISH PASS AT DAM WITH MOD OUTPUT - (AS A RESULT OF IMPLEMENTING MANAGEMENT MEASURE B)			
C1	$189,000	$14,000	$45,000	N.A.	$59,000	647
C2	$756,000	$57,000	$45,000	N.A.	$102,000	731
C3	$3,150,000	$239,000	$45,000	N.A.	$284,000	1,670
C4	$11,214,000	$851,000	$104,000	N.A.	$955,000	4,304
C5	$37,800,000	$2,870,000	$205,000	$5,000	$3,080,000	4,028
C6	$56,700,000	$4,304,000	$205,000	$5,000	$4,514,000	4,028
C7	$73,080,000	$5,548,000	$205,000	$8,000	$5,761,000	4,304

Three stocks; Long Term Ocean Survival Rate; Median Reservoir Survival; Median Fish Passage Survival; Before Commercial Harvest[8]
Average Annual Costs @ 7 1/8%; 50 Yrs; Oct 97 Prices

[12] Costs Provided by the Corps' Cost Engineering Section.

Table B2-14 reflects all of the possible combination of measures sorted by output; from lowest output to highest output. There are 23 separate combination of measures. For measures which have the same output but different costs, the measure with the lowest cost is listed first. The number assigned to each measure has been carried forward from this table. That is, measure #2 shown in Table B2-14 is the same measure #2 shown in all of the following tables in this analysis.

Table B2-15 reflects the elimination of measures which have a higher cost for same level of output. What remains are the least-cost measures for each level of output. As shown, three of the measures from the above table have been eliminated (measures 7,19 and 23) since they had the same output as other measures but a higher cost.

TABLE B2-14. FISH PASSAGE MEASURES COMBINATIONS SORTED BY OUTPUT

Management Measure	Annual Cost (In $1,000)	Annual Output
1. A0 B0 C0	$0	0
2. A1 B0 C0	59	2,120
3. A2 B0 C0	102	2,395
4. A3 B0 C0	284	9,096
5. A4 B0 C0	955	18,851
6. A5 B0 C0	3,080	22,936
7. A6 B0 C0	4,514	22,936
8. A7 B0 C0	5,761	24,933
9. A0 B1 C0	2,591	24,957
10. A0 B1 C1	2,650	25,604
11. A0 B1 C2	2,693	25,688
12. A0 B2 C0	4,477	25,787
13. A0 B2 C1	4,536	26,434
14. A0 B2 C2	4,579	26,518
15. A0 B1 C3	2,875	26,627
16. A0 B2 C3	4,761	27,457
17. A0 B1 C4	3,546	28,411
18. A0 B1 C5	5,671	28,985
19. A0 B1 C6	7,105	28,985
20. A0 B2 C4	5,432	29,241
21. A0 B1 C7	8,352	29,261
22. A0 B2 C5	7,557	29,815
23. A0 B2 C6	8,991	29,815
24. A0 B2 C7	10,238	30,091

TABLE B2-15. FISH PASSAGE MEASURES LEAST-COST MEASURES FOR EACH LEVEL OF OUTPUT

Management Measure	Annual Cost	Annual Output
1. A0 B0 C0	$0	0
2. A1 B0 C0	59	2,120
3. A2 B0 C0	102	2,395
4. A3 B0 C0	284	9,096
5. A4 B0 C0	955	18,851
6. A5 B0 C0	3,080	22,936
8. A7 B0 C0	5,761	24,933
9. A0 B1 C0	2,591	24,957
10. A0 B1 C1	2,650	25,604
11. A0 B1 C2	2,693	25,688
12. A0 B2 C0	4,477	25,787
13. A0 B2 C1	4,536	26,434
14. A0 B2 C2	4,579	26,518
15. A0 B1 C3	2,875	26,627
16. A0 B2 C3	4,761	27,457
17. A0 B1 C4	3,546	29,261
18. A0 B1 C5	5,671	28,985
20. A0 B2 C4	5,432	29,241
21. A0 B1 C7	8,352	29,261
22. A0 B2 C5	7,557	29,815
24. A0 B2 C7	10,238	30,091

Table B2-16 reflects the elimination of measures from Table B2-15 which have a higher cost for a lower level of output than other measures. For example, measure 8 in Table B2-15 has a higher cost with lower output than measure 9. Measure 9, provides a higher output for a lower cost than measure 8. As a result, measure 8 has been eliminated as well as any other measures which are not cost effective. This leaves 12 cost effective measures, which are shown by management measure number, as shown in Table B2-16.

TABLE B2-16. FISH PASSAGE MEASURES COST-EFFECTIVE AND LEAST COST COMBINATIONS

Management Measures	Annual Cost	Annual Output
1. A0 B0 C0	$0	0
2. A1 B0 C0	59	2,120
3. A2 B0 C0	102	2,395
4. A3 B0 C0	284	9,096
5. A4 B0 C0	955	18,851
9. A0 B1 C0	2,591	24,957
10. A0 B1 C1	2,650	25,604
11. A0 B1 C2	2,693	25,688
15. A0 B1 C3	2,875	26,627
17. A0 B1 C4	3,546	28,411
20. A0 B2 C4	5,432	29,241
22. A0 B2 C5	7,557	29,815
24. A0 B2 C7	10,238	30,091

Table B2-17 includes all of the measures and information provided in the above table, plus it presents incremental output, incremental cost and incremental cost per incremental output compared to the preceding plan.

TABLE B2-17. FISH PASSAGE MEASURES COST-EFFECTIVE LEAST-COST WITH INCREMENTAL ANALYSIS

Management Measure	Annual Cost (In $1,000)	Annual Output	Incre. Cost (In $1,000)	Incre. Output	Incre. Cost/Incre. Output
1. A0 B0 C0	$0	0	$0	0	$0
2. A1 B0 C0	$59	2,120	$59	2,120	$28
3. A2 B0 C0	102	2,395	43	275	156
4. A3 B0 C0	284	9,096	182	6701	27
5. A4 B0 C0	955	18,851	671	9,751	69
9. A0 B1 C0	2,591	24,957	1,636	6,106	268
10. A0 B1 C1	2,650	25,604	59	647	91
11. A0 B1 C2	2,693	25,688	43	84	512
15. A0 B1 C3	2,875	26,627	182	939	194
17. A0 B1 C4	3,546	28,411	671	1,784	376
20. A0 B2 C4	5,432	29,241	1,886	830	2,272

Management Measure	Annual Cost (In $1,000)	Annual Output	Incre. Cost (In $1,000)	Incre. Output	Incre. Cost/Incre. Output
22. A0 B2 C5	7,557	29,815	2,125	574	3,702
24. A0 B2 C7	10,238	30,091	2,681	276	9,714

Table B2-18, shows the final remaining measures after iterative recalculation of the incremental cost per unit for each remaining plan over the last selected plan.

TABLE B2-18. FISH PASSAGE MEASURES COMBINATIONS FOR FINAL INCREMENTAL ANALYSIS

Management Measures	Annual Cost (In $1,000)	Annual Output [13]	Incre. Cost	Incre. Output	Incre. Cost/Incre. Output
1. A0 B0 C0	$0	0	$0	0	$0
2. A1 B0 C0	59	2,120	$59	2,120	28
4. A3 B0 C0	284	9,096	225	6,976	32
5. A4 B0 C0	955	18,851	671	9,755	69
15. A0 B1 C3	2,875	26,627	1,920	7,776	247
17. A0 B1 C4	3,546	28,411	671	1,784	376
20. A0 B2 C4	5,432	29,241	1,886	830	2,272
22. A0 B2 C5	7,557	29,815	2,125	574	3,704
24. A0 B2 C7	10,238	30,091	2,681	276	9,714

Long Term Harvest Rates By Species. The long term harvest rates for chinook, coho and steelhead are based on historical harvest data provided by the state of Washington for the years between 1974 and 1991, the latest year available. It should be noted the commercial harvest of salmon over the last 3 years has been virtually stopped in most areas of Washington, Oregon and California. This commercial non-harvest situation is expected to continue but is assumed to only occur over the near term (5-8 years). The non-harvest together with numerous restoration type projects coming on line are expected to increase salmon and steelhead runs to the point where harvest can resume. Catch data provided includes harvest by Indian and non-Indian commercial fishermen plus harvest by sports fishermen. Over the 1974-1991 period, harvests of chinook salmon destined for the Green River have ranged from a low of 24% to a high of 79%, with the long term harvest rate for chinook salmon averaging 55%. The harvest rate for coho salmon destined for the Green River has ranged from 36% to 86% and has averaged over the 1974-91 time frame about 70%. The harvest rate for steelhead trout has ranged from a low of 14% to a high of 65% with a long term average harvest rate of 35%. A summary of the long term harvest rates is shown below.

[13] Expected Number of Returning Adults to Green River But Before Harvest.

