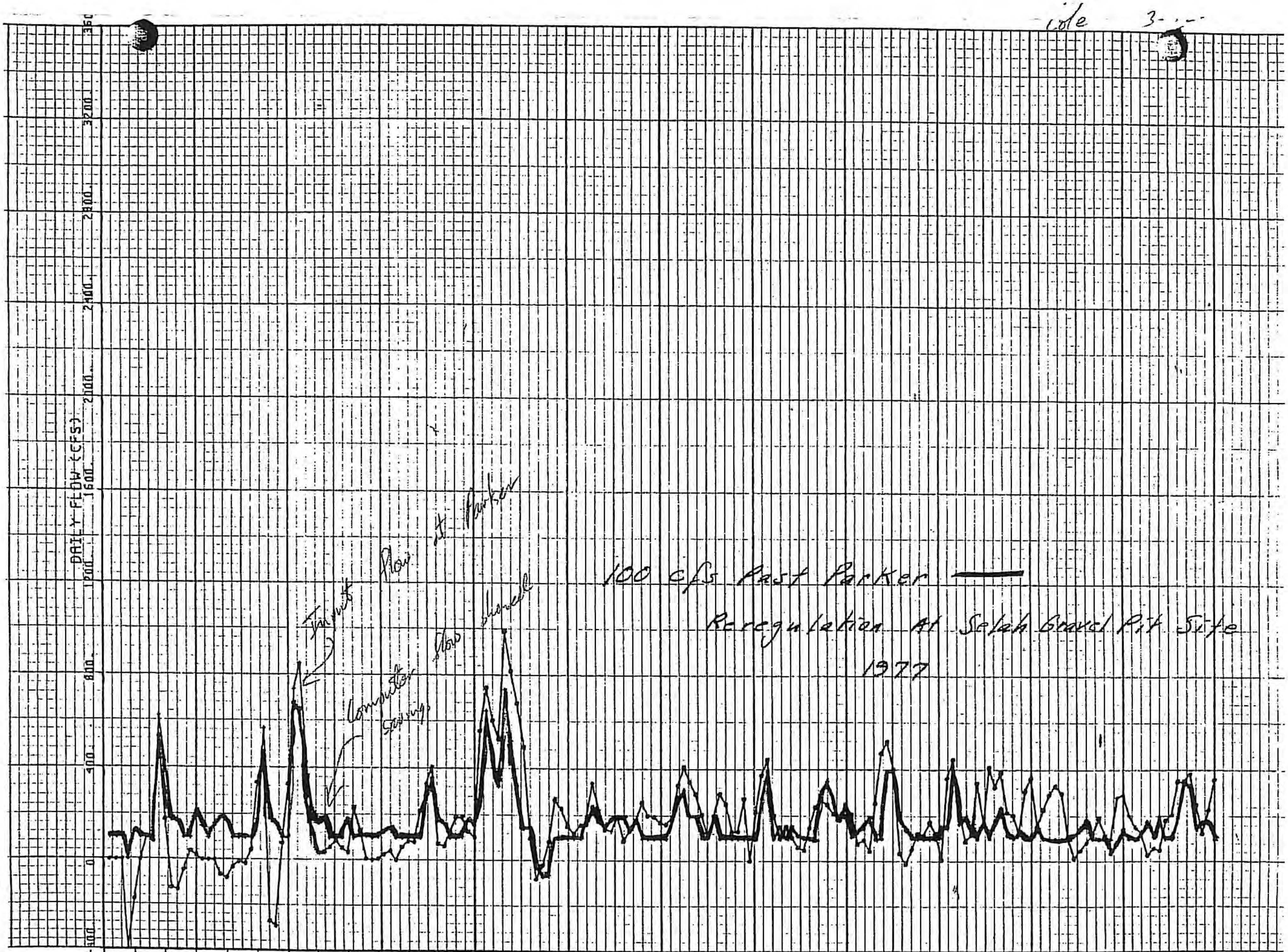
Feasibility Study

Yakima River Reregulating Storage

Prepared for
State of Washington
Department of Ecology

CH2MHILL
May 1978



AT SELAH GP WITH MINIMUM 100 CFS PAST PARKER, WASH.

Cole
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POTENTIAL SITE LOCATIONS

1 - Selah Creek
2 - Wenas Creek
3 - East Selah Gravel Pits

CH2M HILL
engineers
planners
economists
scientists

31 May 1978

S11414.A1

State of Washington
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

Attention: Mr. John Spencer

Gentlemen:

We are pleased to submit our feasibility study of a reregulating storage facility in the Yakima River Basin. To assist your review of the study, a summary and site evaluation matrix are given at the front of the report.

We have enjoyed working with you and the representatives of various irrigation interests in the Yakima Valley, and we are ready to continue the design as soon as a site is identified and the work is authorized.

Sincerely,

John S. Mayo
John S. Mayo, P.E.

William A. Watters
William A. Watters, P.E.

tc

Seattle Office
1500 114th Avenue S.E., Bellevue, Washington 98004 206/453-5000

Feasibility Study

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PREFACE

This report on the feasibility of reregulating the Yakima River with a small storage facility has been prepared by CH2M HILL for the State of Washington Department of Ecology under Contract No. WF-PS-78-005, Amendments No. One and Two.

This report marks the end of the second phase of the overall study of the suitability of such a reregulation facility. The first phase, a reconnaissance study, was concluded with submission of a report in December 1977. Phase 3, the final phase, will consist of design of the facility judged most suitable.

SUMMARY

The development of an equalizing reservoir is being investigated for use in reregulating Yakima River flows. Following a preliminary reconnaissance study, three potential sites have been selected for further study. The sites are located at Selah Creek, Wenas Creek, and the gravel pits in East Selah. The feasibility of each site was evaluated on the basis of the following factors:

- Hydrology
- Engineering Design
- Operational Effectiveness
- Economic and Financial Considerations
- Environmental Impacts

These factors are listed for each site in the matrix at the end of this summary.

HYDROLOGY

The flow of the Yakima River is regulated by the U.S. Bureau of Reclamation for irrigation of approximately 462,000 acres. However, controlling the flow of the river at Sunnyside Dam for this purpose is hampered by two factors: there is a significant amount of uncontrolled runoff coming from drainage areas below the existing reservoirs, and there are long travel times between these reservoirs and Sunnyside Dam.

ENGINEERING DESIGN

The geologic history of the study area is masked beneath tremendous volumes of basalt flow called the Columbia River Plateau. The most recent deposits consist mainly of alluvium and stream deposits. The area is not characterized by extensive seismic activity, and the dams should be designed on the basis of a bedrock acceleration of .1 g.

Selah Creek Damsite

An earthfill dam with an estimated 451,000 cubic yards of fill would be constructed on Selah Creek about 3,000 feet above the confluence of the creek with the Yakima River. The 100-foot-high embankment would create a reservoir with an active storage volume of about 3,000 acre-feet. Water would be pumped from Roza Canal to fill the reservoir and would be released, by gravity, to the river when needed to augment the flow. The base of the dam and reservoir would be on recent alluvium and gravels, and the dam abutments would consist of two basalt flows separated by sand and gravel deposits. The estimated total project cost is $9,264,000.

Wenas Creek Damsite

A 313,000-cubic-yard earthfill dam would be built on Wenas Creek a few hundred feet above its confluence with the Yakima River. The 70-foot-high embankment would contain approximately 2,250 acre-feet of active storage. Water would be diverted by gravity from Roza Canal and released by gravity to the river. The soil in Wenas valley is a fine silty sand, and the dam abutments would be on basalt flows of the Ellensburg formation. The estimated total project cost is $6,490,310.

East Selah Gravel Pits

This facility would consist of three storage cells located at a gravel pit operation on a flood plain along the Yakima River in East Selah. Approximately 560,000 cubic yards of earth and gravel dike would provide an active storage volume of up to 2,800 acre-feet. Through a system of gates, water would be diverted from the river in a screened open channel to fill any combination of cells and would be released by gravity to the river. The gravel pit operation would be able to continue to mine approximately one-third of the area while the remaining two-thirds are used for storage. The total project cost is estimated at $7,344,700.

OPERATIONAL EFFECTIVENESS

The capability of each site for reregulating Yakima River flows was assessed using a computer model. The modeling determined to what extent each site would:

- Conserve water by reducing water releases from the five mountain reservoirs
- Minimize the number of water-short days in a year by providing a minimum target flow over Sunnyside Dam

By using the model, hypothetical water savings for past years were calculated assuming each site in operation. The calculations included the effects of the physical characteristics of the sites, such as lag time between release of water from the storage reservoir and arrival of the increased flow at Sunnyside Dam.

ECONOMIC AND FINANCIAL CONSIDERATIONS

Economic and financial feasibility were determined by weighing project costs against potential benefits. The major economic beneficiaries of the project would be Yakima Basin Project irrigators with the newest (proratable) water rights. Irrigators would benefit from increased crop production resulting from the availability of more water. Other economic benefits would include reduced operating costs for the Sunnyside Irrigation District, maintenance of fisheries, and enhancement of recreational opportunities.

Project costs were allocated to the users at the same rate as they receive benefits. Approximately 1 percent of the cost was allocated to the Sunnyside Irrigation District and 99 percent to proratable water right holders. For an assumed annual cost of $500,000 (the annual cost for the Wenas Creek site), the annual cost per acre-foot of proratable water right would be $.39. The annual benefit per acre-foot would be about $.64.

On the basis of the benefit/cost ratios shown in the Site Evaluation Matrix, all the sites are economically feasible, although the Selah Creek site is only marginally so.

ENVIRONMENTAL IMPACTS

The most significant environmental impact anticipated is the possible disolocation of four homes at the Wenas Creek site and one home at the gravel pits. Some habitat would be lost at each site, but all sites have the potential for creation of new or additional fisheries. Of the three sites, Wenas Creek has the potential for the greatest environmental impact, and the gravel pits are expected to have the least impact.

CONTENTS

TABLES

FIGURES

Chapter 1
INTRODUCTION

During the drought of 1977, the Yakima Basin Association of Irrigation Districts and the Tri-County Commission looked at possible means to alleviate the drought as well as a means to mitigate the effect of future droughts. It was suggested that a small reregulation reservoir located in or along the Yakima River between the Roza Diversion Dam and Parker might provide a useful water management tool.

The flow in the Yakima River is regulated for irrigation purposes by the operation of the five major reservoirs of the U.S. Bureau of Reclamation (USBR) Yakima Project. As a result, streamflow fluctuations have occurred, especially during low water years, because of the lag between the time water is released from the major reservoirs and the time it reaches the major irrigation diversions.

A reregulation reservoir would regulate the flow in the Yakima River through a storage and release cycle, thus reducing streamflow fluctuations in a manner consistent with meeting the Yakima Project obligations. This would conserve water by allowing water to be retained in the major storage reservoirs. The facility might also benefit fisheries during nondrought years by reregulating flows to assist in meeting fishery enhancement goals.

The State of Washington Department of Ecology was requested by the Yakima Basin Association of Irrigation Districts to undertake a feasibility study to determine the engineering, economic, financial, and environmental feasibility for a reregulation facility. The feasibility study is being conducted by the Department of Ecology under contract with the firm of CH2M HILL, Inc.

A preliminary reconnaissance study was completed in December 1977. The consultant (CH2M HILL), in cooperation with the Department of Ecology and the Yakima Basin Association of Districts, looked at all reasonable sites between the Sunnyside Dam and Roza Dam on the Yakima River and at the Naches River as far west as Gleed. The six most likely sites in the study were examined, and reconnaissance data for each site were presented in a reconnaissance report. The sites were ranked on the basis of reconnaissance level findings. The three sites judged most desirable are located on Selah and Wenas Creeks and at the east Selah gravel pits (figure 1-1).

A study of the feasibility of the three sites was conducted, and its findings are presented in this report. The objective of the study was to prepare sufficient engineering, environmental, economic, and financial data to enable a comparison of the three sites. In addition, the capability of each site to reregulate the river flows and save water was evaluated.