ESTIMATED LONG TERM HARVEST RATES BY SPECIES

SPECIES	HARVEST RATE
Chinook	55%
Coho	70%
Steelhead	35%

Critical to the evaluation of the fish passage measures is the biological certainty that a minimum number of returning adults are needed to return to the upper watershed in order to re-establish self sustaining runs of chinook, coho and steelhead. That is, if the minimum numbers of returning adults needed to sustain the run of wild salmon and steelhead are not achieved, then these runs of wild fish will steadily decline until they become functionally extinct. Variables which have a major impact on the returns of each species to the upper watershed of the Green River include: (1) survival rate of juvenile fish across reservoir, (2) survival rate of juvenile fish through fish passage facility, (3) ocean condition impacts on survival of juvenile and adult fish and (4) harvest rate of adult fish. Based on assumed average conditions occurring with each variable, the minimum number of returning adults required and which will accommodate the long term harvest rate of each species, and still have enough fish to provide the minimum number of returning adults to the upper watershed to re-establish self sustaining runs are shown below. Returning adults numbers are shown for both before harvest and after harvest.

	Minimum Needed Before Harvest	Minimum Needed After Harvest
Chinook	5,100	2,300
Coho	21,600	6,500
Steelhead	2,100	1,300
Approximate Total	28,800	10,100

Initially Selected Fish Passage Measure. Based on the initially developed outputs and costs, there are 8 combinations of fish passage measures which remain in the final incremental cost and output analysis (see Table B2-18). The incremental cost per incremental output ranges from $28 to $9,714. Measures A1, A3 and A4 have incremental costs per incremental outputs of $28, $32 and $69 respectively. Measures B1C3, B1C4, B2C4, B2C5 and B2C7 have incremental costs per incremental outputs of $247, $376, $2,272, $3,704 and $9,714 respectively. The first major breakpoint between measures is between measures A4 and B1C3. In addition measure A4 was initially thought to produce enough fish to obtain the desired restoration goal. As a result, fish passage number A4 was the initially selected fish passage measure. It is critically important to note that the long term harvest rates of chinook, coho and steelhead were not available at the time of this initial selection nor had the fish passage committee reviewed the assumptions and analysis used in quantifying the outputs of each fish passage measure.

Further Fish Passage Analysis. After initial selection of fish passage measure A4, the fish passage committee reviewed the assumptions and analysis that were used in quantifying the outputs of each fish passage measure including A4. As part of their review (Agency Resolution Process), the fish passage committee did not agree that the design of A4 or any of the other fish passage measures would produce the number of returning adults used in the initial analysis of the fish passage measures. They believed that given the design of each fish passage measure outputs claimed were significantly too high. Incorporating the fish passage committee comments, the number of returning adults that would most likely occur with the design of each of the initial fish passage measures was revisited by the fish biologist and revised accordingly. The new outputs of each of the initial fish passage measures using average reservoir, fish passage and ocean survival rates and before harvest are as follows:

Management Measure	Revised Output	Management Measure	Revised Output
A1	1,834	C1	594
A2	2,071	C2	692
A3	6,497	C3	1,528
A4	13,633	C4	3,017
A5	17,808	C5	3,822
A6	18,037	C6	3,876
A7	22,163	C7	4,722
B1	21,768		
B2	22,721		

In addition, a new fish passage facility which is expected to provide sufficient fish to meet the ecosystem restoration goal of self sustaining runs, was developed. This fish passage measure incorporates the design features the fish passage committee say are critical to achieving a successful fish passage facility and includes those items which are thought to have worked at other fish passage facilities or would work at this facility but excludes those features which have not worked at other facilities. This new measure is labeled A8 and consists of constructing a new intake tower with a single enlarged modular incline screen with a single fish lock. A live box would capture fish within the lock when the lock is evacuated. Outflow would be routed through a new tunnel and stilling basin. An attenuation chamber would be provided at the tunnel outlet. Maximum discharge capacity would be 1,250 cfs. This measure was subsequently evaluated from both a design cost and a fish output aspect and as a result, the construction cost of A8 is estimated, in October, 1997 prices, at $34.1 million (with an average annual cost of $2,791,000) and the expected output, based on returning adults under average reservoir, fish passage and ocean survival conditions before harvest, is estimated at 23,381. As a result of the revised outputs associated with all of the initial fish passage measures plus the addition of a new fish passage measure, a second incremental cost and cost effectiveness analysis was performed which incorporated these changes. Shown in Table B2-19 are the remaining combinations for final incremental analysis based on the second incremental cost and cost effectiveness analysis. As shown in Table B2-19, both fish passage A4 and A8 are on the final list of cost effective fish passage measures. Incremental cost per incremental output range from a low of $32 for fish passage A1; to $48 for measure A3; to $94 for measure A4; to $188 for measure A8; to $538 for measure B1C4; to $1,019 for measure B1C8; to $1,979 for measure B2C8. The first major breakpoint is between measures A8 and B1C4. In terms of percentage increases, this analysis shows that the most obvious and largest incremental cost per incremental output percentage increase (186%) falls between measure A8 ($188) and B1C4 ($538). This is also shown in terms of absolute incremental cost changes. For example, there is an incremental cost increase of $16 between measures A1 and A3; $46 between measures A3 and A4; $94 between A4 and A8; $350 between A8 and B1C4; $481 between B1C4 and B1C8; and $960 between B1C8 and B2C8. These different ways of evaluating these measures all show that the first major breakpoint falls between measures A8 and B1C4. It should also be noted that fish passage measures A1, A3 and A4, after taking into consideration the long term harvest rates for coho, chinook and steelhead, do not produce sufficient numbers of returning adults to obtain self sustaining runs of salmon and steelhead. Fish passage measure A8, is the least cost fish passage facility which will meet the goal of self sustaining runs.

TABLE B2-19. FINAL FISH PASSAGE MEASURES COMBINATIONS FOR FINAL INCREMENTAL ANALYSIS

Mgmt. Measures	Const. Cost (In $1,000)	Annual Cost (In $1,000)	Annual Output [14]	Incre. Cost	Incre. Output	Incre. Cost/Incre. Output
A1	$189	$59	1,834	$59	1,834	$32
A3	3,150	284	6,497	225	4,663	48
A4	11,214	955	13,633	671	7,136	94
A8	34,100	2,791	23,381	1,836	9,748	188
B1C4	42,991	3,546	24,785	755	1,404	538
B1C8	68,200	5,382	26,587	1,836	1,802	1,019
B2C8	90,800	7,268	27,540	1,886	953	1,979

Prior to selection of the recommended fish passage facility, the total number of anadromous fish by species estimated to reach the upper reservoir, after harvest, including baseline fish (i.e. without-project fish), of fish passage measures A4, A8, B1C4, B1C8, and B2C8 were compared to the minimum number of returning adults needed to meet the restoration goal. Due to the limited output associated with fish passage measures A1 and A3, they were not included in this analysis. As shown in Table B2-20, given the long term harvest rates of 70% coho, 55% chinook and 35% steelhead, the total number of returning adult fish, after harvest, produced by fish passage A4 plus baseline fish are not expected to

[14] Outputs represent incremental numbers of fish produced as result of fish passage measure and exclude baseline fish.

come close to providing the numbers of fish of any species needed to meet the restoration goal of self sustaining runs of chinook and coho salmon and steelhead trout. Fish passage A4 is estimated to provide 52% of the number of needed chinook salmon, 65% of the needed coho salmon, and 69% of the needed steelhead. This means that given the long term harvest rates, this fish passage measure does not produce sufficient wild fish to sustain wild runs, and therefore the number of wild salmon and steelhead returning as adults will decrease each year until the numbers of wild fish are functionally extinct. Therefore, the number of returning adults shown in Table B2-20 represents the number of returning adults from the first cycle of fish. After the first cycle, the numbers of returning adult wild salmon and steelhead will steadily decrease. Fish from fish passage measure A8 plus baseline fish are expected to produce sufficient, after harvest fish, to effectively meet the restoration goal. Fish passage measure A8 together with baseline fish are estimated to provide 96% of the needed chinook, 92% of the needed coho and 100% of the needed steelhead. Measures B1C4 is expected to provide significantly more than the needed chinook and about the amount of coho and steelhead fish needed. Measures B1C8 and B2C8 both are estimated to provided more than the needed numbers of chinook salmon and the amount needed for both coho salmon and steelhead trout.

TABLE B2-20. FISH PASSAGE OUTPUTS COMPARED TO MINIMUM NUMBER OF RETURNING ADULTS REQUIRED TO MEET RESTORATION GOAL

Fish Passage Measure	Fish Passage Outputs [15]	Minimum Number Needed [16]	Percent Of Goal
(A4)			
Chinook	1,200	2,300	52%
Coho	4,200	6,500	65
Steelhead	900	1,300	69
Total	6,300 [17]	10,100	
(A8)			
Chinook	2,200	2,300	96%
Coho	6,000	6,500	92
Steelhead	1,300	1,300	100
Total	9,500	10,100	
(B1C4)			
Chinook	2,900	2,300	126%
Coho	5,900	6,500	91
Steelhead	1,300	1,300	100
Total	10,100	10,100	
(B1C8)			
Chinook	2,900	2,300	126%
Coho	6,300	6,500	97
Steelhead	1,400	1,300	108
Total	10,600	10,100	
(B2C8)			
Chinook	3,100	2,300	135%
Coho	6,500	6,500	100
Steelhead	1,400	1,300	108
Total	11,000	10,100	

Cost Per Fish. The evaluation of the fish passage measures also included a comparison of the total cost and cost per fish of each of the remaining fish passage measures. As shown in Table B2-21, construction costs range from $11.2 million for measure A4; to $34.1 million for measure A8; to $43 million for measure B1C4; to $65.8 million for measure B1C8 and finally $90.8 million for B2C8. The cost per fish are based on the construction cost divided by the expected number of returning adults before harvest over the first 15-year period of returning adults of each fish passage measure. The costs per

[15] After harvest and including baseline(Without-Project) fish totaling 250 Chinook, 1,200 Coho, and 240 Steelhead and an adjustment for in-river survival.

[16] Minimum number of adults needed to upper reservoir to achieve self sustaining runs.

[17] Number of returning adults from first cycle of fish. Numbers of returning wild adult salmon and steelhead will continue to decline until runs of wild fish are functionally extinct.

fish were computed in this manner since fish passage measure A4 has decreasing returns of wild adult salmon and steelhead each year while all of the other fish passage measures produce sufficient numbers of adults to be able to establish self sustaining runs of salmon and steelhead. A fifteen year period of returning adults was selected because the wild runs of salmon and steelhead produced by fish passage A4 are expected to become functionally extinct by this point in time. As shown in Table B2-21, based on the first 15-year period of returning adults, the costs per fish are $117 for measure A4; $97 for measure A8; $116 for B1C4; $165 for B1C8 and $220 for B2C8. If a longer time frame was used the cost per fish for fish passage alternatives which meet the goal of sustainable runs would continue to decline and the cost per fish for A4 would remain relatively constant.

TABLE B2-21. CONSTRUCTION COST, OUTPUTS BEFORE HARVEST AND COST PER FISH

	Total Construction Cost	Fifteen Year Output Before Harvest	Cost Per Fish
(A4)	$11,214,000	96,000	$117
(A8)	34,100,000	351,000	97
(B1C4)	42,991,000	372,000	116
(B1C8)	65,843,000	399,000	165
(B2C8)	90,800,000	413,000	220

While measure A4 costs considerably less than any of the other fish passage measures, it does not come close to meeting the restoration goal of establishing self sustaining runs of chinook and coho salmon and steelhead trout even with baseline fish included. Fish passage A8, as well as B1C4, B1C8, and B2C8 all either virtually achieve the restoration goal or they exceed it. Based on the first cycle of returning adults, the incremental cost per incremental output of fish passage A8 is twice that of A4 ($94 vs $188). However, as shown in Table B2-21, fish passage A8 is the least cost fish passage measure and is fully expected to meet the goal of self sustaining runs of chinook, coho and steelhead. Without a fish passage facility that produces sufficient number of fish that result in self sustaining runs, the amount of wild fish produced each year, after harvest, will decrease to the point where the runs of wild fish will essentially cease to exist.

Incidental Fish Passage Benefits. Incidental benefits associated with the fish passage facilities consist of the number of fish produced by the proposed project which are eventually harvested either commercially or by sports fishermen. The value of these fish depends on whether they are caught commercially and sold for consumption or whether they are caught by sports fishermen. The values per fish used in this analysis are based on the fish values presented in the Columbia River System Operating Review (SOR), Final Environmental Impact Statement, Appendix O, Economic and Social Impact, dated November, 1995. This report shows the value for sport caught salmon is based on $62.90 per trip and .8 trips per fish resulting in a value per fish of $50.32 ($62.90 X .8 = $50.32). The SOR report also shows, sport caught steelhead have a value of $101.27 per fish. This value is computed based on 1.61 trips per fish and a cost \$62.90 per trip (\$62.90 X 1.61 = \$101.27). As shown in the SOR report, the value of commercially caught salmon is \$26.30 per fish and the value of commercially caught steelhead is \$11.00. The number of fish caught commercially and by sport fishing, by species, for each fish passage facility were determined by the fish biologist and are based on the long term harvest rates for Green River coho and chinook salmon and steelhead of 70, 55 and 35% respectively. The number of each species expected to be caught commercially and by sport fishing, the value per species and the total value of harvested fish for each of the fish passage measures A4, A8, B1+C4, B1+C8, and B2+C8 are shown in Table B2-22 and the following summary table.

TABLE B2-22. VALUE OF HARVESTED FISH ASSOCIATED WITH FISH PASSAGE MEASURES

Species & Method Of Harvest	Number Of Harvested Fish [18]	Total Value Of Harvest [19]
	FISH PASSAGE A-4	
Coho	(7,113)	
Sport	854	\$43,000
Commercial	6,259	165,000
Chinook	(1,436)	
Sport	775	39,000
Commercial	661	17,000
Steelhead	(430)	
Sport	189	19,000
Commercial	241	3,000
Total Value Harvested Fish		**\$286,000** [20]
	FISH PASSAGE A-8	
Coho	(11,872)	
Sport	1,425	\$72,000
Commercial	10,447	275,000
Chinook	(2,999)	
Sport	1,320	67,000
Commercial	1,679	44,000
Steelhead	(688)	
Sport	372	38,000
Commercial	316	4,000
Total Value Harvested Fish		**\$500,000**

[18] Based on long term harvest rates for coho and Chinook salmon and steelhead of 70, 55, and 35% respectively.

[19] Numbers rounded to nearest thousand dollars.

[20] This benefit is for first 3 year adult return period. Since returning adults decline, harvest benefits of this fish passage facility steadily decrease until they approach zero value by about project year 18.

Species & Method Of Harvest	Number Of Harvested Fish [18]	Total Value Of Harvest [19]
	FISH PASSAGE B1+C4	
Coho	(11,644)	
Sport	1,400	$71,000
Commercial	10,264	270,000
Chinook	(4,044)	
Sport	1,779	90,000
Commercial	2,265	60,000
Steelhead	(677)	
Sport	366	37,000
Commercial	311	3,000
Total Value of Harvest Fish		**$531,000**
	FISH PASSAGE B1-C8	
Coho	(12,792)	
Sport	1,535	$78,000
Commercial	11,257	296,000
Chinook	(4,098)	
Sport	1,803	91,000
Commercial	2,295	60,000
Steelhead	(728)	
Sport	393	40,000
Commercial	335	4,000
Total Value of Harvested Fish		**$569,000**
	FISH PASSAGE B2-C8	
Coho	(13,297)	
Sport	1,596	$81,000
Commercial	11,701	308,000
Chinook	(4,341)	
Sport	1,910	96,000
Commercial	2,431	64,000
Steelhead	(757)	
Sport	409	41,000
Commercial	348	4,000
Total Value of Harvested Fish		**$594,000**

SUMMARY OF TABLE B2-22

Fish Passage Measure	Value Of Harvested Fish Per Year	Present Worth Value Of Harvested Fish Per Year
A4	$286,000 [19]	$100,000
A8	500,000	407,000
B1+C4	531,000	432,000
B1+C8	569,000	463,000
B2+C8	594,000	483,000

Shown above is a summary of Table B2-22 which shows both the non-discounted and present worth value of harvested salmon and steelhead per year for each fish passage measure. Since returning adults would not begin to return until project year 3, the present worth value of the harvest shown in the above summary table reflects this fact. Also, it is important to note that fish passage measures A8, B1+C4, B1+C8, and B2+C8 all meet the restoration goal of producing self sustaining (wild) runs and still provide enough salmon and steelhead to maintain the long term harvest rates for coho (75%), chinook (55%) and steelhead (35%). However, with fish passage A4 (as well as A1 and A3), if harvest of these salmon and steelhead is incurred at their historical levels mentioned above, the self sustaining runs of wild fish will not occur and in fact, there will be a steadily decreasing return of self sustaining wild fish until they cease to exist. For example, coho salmon only reaches 63% of the required escapement in project year 1. When these fish return as adults in 3 years, a 70% harvest rate will reduce the spawner escapement even further resulting in fewer juvenile fish which in turn results in fewer returning adults. This cycle will continue resulting in steadily decreasing runs of wild fish. As a result, it is estimated by the fish biologist that with fish passage A4 and the current long term harvest rate of 70%, coho salmon above HHD would become functionally extinct in four to five 3-year life cycles or about 15 years from when the first adults return (about project year 18). Chinook, with a long term harvest rate of 55%, would be reduced to 7% of the required escapement and be functionally extinct in the same time frame. Steelhead, with a harvest rate of 35%, would be reduced to 24% of the required number of returning adults in the same time frame. While it would take a few years longer, self sustaining runs of wild steelhead would become functionally extinct as well. As a result, the harvest benefit shown for A4 will decrease over time until it approaches zero value. This fact is reflected in the present worth value of wild fish harvest of $100,000 per year shown above for fish passage A4. Table B2-23 shows how the future number of harvested fish produced by fish passage measure A-4 decrease over the first 18 years of the project. This stream of harvested fish is based on coho returning every 3-years and chinook and steelhead returning every 4-years. The present worth value of $100,000 per year for harvested fish associated with fish passage A-4 shown in the summary of Table B2-22 is based on the stream of harvested fish shown in Table B2-23

TABLE B2-23. FUTURE EXPECTED HARVEST OF COHO, CHINOOK AND STEELHEAD ASSOCIATED WITH FISH PASSAGE MEASURE A-4 [21]

Project Year	Coho	Chinook	Steelhead	Total Number Of Fish
0-2	0	0	0	0
3-5	7,113	1,436	430	8,979
6	4,562	1,436	430	6,428
7-8	4,562	747	301	5,610
9-10	2,896	747	301	3,944
11	2,896	388	211	3,495
12-14	1,810	388	211	2,409
15-17 [22]	1,159	201	146	1,506

There are 3 different management options that could be expected to be implemented with implementation of fish passage A4:

(1) The harvest rates would be significantly reduced. In order to obtain self sustaining runs using fish passage A4, the harvest rate of coho cannot exceed 52%, the harvest rate of chinook cannot exceed 13% and the harvest rate of steelhead cannot exceed 7%. It is important to note that a reduced harvest has the effect of reducing the harvest for all coho, chinook and steelhead fish caught in Washington waters, since Green River fish headed for the upper and lower river are not distinguishable from other Washington fish. This and the prevailing fish management strategy to protect the weakest runs (i.e. upper Green River fish) to assure that natural escapement goals are met result in a lower harvest for all coho, chinook and steelhead fish caught in Washington waters. This management option results in a lost harvest or harvest forgone as fewer fish would be caught than would normally occur in Washington waters.