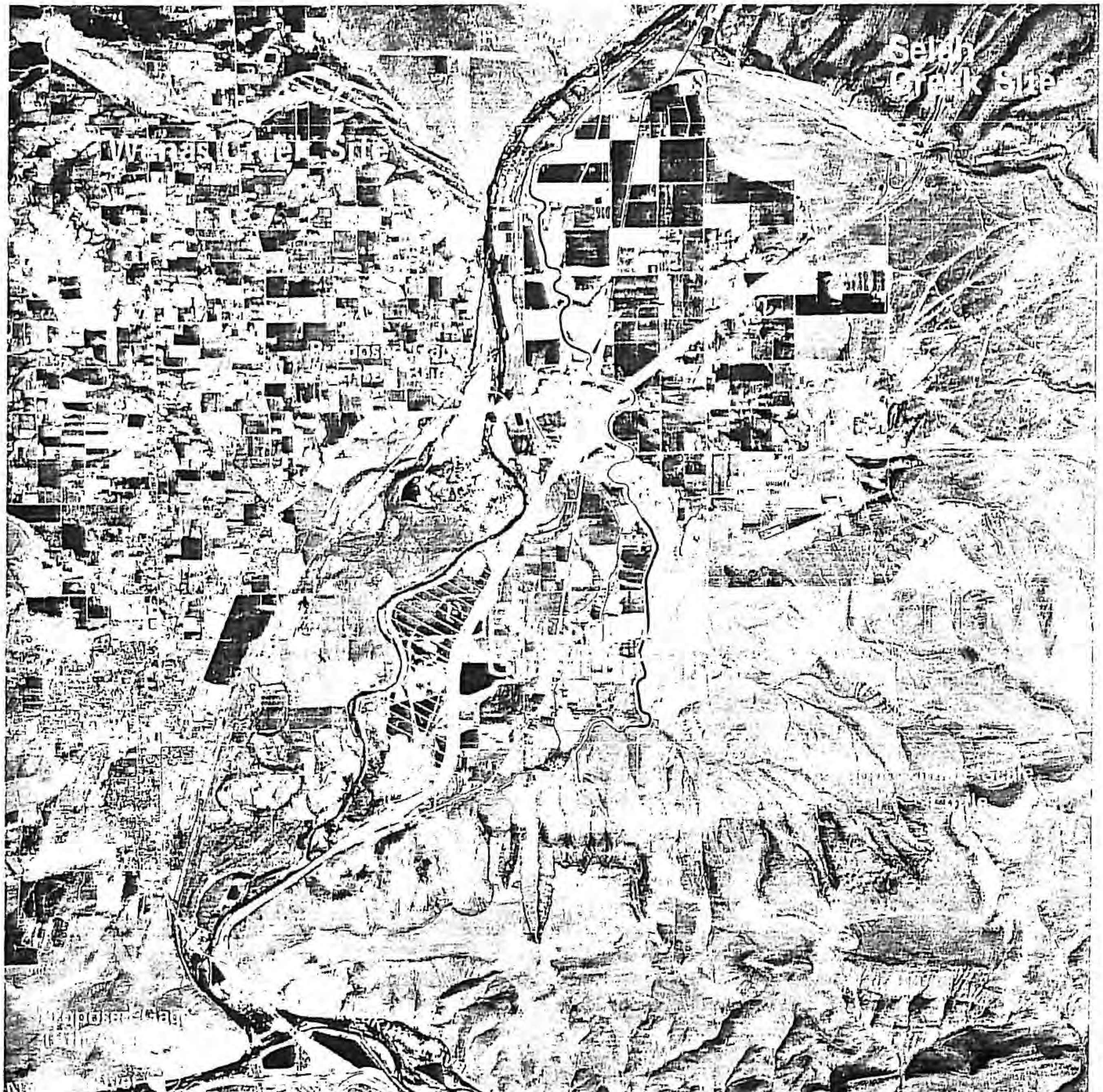


Figure 1–1

POTENTIAL SITES

Chapter 2
HYDROLOGY OF THE YAKIMA RIVER BASIN

GENERAL BASIN OPERATIONS

The Yakima Project as operated by the USBR regulates the natural flow of the Yakima River to allow for irrigation of approximately 462,000 acres. In addition, nearly 100,000 acres outside USBR's Yakima Project are irrigated in the basin by various other means. The two major diversions that are farthest downstream on the river and are dependent on storage and natural flow are Wapato and Sunnyside Canals. Wapato Canal is just upstream of the town of Parker, and Sunnyside Canal is just downstream. The Kennewick district is adequately supplied by return flows to the river between Parker and Prosser.

The water supply features of the Yakima Project are shown in table 2-1.

Table 2-1. WATER SUPPLY FEATURES OF THE YAKIMA PROJECT

Major Storage Reservoirs	Storage (ac-ft)	Drainage Area (sq mi)	Travel Time to Sunnyside Dam (hr)
Bumping	33,700	69.3	19
Kachess	239,000	63.6	37
Keechelus	156,800	54,7	40
Rimrock (including Clear Lake)	203,300	187.0	14
Cle Elum	346,900	203	32
	1,070,700		

During years when normal or above-normal water supply is available, there is usually no problem meeting all the demands for water. However, even in years when there is sufficient water, there are problems associated with controlling the supply. In below-normal years operational control becomes very difficult and cycling problems between shortages and excesses occur at Sunnyside Dam. Water that passes over Sunnyside Dam is not available for use by the major irrigators in the Yakima Basin.

The cause of the uncontrolled flow problem is indicated by the storage and drainage area figures in table 2-1. There is a total storage capacity in the system of 1,070,700 acre-feet. During a normal year, more than 2,500,000 acre-feet are diverted for irrigation. The sequence of operation in a normal year is to fill the major reservoirs during winter and spring with rain and snowmelt runoff. Through a cooperative effort with the U.S. Army Corps of Engineers, some flood control protection is also provided. For the first three months of irrigation season (April, May, and June), water is supplied by excess flow passing the major reservoirs and by uncontrolled tributary runoff. The total drainage area above the major reservoirs is 548 square miles, compared to

3,660 square miles above Sunnyside Dam. Thus the 85 percent of the drainage area that is uncontrolled produces many periods of excess flow at Sunnyside Dam.

Inability to control the cycling problem is caused by the long travel time and distance to Sunnyside Dam from the major reservoirs. To change the flow at Sunnyside Dam by modifying the release from storage, a minimum of 14 hours lead time is required. The lead time might have to be as much as 40 hours if the water is to come from Lake Keechelus. Because released storage flow has to travel down the natural channel of the Yakima River, it is affected by uncontrolled diversion and river channel storage.

In addition, there are two major arms of the Yakima River; this further complicates operation of the project. The Yakima River above Selah Gap is referred to as the Yakima arm. The Naches River, which joins the Yakima just downstream from Selah Gap, is called the Naches arm. Table 2-2 shows the respective drainage areas and storage volumes in each arm.

Table 2-2. YAKIMA RIVER BASIN STORAGE DATA

	Total Drainage Area (sq mi)	Percent of Drainage Area		Volume of Reservoir Storage (ac-ft)
		Controlled by Reservoir	Uncontrolled	
Yakima Arm	2,135	15	85	833,700
Naches Arm	1,106	23	77	237,000
Total at Confluence	3,241	17	83	1,070,700

One significant effect of the travel time factor is that excess water is released to ensure timely delivery of an adequate supply to the major irrigation users. During a year with normal water supply, this does not cause problems because the additional water required is available. However, water used for this purpose in a normal year is lost for possible carryover and use in subsequent years.

Excess water is not available during years with low water supply. The recorded daily flows over Sunnyside Dam for the 1977 irrigation season are shown in the hydrograph in figure 2-1. These flows are shown as the positive values on the hydrograph. Also shown are shortages to Sunnyside Canal (negative values) for days when no water was passing over the dam. The year 1977 was extremely dry, which caused many operational problems.

In summary, there is a water management problem in controlling the flow at Sunnyside Dam to meet the irrigation demands. This is caused by natural runoff from uncontrolled areas and by lack of operational

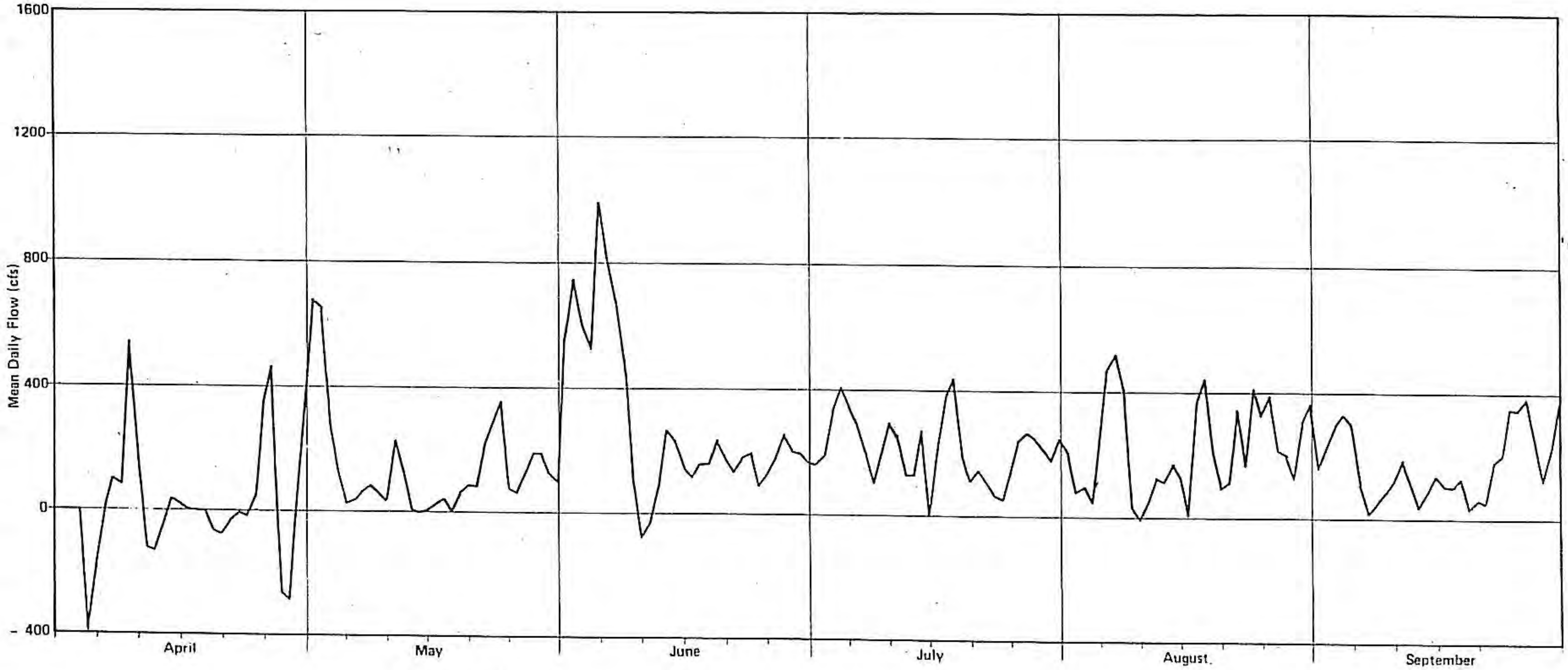


Figure 2–1

YAKIMA RIVER
FLOWS OVER
SUNNYSIDE DAM, 1977

control because of long travel times from the major reservoirs to Sunnyside Dam.

SITE-SPECIFIC HYDROLOGY

As shown in figure 1-1, the Selah and Wenas Creek sites are on tributaries of the Yakima River. The gravel pit site is offstream in the flood plain of the Yakima River. The hydrologic data for these sites were obtained from the Columbia North Pacific Comprehensive Framework study, USBR and U.S. Geological Survey (USGS) publications, and discussions with knowledgeable local individuals.

Selah Creek

Selah Creek drains 93 square miles of arid grass and sagebrush land east of the Yakima River. Elevations vary between 1,180 feet at the damsite to above 3,000 feet on the ridges. The mean annual precipitation for the basin is 10 inches, with most precipitation falling as winter snow and rain. Intense local thunderstorms during the summer usually add little to the annual precipitation because of their limited area coverage and short duration.

There are no streamflow records for Selah Creek at the damsite, and there is only one indirect flow measurement of a minor tributary in the basin. The annual runoff (taken from regional data) for Selah Creek was established to be 2,500 acre-feet. The average annual runoff was separated into average monthly values, as shown in figure 2-2, on the basis of streamflow records for similar streams and from discussions with knowledgeable local individuals.

Floods on Selah Creek come from two types of precipitation events, rain or snow events and thunderstorm events. Both types of events need to be considered for spillway design. The probable maximum flood (PMF) for both types of events was developed from regionalized curves prepared by the USBR. This method is only applicable to a feasibility study, and a full PMF analysis would be required for design. The rain or snow PMF for Selah Creek has a peak flow of 20,000 cubic feet per second (cfs) and a 5-day volume of 65,000 acre-feet. The thunderstorm PMF has a peak flow of 50,000 cfs and a 3-hour volume of 7,000 acre-feet. The PMF thunderstorm was considered to be the result of a thunderstorm covering the lower 50 square miles of the drainage basin. Roza Creek, which is just north of Selah Creek and has a drainage area of 13.6 square miles, had a recorded peak flow of 25,200 cfs as a result of a thunderstorm in August 1952.

Wenas Creek

Wenas Creek drains 188 square miles west of the Yakima River. The basin is roughly bisected at the existing Wenas irrigation dam, which is 18 miles above the mouth of Wenas Creek. The reservoir behind Wenas dam stores approximately 1,125 acre-feet. The 144-square-mile drainage area above Wenas dam is referred to as the upper Wenas valley, which

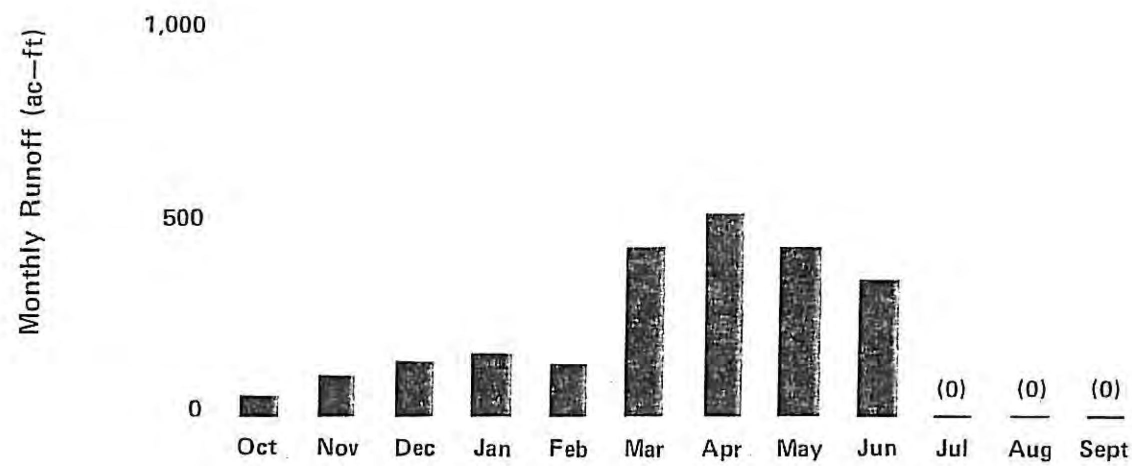


Figure 2–2

ESTIMATED AVERAGE
MONTHLY RUNOFF,
SELAH CREEK

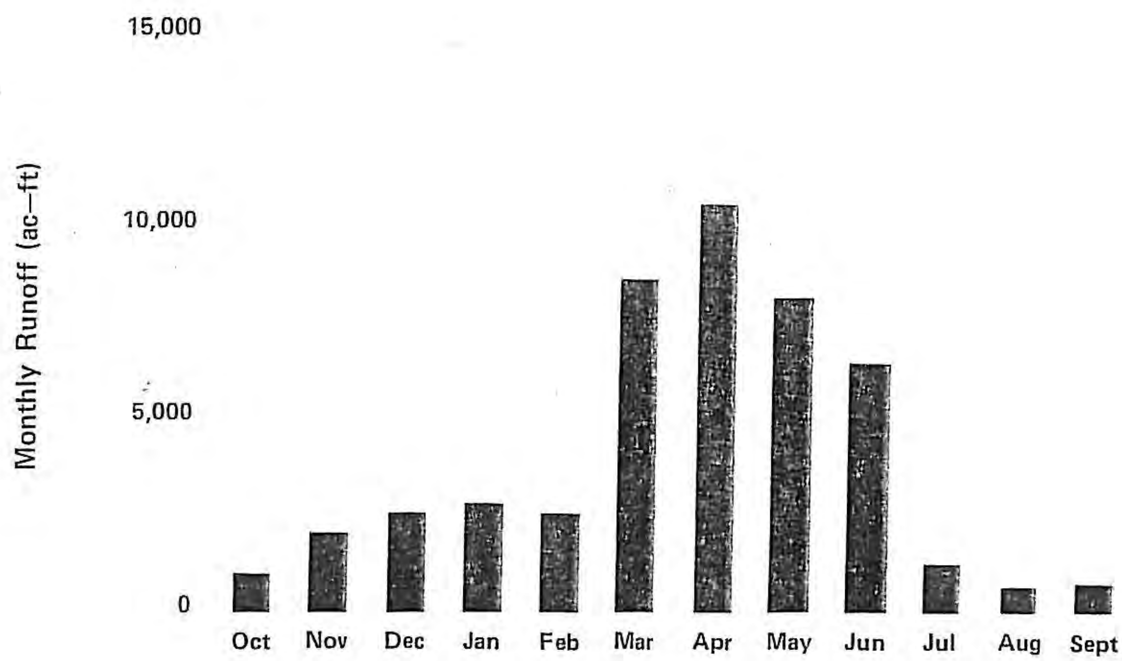


Figure 2–3

ESTIMATED AVERAGE
MONTHLY RUNOFF,
WENAS CREEK

rises from an elevation of 1,850 feet at the dam to over 5,000 feet along the east margin of the Cascade Range.