(2) Harvest rates would be kept as is and additional but much less desirable hatchery produced fish would need to be planted at an increasing rate to reach the required number of returning adults. As a result, self sustaining runs of wild salmon and steelhead in the upper river would cease to exist. Or,

(3) A new fish passage facility, like A8, would be constructed to replace A4.

Impacts Associated With Reduced Harvest When Implementing Fish Passage A-4. A logical question associated with the selection of an alternative that meets sustainable returns is the level of harvest. Theoretically, if the harvest rate is lowered, alternative A4 could meet the restoration goal of sustainable runs of wild salmon and steelhead. While

21 Assumes long term harvest rates for coho, chinook and steelhead are in place.

22 Coho, Chinook and Steelhead are functionally extinct after this point in time.

the Corps does not have control over harvest rates, a theoretical evaluation of a reduction in harvest rates can be considered.

A portion of the effect of a lower harvest rate can be measured through the reduced value of the tribal, commercial and recreational catch in the NED account. If A4 was selected, the harvest would have to be reduced to reach self sustaining runs. The estimated harvest level would need to be lowered to 52% for coho, 13% for chinook and 7% for steelhead. Since the harvest rate is set for all of Puget Sound, not just the upper Green/Duwamish watershed, the total effect (in the NED account) of the reduction cannot be assessed, as that information is not available. However, we can compare the impacts between selecting A8 to A4 (with reduced harvest) using the Green/Duwamish River harvest. For this purpose, the Green/Duwamish fishery was divided into two components: (1) the upper watershed (above HHD) and the lower watershed. Any reference in this report thus far has considered only the upper watershed.

The values of fish used in this analysis are the same as those used in Table B2-22 which were taken from the Columbia System Operating Review Report as presented in the write up on "Incidental Fish Passage Benefits." The values shown in Tables B2-24 and B2-25 have been put in present worth terms in order to account for the fact that the first adult runs are not available for harvest until project year 3. Therefore, the values associated with lost harvest have been discounted 3 years at 7 1/8 percent.

TABLE B2-24. COMPUTATION OF FOREGONE FISH HARVEST BENEFITS WHEN IMPLEMENTING FISH PASSAGE A-4 FOR UPPER GREEN RIVER WATERSHED

Fish Passage Alternative at Harvest Rates Necessary To Achieve Sustainable Runs	Average Annual Value of Harvest (Based on Values Reported in SOR and Discounted 3 Yrs. @ 7 1/8%)	Capitalized Value (Over 50 Year Project Life @ 7 1/8%)
A8 With Existing Long Term Harvest Rates Chinook 55% Coho 70% Steelhead 35%	$407,000	$5,529,000
A4 With Reduced Harvest Rates Chinook 13% Coho 52% Steelhead 7%	$141,000	$1,921,000
Forgone NED Benefits of A4 Within Upper Green River Watershed	**$266,000**	**$3,617,000**

To get a true picture of the total economic loss of selecting A-4 with the reduced harvest over A-8, the cost of the lost harvest of all Puget Sound commercial (including tribal) and recreational fish would have to be incorporated. That is, since Green River fish cannot be distinguished from other Puget Sound fish, a reduced harvest rate because of A4 will result in a reduced harvest of all Puget Sound fish. The Puget Sound wide figure is not available; however, we can consider the existing fishery in the upper and lower Green River basin to help compare the total investment costs of A-4 to A8. The annual forgone NED value of the fishery is capitalized and added to the construction cost of fish passage A4. As shown in Table B2-24, if it is assumed A4 is implemented instead of A8 and harvest rates of A4 are reduced in order to achieve self sustaining runs, the annual economic loss for the upper Green River would be $266,000 and the capitalized present worth value would be $3,617,000. This value, however, is only a small proportion of the loss associated with implementing fish passage A4. Since Green River fish cannot be distinguished from other Puget Sound fish, a reduced harvest rate because of implementing A4 will result in a reduced harvest of all Puget Sound fish.

Although we do not know the percent of the total Puget Sound returns the Green River comprises, harvest rates for the lower Green River are available. These fish are primarily hatchery stock, so we cannot compare them directly to those in the upper watershed in terms of ecosystem value; however, we can compare them to estimate their commercial/recreational value. Table B2-25 shows that, under the existing condition harvest rates, the annual NED discounted value of the harvest associated with lower river fish is $5,077,000 ($6,241,000 non-discounted). If A4 were implemented with a reduced harvest in order to achieve self sustaining runs, the present worth NED value of the fishery would drop to $1,764,000 ($2,168,000 non discounted). This analysis results in a net annual present worth loss for the lower river fishery of $3,313,000. As shown in Table B2-25, the capitalized value of the foregone harvest of lower Green River fish over the 50 year project life at 7 and 1/8 percent is $45,000,000.

TABLE B2-25. COMPUTATION OF FOREGONE FISH HARVEST BENEFITS WHEN IMPLEMENTING FISH PASSAGE A-4, LOWER GREEN RIVER WATERSHED

Fish Passage Alternative at Harvest Rates Necessary To Achieve Self Sustaining Runs	Average Annual Present Worth Value of Harvest	Capitalized Present Worth Value (Over 50 Year Project Life @ 7 1/8%)
A8 With Existing Long Term Harvest Rates Chinook 55% Coho 70% Steelhead 35%	$5,077,000	$68,974,000
A4 With Reduced Harvest Rates Chinook 13% Coho 52% Steelhead 7%	$1,764,000	$23,965,000
Forgone NED Harvest Benefits of A4 Within the Lower Watershed	$3,313,000	$45,009,000

As shown in Table B2-24 and B2-25, the total capitalized value of the lost harvest if fish passage measure A4 is implemented is $48.6 million. That is, to compare the two fish passage alternatives (A4 vs. A8), the NED fish harvest losses of $48.6 million would have to be added to the construction cost of A4. If this was done, the NED cost of A4 would be $59.8 million ($11.2 million plus $48.6 million). This compares to a NED first cost of A8 of $34.1 million. Taking all NED costs into consideration shows that the overall cost of fish passage A8 is a more cost effective solution to ecosystem restoration than fish passage A4.

Focusing on a reduction in harvest rates has several flaws. The proposed project is an environmental restoration project, not a commercial fisheries project. Commercial fishing benefits are incidental to the overall project goal. Additionally, harvest rates like ocean survival rates are exogenous variables. Holding these variables constant or using historical averages to evaluate the effects of different restoration alternatives is the best method of evaluating the outputs of each alternative. Finally, the Corps does not have control over these variables, so this can only be a theoretical exercise. However, as shown in the above analyses, the least cost and most cost effective fish passage facility that results in sustainable runs, whether these factors are held constant or not, is fish passage A8.

Other Selection Factors. Construction of Howard Hanson Dam has prevented hundreds of millions of dollars in flood damages ($695,000,000) through fiscal year 1996. In addition, because of the flood protection provided by this project, the Kent Valley area has gone from a primarily agricultural area to a major commercial and industrial complex. Billions of dollars of commercial and industrial development and the resulting employment opportunities have been created all as a result of constructing Howard Hanson Dam. While this economic development is considered good for the nation and Puget Sound economy, it has, however, come at the expense of the ecosystem resources on the Green River, especially the runs of anadromous fish. Mitigation of the resource associated with constructing Howard Hanson Dam has to this point in time been minimal. Viewed from this standpoint, spending $34 million toward restoring fish runs on the Green River, compared to the economic development created by the project at the expense of the ecosystem, is a relatively small price to pay. Based on comments made by the fish passage committee, developing fish passage facility A8 instead of A4 will significantly increase the likelihood of achieving the goal of self sustaining runs of chinook and coho salmon and steelhead trout to the upper watershed.

Recommended Fish Passage Measure. Lastly, each of the final fish passage measures were evaluated against the ecosystem restoration final decision criteria of: (1) acceptability (plan should be acceptable to state and federal resource agencies and local government as well as project sponsor), (2) completeness, (3) efficiency, (4) effectiveness, (5) partnership and (6) reasonableness of cost criteria as stated in EC1105-2-210, dated 1Jun95, paragraph 22b, pages 25-26. The screening criteria most central to the recommendation of alternative A8 are: (1) Acceptability, (4) Effectiveness and (6) reasonableness of costs. Acceptability (to the local sponsor and resource agencies) and project effectiveness were determined and measured through how well each of the alternatives in the final incremental evaluation meet the fish passage planning and design criteria which were required to reach the restoration goal of sustainable naturally reproducing runs of wild salmon and steelhead. Imposing these criteria led to the selection of the recommended fish passage facility. Less costly alternatives were not acceptable to the resource agencies and were not effective in addressing the ecosystem problems to a meaningful degree. Alternatives with outputs greater than A8 had unreasonable project costs, which was supported by the incremental analysis. Based on the above criteria, as well as taking the economic development and impacts created by HHD into consideration plus the goal of trying to establish self sustaining runs of chinook and coho salmon and steelhead trout, plus the incidental salmon and steelhead harvest benefits as well as the value of harvest forgone, Seattle District Corps of Engineers recommends that fish passage measure A8 be constructed. Additional information associated with the technical merits and other benefits of measure A8 and additional rationale for selecting this measure is presented in Appendix F.

d. Habitat Improvement Measures. These habitat improvements assumes that the recommended fish passage measure is in place. Implementation of these measures increases the probability of reaching the claimed outputs associated with the fish passage facilities but also produces some additional fish by providing habitat in both the reservoir and in the river which is needed for their migration to and from the ocean. Project restoration also included an incremental cost and cost effectiveness analysis of three habitat improvement measures. This analysis assumed that fish passage A8 was constructed and in operation. The outputs represent the additional adult salmon returns that are expected as a result of implementing the habitat improvement measure. The cost and output of each measure are displayed in Table B2-26. A brief description of each measures is presented below. A more detailed description of each measure can be found the Environment Appendix F.

(1) Measure E - Create a slough on the south side of the Green River below Tacoma control station. The number of before harvest returning adults produced by this measure is estimated at 1,718. Of this total, approximately 20% (or 345 fish) are fish returning to the upper watershed and are associated with the restoration goal of self sustaining runs in the upper watershed. Construction cost of this measure is estimated at $1,147,000.

(2) Measure F. In the upper watershed, improve river channels between elevations 1080 and 1141 feet. The number of before harvest returning adults to the upper watershed produced by this measure is estimated at 681 fish. Cost of this measure is estimated at $769,000.

(3) Measure G. In the upper watershed, improve river channels between elevations 1177 feet and 1240 feet. The number of before harvest returning adults to the upper watershed associated with this measure is estimated at 3,576 fish. Construction cost of this measure is estimated at $464,000.

TABLE B2-26. ECOSYSTEM RESTORATION, ANALYSIS OF HABITAT IMPROVEMENTS COST AND OUTPUTS

Management Measure	Const. Cost	I & A	Average Annual Costs O & M	Repl	Total Annual Cost	Habitat Outputs
E	$1,147,000	$99,950	$40,000	$3,000	$142,950	1718
F	$769,000	$67,011	$30,000	$5,000	$102,011	681
G	$454,000	$39,562	$10,000	$11,000	$60,562	3576

As mentioned above, these habitat improvement measures were also evaluated using the cost effectiveness and incremental cost computer program. Shown in Table B2-27 is the table which shows the combination of measures remaining for the final incremental analysis of habitat improvements.

TABLE B2-27. HABITAT IMPROVEMENT COMBINATIONS FOR FINAL INCREMENTAL ANALYSIS

Management Measure	Annual Cost (In $1,000)	Annual Output	Incre. Cost (In $1,000)	Incre. Output	Incre. Cost/Incre. Output
1. E0 F0 G0	$0.0	0.0			$0.0
2. E0 F0 G1	61,000	3,576	61,000	3,576	17.06
3. E1 F0 G1	204,000	5,294	143,000	1,718	83.24
4. E1 F1 G1	306,000	5,975	102,000	681	149.78

e. Other Habitat Improvement Measure (Gravel Placement). In addition to the above habitat improvement measures one other habitat measures was evaluated separately from those in Table B2-26. This measure consist of placing gravel in the streambed at various locations in the upper reaches of the Green River (RM 40-46) and was evaluated separately because the units of output were in different units than the other habitat improvement measures plus the cost per unit of gravel coverage is basically the same for each scale of this measure. In addition, an incremental cost and cost effectiveness analysis was not performed on this measure since there are only three different scales which can be evaluated without the need to utilize that analytical computer model. Implementation of any of these measures though would increase the probable success of all the habitat improvement measures evaluated above. Cost of each measure is a function of the cubic yards of gravel placed per year and whether the gravel is screened or not prior to placement. Cost of each measure consists of constructing a 1,500 ft access road on the north side of Flaming Geyser State Park estimated at $79,000 ($6,000 average annual) plus the purchase and placement of the rock. Shown in Table B2-28, are the average annual cost of each measure including the area of gravel coverage.

TABLE B2-28. GRAVEL NOURISHMENT MEASURES FIRST COST, AVERAGE ANNUAL COST AND AREA OF GRAVEL COVERAGE

Measures	Location	Cubic Yds Of Gravel Per Yr.	Annual Cost For Screened Gravel	Annual Cost For Non-Screened Gravel	Square Feet Of Coverage
Gravel #1	Middle Green	3,900	$99,000	$73,000	16,000
Gravel #2	Middle Green	7,800	$193,000	$141,000	32,000
Gravel #3	Middle Green	11,700	$287,000	$208,000	48,000

(1) Selected Habitat Improvement Measures. In addition to the recommended fish passage facility are improvements to fish habitat consisting of habitat restoration measures E, F and G discussed in Paragraph 2.7.3b. As shown in Table B2-26, the outputs are measured in returning adult salmon and total an estimated 3,576 for measure G, 1,718 for measure E and 681 for measure F. The incremental cost per incremental output of each measure range from $17.06 for measure G, $83.24 for measure E and $149.78 for measure F. The habitat improvement measures selected to be implemented include measures E and G from Table B2-26. Measure E consists of developing a slough on the south side of the Green River downstream of Tacoma control station. Measure G consists of improving river channels in the upper watershed between reservoir elevations 1177 and 1240 feet. Implementation of these two measures will provide habitat improvements to both the reservoir area of the project as well as downstream.
The other evaluated habitat improvement measure consists of placing three different amounts of spawning gravel in the Green River stream bed near Palmer. Salmon and steelhead use these areas of gravel for spawning. Fish eggs laid in gravel rather than mud or sand have a better chance of surviving. Outputs were measured using cubic yards of gravel. The minimum amount of gravel needed to be placed and still be effective is estimated at 3,900 cubic yards. This amount of gravel will provide 16,000 square feet of coverage. The other two measures consisted of placing increasing amounts of gravel which will provide ever greater square feet of coverage. The selected gravel placement habitat improvement measure was the least cost of the three and consists of placing the least amount needed in order to provide effective habitat or 3,900 cubic yards. It is also recommended that this site be monitored to determine the actual level of use.

For detailed information on all of the restoration measures, refer to the Environmental Appendix F.

f. Low Flow Augmentation. This restoration measure consists of allocating 8 feet of reservoir space in order to enhance the existing in stream flows. This reservoir space will be used to help meet the minimum in stream flows of 300 cfs in the spring and 400 cfs in the fall (15 September through 31 October). The amount of storage space set aside for low flow augmentation was determined through negotiations with the State of Washington, Muckleshoot Indian Tribe, project sponsor and Corps of Engineers. For more detailed information on low flow augmentation, see Hydrology and Hydraulics Appendix D, Part1, Hydrology, Section 7.

2.8 PROJECT COSTS

2.8.1 Construction Cost and Investment Costs

Project first costs consist of construction cost. Major construction items consist of modification to the outlet works to include lands, intake tower, intake gates and equipment, seepage control, foundation work, access road, mitigation measures and all costs associated with monitoring of fish and wildlife facilities. Total construction costs are estimated to be $74,707,000 in October 1997 prices. Investment costs include construction costs plus interest during construction (IDC). IDC was computed by compounding interest over the construction period at 7 1/8 percent interest. Shown below is a summary of project construction costs and investment costs.

2.8.2 Annual Costs

Estimated annual costs are based on investment costs levelized over the 50-year economic life of the project at 7 1/8 percent interest. The estimated incremental increase in annual operation and maintenance costs associated with the proposed project are also included. Shown below are the estimated annual costs of the proposed project.

Construction Cost	$ 74,707,000
Interest During Construction	5,500,000
Investment Cost	$ 80,207,000
Average Annual Costs	
Interest and Amortization (50-Yrs @ 7 1/8%)	$ 5,904,000
Operation and Maintenance	468,000
Total Annual Cost	$ 6,372,000

2.8.3 Allocation of Project Costs

While the proposed project does not affect the outputs of the existing project, the project does add two additional project purposes; both with different cost sharing requirements. As project sponsor, Tacoma Water Division is responsible for paying 100% of the construction, operation, maintenance and replacement costs allocable to water supply and 35% of the construction and 100% of the operation, maintenance and replacement costs allocable to ecosystem restoration. As a result, a preliminary allocation of the proposed project costs is necessary. This preliminary cost allocation establishes a basis for determining the proportion of project costs which are assigned to the project purposes of M&I water supply and ecosystem restoration. A final cost allocation will be prepared after construction and audit is completed. In addition, cost allocable to water supply and restoration were further broken out between Phase I and Phase II costs. The construction costs in this cost allocation include the capital and labor costs associated with-project monitoring.