Lower Wenas valley drains 74 square miles of semiarid ridges and irrigated bottom land. Elevations vary between 3,000 feet on the ridges and 1,120 feet at the mouth of Wenas Creek.

The mean annual precipitation for the basin is 18.4 inches, ranging from about 60 inches in the higher mountains to 10 inches in the lower valley. Intense thunderstorms can occur during the summer.

The USGS and the Soil Conservation Service have gathered limited streamflow data in the basin between 1909 and 1911 and between 1942 and 1944, respectively. In addition, several special flow measurements were made for low- and high-flow events. Of particular interest was a peak discharge estimated to be 12,800 cfs in Cottonwood Canyon. This discharge came from an 11.1-square-mile drainage area as a result of a thunderstorm in August of 1952.

Mean annual and mean monthly runoff values for Wenas Creek were determined by the same methods used for the Selah Creek analysis. The mean annual runoff was estimated to be 50,000 acre-feet. The mean monthly runoff is shown in figure 2-3.

Floods on Wenas Creek are from the same two sources as floods on Selah Creek: rain or snow events and thunderstorm events. The rain or snow PMF is 35,000 cfs, with a 5-day volume of 110,000 acre-feet. The thunderstorm PMF is the same as for Selah Creek.

East Selah Gravel Pits

The East Selah gravel pit site is situated in the 100-year flood plain of the Yakima River and is located between the main channel of the river and Interstate 82. The 100-year flood for this reach of the Yakima River is estimated by the Army Corps of Engineers to be 38,000 cfs. Of the total 100-year discharge, only 1,300 cfs would pass through the gravel pit area as out-of-bank flow. In addition, emergency spillway sections would be built into the dikes at suitable locations to accommodate the excess flow without damage to the storage cells. Therefore, little adverse impact from flooding is expected at the gravel pit site.

Chapter 3
ENGINEERING DESIGN

GEOLOGIC SETTING OF STUDY AREA

History

Much of the geologic history of the study area is masked beneath tremendous volumes of Tertiary basalt flows that cover the area and compose what is called the Columbia River Plateau. This topographic surface was buried in late Tertiary time by the flows making up the Columbia River basalt. These flows cover an area of 200,000 square miles. The bedrock below these flows is thought to consist of deformed Paleozoic and Mesozoic age metamorphic rocks and associated intrusives. Toward the end of the Tertiary (late Miocene - early Pliocene), consecutive flows were separated by a greater time span, thus allowing soil formation and a vegetative cover to form on the basalt flow surface. River and lake deposits were interlayered between the flows. This interbedded sequence of flows and lacustrine and fluvial deposits is known as the Ellensburg Formation. In the study area, the upper three members of this formation are present. The lowest is the Selah member (a sedimentary deposit), which is topped by the Pomona (also called Wenas) basalt flow, which is overlain in some areas by a sand and gravel layer (figure 3-1).

Coincident with the deposition of the Ellensburg Formation was an uplift that occurred to the west and created the Cascades. This gave a regional dip to the flows and made the environment more conducive to the accumulation of the sedimentary deposits. At the same time, a regional north-south compression was creating the anticlines and synclines (ridges and valleys) that are present in the area. Minor faulting accompanied this folding, but it is not significant. Three small faults 3 to 6 miles in length are present 6 to 10 miles north of the Selah and Wenas sites.

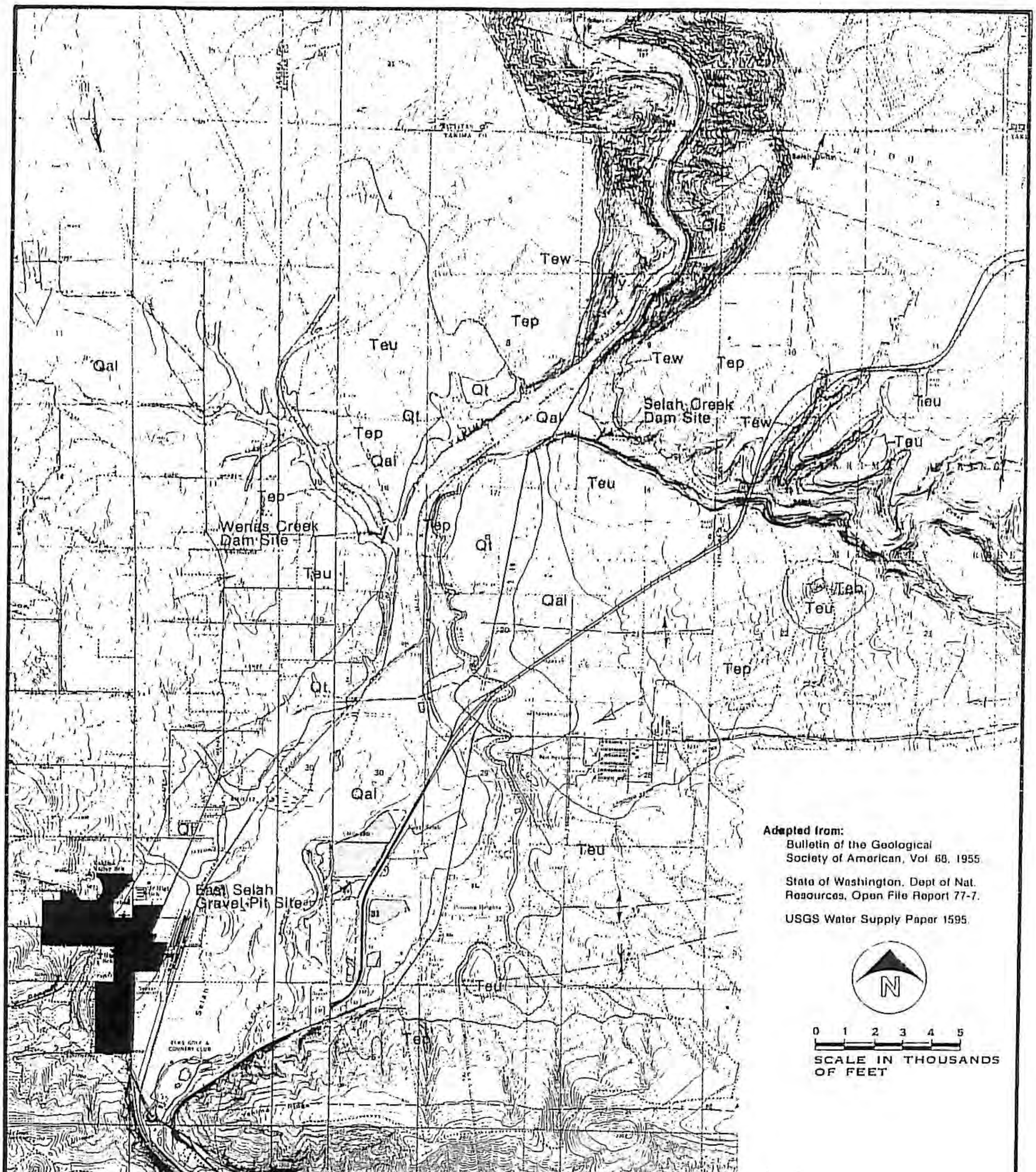
In the Quaternary, the Pleistocene glacial deposits consist of outwash that can be present deeper in the river valleys, as well as stream terrace deposits. Recent additions include river-laid alluvium, wind deposits, landslides, and alluvial fans, as well as manmade alterations to the landscape.