Following is a discussion of how all construction costs, except the labor costs associated with monitoring, were allocated. Due to the uncertainty regarding what number of years labor required for monitoring is considered a construction cost item, a separate allocation(s) of the labor costs associated with monitoring was developed and is discussed in sub-paragraph c of this Paragraph with the results shown in Table B2-31.

Since ecosystem restoration benefits are not quantified in dollar terms, the normal separable cost - remaining benefits cost allocation methodology cannot be used. As a result, a modified use of facilities cost allocation method was developed and used for this project. The modified use of facilities cost allocation methodology used for this project (excluding labor costs for monitoring) has been approved by the Corps' Northwest Division as well as Headquarters and consists of determining the separable costs allocable to each project purpose and then allocating the remaining joint use costs based on the height of the fish passage facility. See Paragraph 2.8.3c below.

Separable costs are defined as the difference in cost between the multiple purpose project and the multiple purpose project with a project purpose omitted. That is, separable costs are the costs incurred by adding a project purpose. The sum of the total separable costs subtracted from the cost of the multiple purpose project leaves residual joint-use costs. The residual joint-use costs are then allocated to each project purpose based on a formula described in sub-paragraph c below.

The sum of the separable costs and the allocated residual joint-use cost for each project purpose constitutes the total construction cost of the proposed project allocated to that purpose. In addition, there are water supply costs associated with the existing project which are also allocated to water supply.

a. Multiple-Purpose Projects With Function Omitted. [23]

The construction cost estimates for each of these projects were determined based on input from the design and cost engineers. Each accounting feature line item presented in the multiple-purpose project was evaluated with respect to each of these multiple purpose projects with a function omitted. Following is a discussion of each project:

(1) Without M&I Water Supply. Facilities and operation of the project with water supply omitted would be the same as the alternative single-purpose ecosystem restoration project. This alternative would provide ecosystem restoration benefits equal to those of the multiple purpose project. This project would consist of a single purpose restoration project constructed at the same site to pool elevation 1155 (1147 plus 8 feet for low flow augmentation). A fish passage facility similar to the multiple purpose project (A8) would be constructed but to elevation 1155 instead of elevation 1177. The habitat improvement measures would be the same as the multiple purpose project. Right bank seepage treatment would also be performed but only to elevation 1155. The construction cost of this project in October 1997 prices is estimated at $53,512,000.

(2) Without Ecosystem Restoration. Facilities and operation of the project with ecosystem omitted would be the same as the alternative single-purpose water supply project. This alternative would provide water supply benefits equal to those of the multiple-purpose project. This project would consist of a single purpose water supply project constructed at the same site but to pool elevation 1169 instead of 1177. Fish mitigation would consist of a fish passage facility similar to measure A4 but constructed to elevation 1169, instead of 1177. Other mitigation measures associated with water supply impacts would be the same as the multiple purpose project. Right bank seepage treatment would also be performed but to pool elevation of 1169, instead of 1177. Cost of this project in October 1997 prices is estimated at $29,440,000.

Shown in Table B2-29 are the construction costs, by accounting feature and sub-feature for the multiple-purpose project and the alternative multiple-purpose projects with a function omitted.

[23] See Libby Dam Project, Design Memorandum 29, Cost Allocation, Nov. 1976.

TABLE B2-29. HOWARD HANSON DAM WATER SUPPLY AND ECOSYSTEM RESTORATION PROJECT PRELIMINARY COST ALLOCATION[24] (OCTOBER 1997 PRICES)

	Multiple -Purpose Project			Multiple-Purpose Projects With Function Omitted	
Permanent Features	**Specific Restor.**	**Joint Use**	**Total**	**Without Restor.[25]**	**Without W.S.[26]**
01. Land & Damages		$3,948,000	$3,948,000	$2,600,000	$1,335,000
04. Dams		56,268,000	56,268,000	23,216,000	47,494,000
06. Fish & Wildlife					
03.99 Wildlife Mitigation		2,951,000	2,951,000	1,965,000	986,000
03.99 Fish					
Mitigation		3,545,000	3,545,000	1,659,000	1,886,000
Restoration	$1,811,000		1,811,000		1,811,000
Total Project Cost	**$1,811,000**	**$66,712,000**	**$68,523,000**	**$29,440,000**	**$53,512,000**

b. Determination of Separable Costs. The cost information for the multiple purpose project and multiple purpose project with a function omitted shown in Table B2-29 is used in Table B2-30 to determine the separable cost of each project purpose. As shown in Table B2-30, separable costs of water supply total $15,011,000 and the separable costs of ecosystem restoration total $39,083,000. Separable costs total $54,094,000 leaving $14,429,000 in joint-use costs.

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[24] Excludes labor costs associated with-project fish and wildlife monitoring of $6,184,000.

[25] Also serves as single purpose water supply project.

[26] Also serves as single purpose restoration project.

TABLE B2-30. HOWARD HANSON DAM WATER SUPPLY AND ECOSYSTEM RESTORATION PROJECT DETERMINATION OF SEPARABLE AND RESIDUAL JOINT COSTS (OCTOBER 1997 PRICES IN $1,000)

	Project Cost
MULTIPLE-PURPOSE PROJECT	$68,523 [27]
MULTIPLE-PURPOSE WITH FUNCTION OMITTED:	
Without Water Supply	$53,512
Without Restoration	29,440
SEPARABLE COSTS:	
Water Supply	15,011
Restoration	39,083
TOTAL SEPARABLE COSTS	$54,094
RESIDUAL JOINT-USE COSTS	$14,429

c. Allocation of Joint-Use Construction Costs. Since the project purpose of ecosystem restoration does not have benefits which are quantified in dollar terms, the separable cost-remaining benefit (SCRB) cost allocation could not be used to allocate the residual joint-use costs between water supply and ecosystem restoration. As a result, a modified use of facilities method was developed and used to allocate the remaining joint-use costs. The cost allocation methodology used in this study is as follows and is the methodology for allocating joint-use costs approved by Northwest Division and Headquarters:

It was determined that most residual joint-use costs are directly or indirectly associated with the fish passage facility and, therefore, the height of the fish passage facility associated with each project purpose was used to allocate the residual joint-use costs. The proposed project will produce a project with a total storage elevation of 142 feet. Of this total, the existing project comprises 112 feet while the proposed project consists of an additional 30 feet of storage (elev. 1,147-1,177). In this allocation of joint-use costs it is important to note that the existing project with an elevation of 112 feet, is currently preventing most of the juvenile fish from successfully passing from reservoir to river. That is, since the current project is not successfully mitigating the impacts to the anadromous fish population, that portion of the fish passage facility associated with the existing reservoir (i.e. 112 feet) is considered allocable to ecosystem restoration. As stated above, the proposed project will add an additional 30 feet of summer storage for a total storage of 142 feet. Of the additional 30 feet of storage, 8 feet is set aside to provide additional low flow augmentation for anadromous fish and is therefore, also allocable to ecosystem

[27] Excludes monitoring costs of $6,184,000 for mitigation and restoration measures.

restoration. The remaining fish passage elevation needed to accommodate the storage provided for M&I water supply is 22 feet and is allocable to water supply.

Based on this modified use of facilities allocation methodology, 120 feet of the fish passage is associated with ecosystem restoration (112 feet for the existing project plus 8 feet for the proposed low flow augmentation for fish) and 22 feet is associated with M&I water supply. Converting these elevations to percentages, 85% of the residual joint-use costs, $12,265,000 are allocable to ecosystem restoration (120ft./142ft) and 15% (22ft/142ft) or $2,164,000 is allocable to M&I water supply.

d. **Allocation of Fish and Wildlife Monitoring Costs.** Labor costs for monitoring fish and wildlife facilities is expected to last as long as 15 years in many cases. All monitoring costs expended over this time frame are considered to be construction costs and have been included as part of the overall project cost allocation of construction costs. Labor costs associated with monitoring the fish and wildlife features (restoration and mitigation) of the proposed project consist of six major items. These items and years of monitoring consist of: (1) downstream fish passage (15 years), (2) downstream impacts to habitat and aquatic resources (5 years), (3) fish habitat restoration (10 years), (4) fish habitat mitigation (years 1, 2, 5 and 10), (5) wildlife mitigation (years 1, 2, 5,and 10), and (6) adult salmon and steelhead returns (years 1, 2, 5 and 10). Items 1 and 2 are considered joint-use costs and are allocable based on the height of the fish passage facility associated with each project purpose with 85% of the cost allocated to restoration and 15% allocated to water supply. Item 3 is separable to restoration and 100% of this cost was assigned to restoration. Items 4 and 5 are associated with Phase I reservoir impacts and are therefore separable to water supply and 100% of these costs are allocable to water supply. Item 6 is all associated with restoration and 100% of this cost is allocable to restoration. However, it is recommended that the cost sharing formula for this item be 33% federal government and 67% shared between the project sponsor and resource agencies. Shown in Table B2-31 is the recommended allocation of labor costs associated with monitoring fish and wildlife features.

TABLE B2-31. ALLOCATION OF LABOR COSTS ASSOCIATED WITH-PROJECT MONITORING

Item And Years Of Monitoring	Allocation	Total Cost	Water Supply	Restoration
(1) Fish Passage (15 years)	85% Restoration 15% Water Supply	$3,300,000	$495,000	$2,805,000
(2) Downstream Impacts (5 years)	85% Restoration 15% Water Supply	$852,000	128,000	724,000
(3) Fish Habitat Restoration (10 years)	100% Restoration	$351,000	0	351,000
(4) Fish Habitat Mitigation (Years 1, 2, 5 & 10)	100% Water Supply	$183,000	183,000	0
(5) Wildlife Mitigation (Years 1, 2, 5 & 10)	100% Water Supply	$328,000	328,000	0
(6) Adult Returns (Years 1, 2, 5, & 10)	100% Restoration w/33% Federal & 67% Sponsor & Resource Agencies	$1,170,000	0	1,170,000 [28]
TOTAL		**$6,184,000**	**$1,134,000**	**$5,050,000**

The results of the preliminary allocation of total estimated construction costs associated with the proposed project, including the separable cost of each project purpose and the allocation of remaining joint costs of 85% to restoration, 15% to water supply, plus the allocation of monitoring costs, show that $18,309,000 is allocable to water supply and $56,398,000 is allocable to ecosystem restoration. See Table B2-32 for a summary of the proposed project cost allocation results.

[28] 100% allocable to restoration with federal government paying 33% or $386,000 and project sponsor and resource agencies paying 67% or $784,000.

TABLE B2-32. HOWARD HANSON DAM WATER SUPPLY AND ECOSYSTEM RESTORATION PROJECT COST ALLOCATION OF PROPOSED PROJECT (OCTOBER 1997 PRICES)

	M&I Water Supply	Ecosystem Restoration
Separable Cost	$15,011,000	$39,083000
Remaining Joint Costs	2,164,000	12,265,000
Allocation of the New Project Construction Costs w/o Monitoring	$17,175,000	$51,348,000
Monitoring Costs	1,134,000	5,050,000
Total Proposed Project	**$18,309,000**	**$56,398,000**

e. Share of Existing Project Construction Costs. In addition to the construction costs associated with the proposed project are the construction costs associated with the existing HHD project. The cost sharing formula requires the local sponsor to repay a portion of the existing project when storage is being added to an existing project for the purpose of M&I water supply. The sponsors share of the existing project construction cost was computed in accordance with ER1105-2-100, Paragraph 4-32e, with an adjustment to reflect the number of months during the year HHD is used to provide water supply storage. In this case, water supply storage will be provided during the May through September season or 5 months during the year. Therefore, the sponsor's share of the existing project was adjusted accordingly (5/12 = 42%). See Table B2-33 for computation of sponsors estimated share of existing project use for water supply.

TABLE B2-33. HOWARD HANSON DAM WATER SUPPLY AND ECOSYSTEM RESTORATION PROJECT COMPUTATION OF SPONSOR'S ESTIMATED SHARE OF EXISTING PROJECT USE FOR WATER SUPPLY [29]

COST OF LEAST COST ALTERNATIVES (Oct 97 Prices)	$19,267,000
LESS: SPONSOR'S SHARE OF WATER SUPPLY	18,309,000
REMAINING BENEFITS	$958,000
SPONSOR'S SHARE IS 1/2 THE REMAINING BENEFITS	$479,000
ADJUSTMENT FOR SEASONAL USE ($313,000 X 42%)	$201,000

[29] Numbers rounded to nearest $1,000.

Cost Allocation Summary.

Shown in Table B2-34, is a summary of all construction cost allocable to water supply and restoration. The total includes construction costs associated with the new water supply and restoration project plus the construction costs associated with the existing project assigned to water supply.

TABLE B2-34. SUMMARY OF COSTS ALLOCATION RESULTS NEW PROJECT PLUS SHARE OF EXISTING PROJECT

	M&I WATER SUPPLY	ECOSYSTEM RESTORATION
NEW PROJECT	$18,309,000	$56,398,000
EXISTING PROJECT	201,000	0
TOTAL ALLOCATION	**$18,510,000**	**$56,398,000**

Since 100% of all operation and maintenance costs, whether expended for water supply or restoration are a non-federal responsibility, an allocation of operation and maintenance costs between water supply and restoration was not required. However, it should be noted that an accounting methodology which can identify or distinguish between operation and maintenance costs of the existing project versus operation and maintenance costs of the additional/new project needs to be established prior to completion of construction. Operation and maintenance costs, in 1997 prices are estimated at $468,000 on an average annual basis. Of this total, approximately $100,000 is incurred as a result of Phase II.

2.8.4 Cost Sharing

As previously mentioned, M&I water supply and ecosystem restoration have different cost sharing requirements. All costs (construction, operation, maintenance and replacement costs) allocated to water supply including monitoring are considered non-federal costs and are the responsibility of the project sponsor. Construction costs allocable to restoration are cost shared 65% federal and 35% non-federal (except for monitoring associated with adult returns – see Table B2-31). Operations and maintenance requirements are the responsibility of the non-federal project sponsor.

a. Construction Costs. Shown below are the estimated construction cost sharing requirements based on the current sharing of construction costs and the results of the preliminary cost allocation. Costs sharing number are in 1997 prices as well as to the mid point of construction or full funded dollars. The full funded share of costs allocated to each purpose was determined based on the percent of construction costs allocated to each purpose using October 1997 price level and the full funded estimate of project construction costs. That is, based on a full funded construction cost estimate of $84,000,000, 48.5% was allocated to the federal government and 51.5% was allocated to the non-federal sponsor as shown in Table B2-35.

TABLE B2-35. HOWARD HANSON DAM WATER SUPPLY AND ECOSYSTEM RESTORATION PROJECT FEDERAL AND NON-FEDERAL SHARE OF CONSTRUCTION COSTS (OCT 1997 PRICES AND FULL FUNDED)

	COST SHARING BY PROJECT PURPOSE		
PROPOSED PROJECT	FEDERAL	NON-FEDERAL	TOTAL
WATER SUPPLY	$0.0	$18,510,000	$18,510,000
ECOSYSTEM RESTORATION	$36,284,000 [30]	$20,114,000 [31]	$56,398,000
TOTAL COST-PROPOSED PROJECT (97 Prices)	$36,284,000	$38,624,000	$74,908,000 [32]
ALLOCATED SHARE IN PERCENT	48.5%	51.5%	100.0%
FULL FUNDED SHARE	**$40,740,000**	**$43,260,000**	**$84,000,000**
LESS: NON-CASH LANDS [33]	**0**	**2,356,000**	**2,356,000**
CASH REQUIREMENT	**$40,740,000**	**$40,904,000**	**$81,644,000**

Table B2-33 shows the estimated share of full funded construction costs, including the cash share for the project sponsor and federal government. These construction costs include costs for both Phase I and Phase II of the project. The estimated construction cost incurred in each phase of the project is shown in Table B2-36. Except for an estimated $90,000 associated with Phase II of the fish passage facility, all other Phase II costs will be expended when Phase II is implemented. Phase II fish passage costs will be expended during Phase I.

TABLE B2-36. ESTIMATED CONSTRUCTION COST EXPENDITURES BY PHASES

	PHASE I	PHASE II
Construction Costs	**$79,274,000** [34]	**$4,726,000**

30 (($56,398,000 - $1,170,000) X .65) + 386,000 = $36,284,000

31 (($56,398,000 - $1,170,000) X .35) + 784,000 = $20,114,000

32 Includes $201,000 associated with existing project.

33 Estimated value.

34 Includes $90,000 for Phase II fish passage facility expended during Phase I.

b. Operation and Maintenance. All operation and maintenance cost associated with water supply and ecosystem restoration are the responsibility of the project sponsor. Based on October 1997 prices, average annual operation and maintenance costs are estimated to be $468,000 per year of which $100,000 is associated with implementation of Phase II. Future operation and maintenance costs can be expected to increase over time due to price level increases plus any agreed to changes in or modifications to the proposed project.

2.8.5 Description of Phase I and Phase II

Based on negotiations between the project sponsor, resource agencies, Muckleshoot Indian Tribe and Corps of Engineers, the operation of the recommended project has been divided into two separate phases called Phase I and II. Phase I begins when the proposed project goes into operation in year 2003 and ends at the completion of year 2007 (or 5 years). Phase II begins in year 2008 and extends over the remaining economic life of the project to year 2053 (45 years). The difference between the two phases can be separated into two separate elements. The first element reflects a change in the water storage operation of the proposed project between Phase I and Phase II. The second element is based on the outputs associated with each phase (i.e. how much water is stored) and the additional cost associated with implementing construction elements associated with that phase.

Following is Table B2-37 which presents the reservoir elevation, summer storage provided in acre feet, project outputs and a description of project operations for each phase of the project. The table also presents the incremental change between phases associated with each item.