Rock Formations

The lithologic (rock) description of the geologic formations at the site is presented below in order of age, from oldest to youngest.

Yakima Formation

The Yakima Basalt is the upper formation of the great series of flows that make up the Columbia River Group. The rock type is a basalt lava flow with a characteristic gray-black color that weathers to a red color because of the presence of iron in the formation. Singular flows can reach up to 100 feet in thickness and are generally porous or vesicular in the upper portions, with large (up to 4 to 6 feet) columns created by



Adapted from:
Bulletin of the Geological Society of American, Vol 66, 1955
State of Washington, Dept of Nat. Resources, Open File Report 77-7.
USGS Water Supply Paper 1595.

LEGEND

Quaternary
Recent
- Qal — Alluvium: alluvial fans and flood plain deposits
- Qls — Landslide debris

Pleistocene
- Qt — Stream terrace deposits

Tertiary
Miocene —Pliocene
Ellensburg Formation
- Teb — Basalt conglomerate
- Teu — Undifferentiated unit consisting mainly of pumiceous and andesitic silts, sands and gravels.
- Tep — Pomona Basalt
- Tew — Selah Member. Sand, gravel and silt composed of andesite and pumice.

Columbia River Basalt
- Ty — Yakima Basalt

- Anticline
- Syncline
- Divide between groundwater basins
- General direction of groundwater movement
- Reach of stream where appreciable groundwater discharge occurs

FIGURE 3–1

GEOLOGIC MAP

CH2M HILL

cooling joints in the lower part of the flow, and smaller, occasionally fan-shaped columns present in the upper half.

Ellensburg Formation

The Columbia River Basalt is overlain by the Ellensburg Formation, which in the study area consists of the Selah Member, the Pomona Basalt, and an unnamed sand and gravel unit.

Selah Member. Usually found in the low-lying areas, the Selah Member was deposited by mudflows and by streams whose headwaters were in the andesitic volcanoes to the west. The deposits are stratified, but bedding is often discontinuous. The series consists of clay, silt, sand, and gravel-size particles of pumice, volcanic ash, and hornblende andesite. In some areas it is over 1,000 feet thick. It is of varying permeability, but its average porosity is thought to be greater than that of the underlying basalt.

Pomona Basalt. The Pomona flow, or Wenas flow as it is sometimes called, is one of the flows that is interbedded within the Ellensburg Formation. It is thought to be the final renewal of the volcanic activity that gave rise to the Yakima Basalt. The upper portion of this flow has fan-shaped columns.

Sands and Gravels. This unnamed unit is the top of the Ellensburg Formation. It is composed of gravel and coarse sand particles whose main constituent is pumice and andesite.

Pleistocene Deposits

Pleistocene deposits consist of glacial and stream terrace deposits. Glacial deposits are not present superficially, but outwash deposits resulting from glaciers that were present further north can be expected at depth in the valleys. Stream terrace deposits, reminiscent of higher river levels, are present as coarse gravel and sand.

Recent Deposits

In the proposed site areas, the recent deposits consist mainly of alluvium and stream deposits.

Soils in the Selah Creek area are mainly gravels in a sand matrix. The fines are classified as well-graded silty sands. In the Wenas Creek area, the surficial soil is primarily a fine sandy silt. Data on borrow pits in the river valley indicate the material varies between well- and poorly graded gravel. The rock type is predominantly basalt that is subangular to subrounded in shape.

Seismic History

In the late Miocene - early Pliocene period, some faulting accompanied the regional north-south compression and uplift of the Cascades. Small faults are present 6 to 10 miles north of the study site and range from 3 to 6 miles in length.

The area is not characterized by extensive seismic activity. A National Oceanic and Atmospheric Administration (NOAA) listing of earthquakes within a 200-kilometer (km) radius from the site indicates that 109 events have occurred since 1859. The event closest to the site had an intensity of 5 and occurred 25 km from the site on 28 February 1928. Higher intensity events (VII, VIII[1]) have their epicenters in the active Puget Sound area, which is more than 165 km from the proposed sites, or along faults that are greater than 100 km from the sites. Because of the damping that is usually experienced at large distances from the epicenter, it is believed that the smaller, closer seismic activity would be more likely to affect the site.

Design Earthquake

Two types of earthquakes are used to describe potential risks associated with seismic activity. These are the Maximum Credible Earthquake (MCE) and the Maximum Probable Earthquake (MPE). The MCE is an estimate of the worst earthquake that can realistically occur in the site area. The possibility of it occurring during the lifetime of the structure is not known, but is highly unlikely. The MPE is a reasonable estimate of the seismic activity the site might be exposed to during the project's expected lifetime. A dam is normally designed to experience the MPE with no damage and to survive the MCE with probable damage but no uncontrolled release of the reservoir.

The MCE for a site is based on a review of the faults in the area and the lengths of the associated surface ruptures. The known fault nearest to the Selah site is 6 miles away and approximately 3 miles long. Movement along the total length of this fault is capable of producing a magnitude-5.7 MCE, with corresponding bedrock accelerations of up to .25g.[2] For the Wenas site, the same MCE is postulated. Nine miles distant, this fault would produce bedrock accelerations of .2g at the East Selah gravel pit site. However, movement along the entire length of a small inferred fault, 2.5 miles east-southeast of the site and about 2 miles long, is capable of producing a magnitude-5.5 earthquake with bedrock accelerations of up to .35g at the gravel pits and .25g at the damsites. There are larger faults in the area, but because of the distance involved, the small, close fault would have a greater impact on bedrock accelerations.

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1 Earthquake strength is generally described using one of two scales. The Modified Mercalli Intensity Scale is a measure (I to XII) of the intensity of the event as noted by effects such as rattling dishes and structural damage. The intensity observed varies with the distance from the epicenter. The Richter Magnitude Scale is a measure of the energy released as recorded by a seismograph. Each increasing whole arabic numeral represents a 10-fold increase in energy released.

2 Earthquake force imparted on a structure is expressed as a percentage of gravity.

Evaluation of the MPE involves a review of past seismic events that have occurred in the site area. Three events that represent typical seismic activity at increasing distances and intensities from the site have been checked with respect to bedrock accelerations expected at the site. The closest was an intensity-V event 25 km from the study area, occurring on 28 February 1918.

An intensity-VI earthquake on 1 November 1918 represents a moderate intensity event at 76 km from the site. Higher intensity events such as those occurring in Puget Sound or along large faults are represented by the 13 April 1949 intensity-VIII earthquake occurring 163 km away. Considering initial intensity and attenuation with distance, all these events would produce bedrock accelerations at the site of less than .05g. However, the proposed sites are located in Zone 2 on the Seismic Risk Map of the United States. This corresponds to a Modified Mercalli Intensity of VII and places them in a zone of moderate damage. Design for this zone should be based on a bedrock acceleration of .1g. Therefore, the MPE is postulated as an intensity-VII event that can produce bedrock accelerations of up to .1g.

Sedimentation

The storage capacity of a reservoir is gradually decreased by sediment that enters the reservoir in suspension or as part of the bedload and is dropped because of an abrupt change in velocity. To obtain a valid estimate of the amount of sediment that can be expected in the design life of the structure, data on water discharge and suspended sediment are needed for the streams in question. Because no information is available for the Selah or Wenas Creek sites, data for streams in similar geologic, geographic, and climatic areas were used. General information on sediment inflow is available for the whole Yakima River Basin, and specific data exist for a ranch pond further upstream in Wenas Creek and for Ahtanum Creek where it discharges into the Yakima River at Union Gap.

Several methods of estimating the sediment accumulation rate were used, including annual sediment inflow based on size of drainage area, and relating streamflow and flood frequencies to sediment yield. The use of general annual sediment inflow values per square mile of drainage basin for streams in the Yakima Basin resulted in the largest estimated accumulations. These accumulations are:

			Accumulation	
Site	Sediment/Year (ac-ft)	Bedload (ac-ft)	Total/Year (ac-ft)	Total/50 Years (ac-ft)
Selah Creek	1.9	.2	2.1	105
Wenas Creek	3.8	.4	4.2	210

DIVERSION OF WATER USED FOR POWER GENERATION

Diversion of water for both the Wenas and Selah Creek sites will be from Roza Canal. This canal currently delivers a maximum of 2,200 cubic feet per second (cfs): 1,050 cfs for power production and the rest for irrigation use. Because the Selah and Wenas sites might withdraw up to 400 cfs from the canal at times, the effect of such a withdrawal must be evaluated.

There are three alternatives for reconciling the competing water uses. These are:

- Provide additional capacity in Roza Canal, making a new capacity of 2,600 cfs, by modifying the channel
- Use a portion of the existing power water when the reservoir requires filling and cut back on power production during these times
- A combination of the previous two alternatives

To increase the capacity in the Roza Canal to 2,600 cfs would be expensive. The concrete flume wall would require raising in some locations, the horseshoe tunnel would require a smoother lining to pass the additional flow, and the fish screen area might require enlargement at the Roza Dam diversion.

Consequently, for this study it was assumed that the filling of the reregulation reservoir would take precedence over power production. During periods of withdrawal by the reregulation facility from Roza Canal, power generation would be cut back. The annual costs of this lost power producing capability are shown in the following table for the study years.

Lost Production Capability

		0 Cfs Target Flow			300 Cfs Target Flow		
Site	Year	Water Volume (ac-ft)	Energy (kWh)	Cost ($)	Water Volume (ac-ft)	Energy (kWh)	Cost ($)
Selah	1968	15,966	$2.06x10^6$	14,409	22,836	$2.94x10^6$	20,610
	1969	8,454	$1.09x10^6$	7,630	10,800	$1.4\ x10^6$	9,747
	1970	7,866	$1.02x10^6$	7,140	16,182	$2.1\ x10^6$	14,605
	1973	19,798	$2.55x10^6$	17,868	20,800	$2.68x10^6$	18,772
	1977	19,272	$2.5\ x10^6$	17,393	20,386	$2.63x10^6$	18,398
Wenas	1968	14,250	$1.84x10^6$	12,861	18,426	$2.37x10^6$	16,630
	1969	7,032	$.91x10^6$	6,346	9,938	$1.29x10^6$	8,969
	1970	7,488	$.97x10^6$	6,758	13,296	$1.72x10^6$	12,000
	1973	15,292	$1.97x10^6$	13,801	16,936	$2.18x10^6$	15,285
	1977	16,804	$2.17x10^6$	15,166	18,000	$2.32x10^6$	16,245

The costs of lost power production in the table are based on a rate of 7 mills per kWh. The present costs are 3.3 mills per kWh, but rates are expected to double in the near future.

DISCUSSION OF SITES

Selah Creek Damsite

Site Conditions

Selah Creek is located in a valley flanked by steep-sided slopes. The valley width averages from 500 to 600 feet in the reservoir area and narrows upstream. Stream gradients in the reservoir are 1.3 percent and average 2.2 percent for the lower 4 miles of the stream. This intermittent stream flows in a west-northwest direction, emptying into the Yakima River about 3,000 feet downstream from the damsite. Vegetative cover is sparse and consists mainly of sagebrush interspersed with some grass. The area is mainly used for cattle grazing.

The base of the dam and the reservoir are situated on Recent alluvium and gravels, which, from the well log data available, extend about 130 feet below the ground surface. The dam abutments consist of two basalt flows separated (and capped to the south) by sand and gravel deposits. The upper basalt flow is exposed on the left abutment. The underlying basalt flow and the sand and gravel member are not exposed at the dam axis. These formations are covered by talus at the base of the basalt cliff on the left abutment and by a hummocky, flattened slope of talus material on the right abutment.

Feasibility Analysis

Reservoir. The Selah Creek reservoir was sized for 3,000 acre-feet at a normal water surface elevation of 1262 feet. A reservoir at this elevation would pool to a point just upstream of the I-82 bridges. The Probable Maximum Flood (PMF) flood pool elevation is 1284.8. The reservoir slopes are basalt cliffs or talus slopes that would be stable under the proposed filling and drawdown cycles.

There is a possibility of excessive reservoir seepage losses. Selah Creek flows intermittently during the year. Available groundwater information indicates a north-to-south groundwater gradient, suggesting that Selah Creek is an influent stream (the streamflow feeds the groundwater). The groundwater flows to the south under the ridge containing the reservoir.

Evaluation of well log data in the Pomona Heights area (approximately 1 mile south) provides a crude measure of the seepage potential. These data indicate possible reservoir losses in the range of 10 to 100 cfs. An intensive investigation of the site would include pressure tests of borings to better determine the potential for reservoir leakage. Additional seepage would be expected around the dam but would be controlled by dam design features incorporated to prevent failure of the embankment or foundation.

Foundation and Abutments. The embankment is founded on sand and gravel alluvium. The alluvium appears to be dense with adequate strength to support the dam. Test pit samples indicate the alluvium is a well-graded silty sand and gravel with cobbles to 8 inches. There is a strong likelihood that openwork gravel seams were formed and buried as the alluvium collected. For this reason, a slurry trench cutoff has been included in the conceptual design. The cutoff extends to rock, which, according to well logs just downstream, is approximately 130 feet deep.

The material exposed on the right abutment includes 6- to 12-inch basalt fragments with a silty sand soil matrix. Just below the surface there is less soil and increasing void volume. The right abutment slope averages about 15 degrees, considerably flatter than the normal talus slope of 40 to 45 degrees. The low angle and irregular surface indicate that this slope is the result of a landslide (see centerline profile in appendix A figure A-1).

For cost estimating purposes, we have assumed that the landslide failure surface is near the top of a basalt flow and that the existing slide material will be excavated to rock to provide a cutoff at the upstream toe.

The left abutment is a sheer basalt face with a 45± degree talus slope at the toe. The talus would be removed beneath the embankment and the rock face excavated sufficiently to expose fresh rock on a slope suitable for placing the embankment and upstream membrane cutoff. There is reason to suspect that the sand and gravel Selah Member will be exposed by removal of the talus. Both abutments would be grouted to a depth of 50 feet. A special grouting effort might be required in the Selah Member to ensure that the seepage gradients are not too large. The rock surfaces at the upstream toe cutoff would be treated as required to control seepage prior to constructing the embankment and membrane.

Conceptual Design. In the conceptual design the 100-foot-high embankment is zoned, consisting of a free-draining rock fill zone and a random zone. The upstream face of the embankment is covered with a 6-inch-thick hydraulic mix asphalt membrane. The membrane is placed on a select base material and tied into the slurry trench foundation cutoff and abutment grout curtains along the upstream toe of the embankment. Material for the rock and random zones would come from the spillway excavation. The additional rock required would be borrowed from the talus slopes in the reservoir area.

The spillway is an open cut into the basalt in the left abutment. The crest is 140 feet wide and 23 feet below the top of the dam, which provides sufficient capacity to pass the PMF. We have assumed that 75 percent of the spillway excavation will be suitable for use in the embankment and that the remainder will be wasted.