TABLE B2-37. PROPOSED PROJECT - SUMMER/FALL OUTPUTS BY PHASES

Item	Phase I	Phase Ii	Incremental Change Between Phases
Reservoir Elevation (from 1147)	1,167	1,177	10 FEET (8 feet Restoration) (2 feet Water Supply)
Summer Storage (af)			
* Low Flow Augmentation	NONE	9,600	9,600
* Water Supply	20,000	22,400	2,400
TOTAL ACRE FEET	20,000	32,000	12,000
OUTPUTS			
Ecosystem Restoration			
* Low Flow Aug.	NO	39 cfs @ 78% Rel. Over 123 Day Period	39 cfs @ 78% Rel. Over 123 Day Period
* Fish Passage	YES (to elev. 1177)	No Change From P1	No Change
* Habitat Improvement	YES	No Change From P1	No Change
Water Supply	42 mgd @ 95% Rel. Over 153 Day Period	48 mgd @ 95% Rel. Over 153 Day Period	6 mgd @ 95% Rel. Over 153 Day Period
Project Operations			
Water Right: • 1933 First Diver. Water Claim 113 cfs • State Min. In-Stream. 300 cfs[35] • 1995 Second Supply Water Right 100 cfs	Store Second Supply Water Right of 100 cfs during spring for release during summer and early fall.	Water in excess of First Diversion water right, minimum in-stream flows, and Second Supply Water Right (113 + 300 + 100 cfs = 513cfs) is stored during spring for release during summer and early fall.	No storage of Second Supply Water right for release during summer and early fall.

Phase I - The outputs/benefits produced during this phase consists of: (1) 42 mgd of M&I water supply at 95% reliability over a 153 days summer period; (2) a fish passage facility to elevation 1177; and (3) all fish habitat improvements.

[35] This water volume is for a average water year. Minimum in-stream flow requirements vary from 350 cfs during a wet year to 250 cfs during a dry year.

Phase I storage for water supply would be accomplished as follows:

> In 1995, Tacoma obtained an additional water right for water from the Green River. This right is known as the Second Supply Water Right (SSWR) and consists of 100 cfs which Tacoma is entitled to year around as long as minimum in-stream flows can be met. Since Tacoma has a surplus of water during the spring, this 100 cfs of water, instead of being withdrawn from the river, will be stored behind HHD during the spring months for release during the summer and early fall. Storage of this water will be sufficient to supply 42 mgd at 95% reliability over the 153 day summer demand period.
>
> During Phase I, from 2003 to 2008, adaptive management of the resources will be undertaken to determine the actual impacts of a higher pool and to determine what if any modifications to Phase I and 2 should be undertaken.

Phase II - The primary output of this phase is to provide 9,600 ac-ft of storage for low flow augmentation which will produce 39 cfs at 78% reliability over a 123 day summer period. In addition, 2,400 ac-ft, or 6mgd at 95% reliability over the 153 day summer period, would be provided for water supply. (See Table B2-31).

Storage for low flow augmentation and water supply during Phase II would be provided as follows:

> In addition to Tacoma's 1995 Second Supply Water Right of 100 cfs they also have a 1933 First diversion water claim of 113 cfs. This water claim has a higher priority than even minimum in-stream flows. That is, this water can be withdrawn from the river even if by doing so, minimum in-stream flows cannot be met. During this phase, water associated with Tacoma's Second Supply Water Right would no longer be stored during the spring. Instead, water in excess of Tacoma's First diversion water right, minimum in-stream flows (300 cfs on average), and Second Supply Water Right (113 + 300 +100 cfs = 513 cfs) would be stored during the spring for release during summer and early fall. See Table B2-30 for more information.

a. Economic Evaluation of Phase II. This analysis is specific to evaluating the feasibility of expending additional construction costs in Phase II versus outputs achieved. It is important to note that from an analytical standpoint the proposed change in operation of project for storage purposes can be accomplished without expending any additional costs and is not contingent on providing additional low flow or water supply. That is, Phase II could be implemented from an operational standpoint and no further construction costs would necessarily be required.

The additional construction costs incurred as a result of producing additional outputs associated with Phase II consists of constructing several fish and wildlife mitigation sites associated with the higher pool for low flow augmentation and water supply, land associated with the mitigation measures, plus constructing an additional 10 feet of fish passage tower. Cost of these items in 1997 prices and including interest during construction of $75,000 is estimated at $4,295,000. Discounting these costs from year 2008 to 2003 results in a present worth investment cost of $3,044,000. Annualizing the investment cost over the 50-year project life results in an annual cost of $224,000. Phase II present worth annual operation and maintenance cost is estimated at $71,000 for a total Phase II present worth annual cost of $295,000.

Project costs and benefits of Phase II are primarily associated with providing the low flow restoration feature. Of the total annual cost of $295,000, approximately $290,000 is associated with restoration and the remaining $5,000 is associated with water supply.

b. Low Flow Augmentation Outputs. All of the anadromous salmonids in the Green River begin their life as embryos incubating within the substrate of the stream bed, with most incubation occurring from fall to early spring. Failure to maintain water quantity and quality can lead to drying and mortality of eggs and fry. Adult salmon in their upstream migration and spawning are also dependent on adequate water quantity and quality. Adult chinook salmon require a minimum flow volume, flow depth and temperature range to migrate upstream to preferred spawning areas. In recent years, the channel shape of the Green River has become wider and shallower and during low flow years adult chinook salmon have become trapped in lower river areas. In addition, riparian areas along the river are almost non-existent through the lower 35 miles of river. In most years, summer temperatures in the Green River may reach a point where chinook salmon are delayed on their upstream migration for extended periods. Researchers have established an optimum or preferred range of flows for spawning of salmon in the Green River. Successful spawning requires a useable range of stream temperatures for adult salmon migration, spawning and egg incubation. Fall stream temperatures in the Green often exceed this range for days to weeks. Flow augmentation will restore a major limiting factor for the Green River, low flows during summer and early fall. Phase II of the proposed project will provide 9,600 ac-ft of storage available for low flow augmentation. Augmenting flows during the summer and early fall months alters the flow regime from HHD (RM64) to the estuary (RM 7) during the period when (1) juvenile salmonids are rearing in the river, (2) steelhead eggs are incubating and fry are emerging, (3) adult chinook and coho salmon are migrating upstream, and (4) chinook salmon are spawning in the river. Flow augmentation produced by Phase II can be used to increase summer and fall flows which will increase available habitat with potential improvements in water temperature from increased stream velocities, pool depths and wetting of side-channel areas. The analysis of Phase II augmentation assumed that the water would be held and released in the late summer and fall to benefit adult salmon migrating and spawning. Adult chinook and coho salmon begin their upstream migration into the lower Green River during August and September. Even with the benefit of increased summer flows .

c. Water Supply Outputs. Constructing Phase II of the proposed project will incrementally add 2,400 ac-ft of storage for M&I water supply. These acre feet of storage will provide an additional 6 mgd of water at 95% reliability over the 153 day summer period. Based on the medium growth forecast for M&I water during the summer demand period and assuming Phase I water continues to be provided as defined until the deficits exceed the amount of Phase I water, the additional 6 mgd of water provided by Phase II would not be needed for meeting average summer demand until project year 45. In addition, this water would not be needed to help meet the 4-day peak demand until project year 35. Based on these conditions, the present-worth value of Phase II water supply is estimated at $7,000 per year.

2.8.6 Risk and Uncertainty

a. Water Supply. Water supply benefits are sensitive to the water demand forecast and resulting supply deficits over time. The Tacoma Water Division prepares a high and low demand forecast. Since water supply benefits are sensitive to the forecast used to determine the level of supply deficits over time, a medium demand forecast (midway between the high and low forecast) was used to quantify water supply benefits for this report. Should actual demand turn out to higher or lower than the forecast used, water supply benefits (and cost sharing) will be impacted accordingly. For example, if the low demand forecast is used in quantifying water supply benefits, these benefits decrease to approximately $8,600,000. Based on the separable water supply costs developed in the cost allocation, these benefits would not be sufficient to cover separable water supply costs and water supply would be eliminated from the proposed project leaving a single purpose ecosystem restoration project. On the other hand, if the high demand forecast is used, waters supply benefits increase to approximately $27,000,000. This benefit is not only higher than the water supply separable costs, based on the cost allocation, it would increase the costs, in 1996 prices, allocated to water supply from an estimated $18,510,000 to an estimated $20,130,000.

The risk taken by the local sponsor if the water supply deficits are lower than used in this report is they will have paid more for a project than necessary and for a project whose need is not immediate. On the other hand, the federal government will have received more than full value for use of HHD. If the deficits turn out to be greater than forecast, the sponsor will have paid less for a project than they should have and the federal government will not have received full value for use of HHD. Using a medium water demand forecast in this analysis of benefits and cost sharing is a viable way of trying to equalize the risk for both parties in this project.

b. Ecosystem Restoration. There is always some level of risk and uncertainty associated with the outputs claimed for any project. Ecosystem restoration is certainly no exception. Measurement of the risk and uncertainty for a project with a goal of increasing the number of returning adult salmon to the point where self sustaining runs are established is very difficult. It is difficult because of the many risks and uncertainties anadromous fish face in their cycle of life. For example, while there is risk and uncertainty about the success of the proposed fish passage measure itself there is also even greater risk and uncertainty associated with the likelihood of salmon surviving the obstacles they encounter in the open seas and successfully returning to the project to spawn. Obstacles such as water temperature (El Niño), disease, predation, commercial and recreational fishing from both U.S. and Canadian fishermen all play a significant part in the perceived success of a project. While risk and uncertainty at the project site can be measured and controlled to some degree, risk and uncertainty in the open seas is a wild card and cannot be controlled. Therefore, while a restoration project may be operating as planned and designed, other important factors outside the control of the restoration measure will also play a critical role in the achieving the desired goal of the project. For these reasons, a risk and uncertainty analysis for restoration was not performed.