The reservoir would be filled by pipe from a concrete flume section of the Roza Canal, which is located on the west side of the Yakima River (appendix A figure A-2). The canal flow is screened for fish at the Roza Diversion; therefore, only a bar screen is provided at the pipe inlet to exclude tumbleweeds or animals that fall into the canal (appendix A figure A-3). A hand-operated fabricated gate is provided at the inlet to allow dewatering of the pipe. The normal (full) reservoir water surface is 55 feet above the canal water surface, so that a pump station is required to fill the reservoir. The rate of filling will be approximately 200 cfs.

The pipe is a buried 6-foot-diameter concrete cylinder pipe. It crosses the Yakima River, a mainline railroad, and old Highway 97. The pipe beneath the dam is cast-in-place, having 24-inch-thick reinforced concrete walls with a steel liner.

The inlet-outlet structure located at the upstream toe of the dam is gated with a hydraulic manually operated slide gate. Trash racks prevent debris from entering the pipe from the reservoir. A road to the top of the dam provides the gate operator with access to the hydraulic pump and valves.

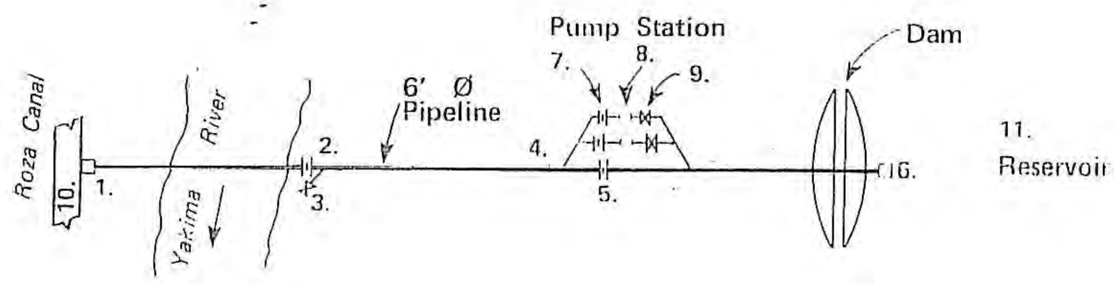
The irrigation release valves are located on the left bank of the Yakima River at the head of the Selah Moxee channel. Two valves are required, each one capable of discharging 200 cfs. The head differential across the valves can exceed 140 feet, which will involve discharging under very low backpressure conditions. A ported sleeve valve has been selected for this situation because of the rather severe discharge conditions. Additional hardware to control and measure flows is shown in the drawing on the following page.

Wenas Creek Damsite

Site Conditions

The damsite is at the mouth of Wenas Creek a few hundred feet above the creek's confluence with the Yakima River. The valley upstream of the proposed dam axis averages about 400 to 600 feet wide. Wenas Creek is a year-round stream having its headwaters in the Cascades and flowing in an east-southeast direction to the Yakima River. Stream gradients in the reservoir area are about 0.7 percent. The soil in the valley is a fine sandy silt that supports a grassland vegetation used for grazing. Swampy areas are evident in the valley during periods of high streamflow.

Both abutments at the dam axis are in the basalt flows of the Ellensburg Formation. The sand and gravel upper member of the Ellensburg Formation is present on the uplands both north and south of the site.



1. Inlet. Manually operated slide gate, normally open.
2. Control Valve. Remotely operated; open for filling reservoir and closed to retain storage or release to river.
3. Release Valve. Remotely modulated for desired release flow.
4. Flow measurement. Bidirectional, remote readout; provides input for modulating release valve, pumps, and pump discharge valves.
5. Control Valve. Remotely operated, open for gravity flow to reservoir and releases to river, closed for pumping to reservoir.
6. Inlet-Outlet. Hydraulically operated slide gate, normally open.
7. Pump Isolation Valve (2). Manually operated, normally open.
8. Pumps (2). Remotely controlled.
9. Pump Discharge Valve (2). Remotely modulated to control pump discharge head. Automatic closure for pump or power failure. Closed for releases to river.
10. Canal Water Surface. Remotely monitored to confirm that water is available for diversion.
11. Reservoir Level. Remotely monitored.

Feasibility Analysis

Reservoir. The normal water surface elevation at this site was selected to minimize the amount of developed area impacted but still provide an adequate storage volume for the project. At the normal water surface elevation of 1190 feet, the reservoir would have a storage volume of 2,250 acre-feet. The PMF flood pool elevation is 1201.2 feet. Three homes located near the head of the reservoir and one on the south shore near the dam have ground elevations at foundation between 1200 and 1204 feet.

Wenas Creek flows year round. The available groundwater information indicates the stream is effluent, that is, the groundwater flows into the stream. Reservoirs built in effluent streams usually have no problem with leakage other than the normal leakage around the dam. The reservoir slopes are steep basalt cliffs overlain by gently sloping andesitic sands, silts, and gravels. The sands, silts, and gravels will tend to bench from wave action, but the slopes should be stable during the proposed filling and drawdown cycles.

Foundation and Abutments. The actual foundation conditions are not certain. The valley bottom at the damsite is a nonplastic fine sandy silt. Hand-excavated holes and the stream-cut banks indicate a depth of at least 4 to 5 feet. Sands and gravels are present in the Yakima River at the mouth of Wenas Creek about 12 feet below ground level at the dam. It seems probable that these sands and gravels underlie the sandy silts at the damsite. The alluvium is estimated to be 100 feet deep. A slurry trench cutoff to rock would be constructed through the alluvium along the centerline of the dam (appendix A figure A-4).

Both abutments will be in exposed basalt cliffs for about 75 percent of the dam height. The remainder of the abutments are in the andesitic sands, gravels, and silts. The basalt would be excavated to expose fresh unweathered rock on a slope that is suitable to place the embankment. The basalt is to be grouted to a depth of 50 feet and the surface treated to provide a suitable surface for placing the core material. A core trench would be excavated in the andesitic sands and gravels down to the basalts. The grout curtain and foundation treatment would be extended the full length of the core trench.

Conceptual Design. The conceptual design shows the 70-foot-high dam as a zoned earthfill type. The core is constructed with the fine sandy silts from the valley bottom in the reservoir area. The material used to construct the core is nonplastic and easily eroded. Therefore, a carefully constructed graded filter is placed upstream and downstream of the core. The filter zone also extends beneath the downstream shell to protect the foundation from the possibility of piping and to keep the downstream shell drained. The shells are constructed from the andesitic sands and gravels from the spillway excavation.

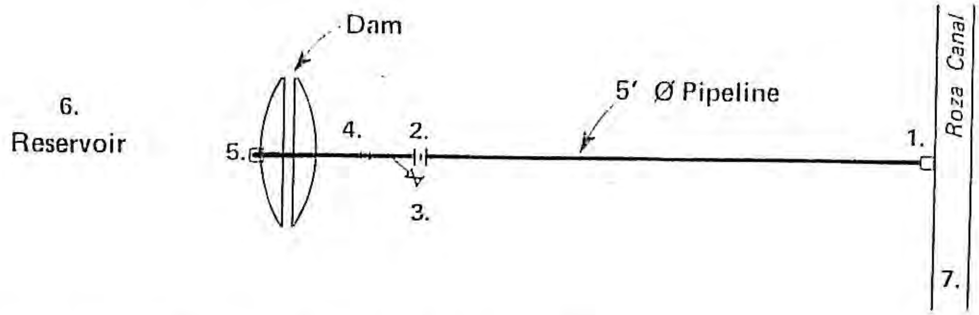
A relatively thick rock slope protection zone is placed on the upstream slope. This zone provides wave protection and stability during the filling and drawdown cycles of the irrigation season.

The spillway, an open cut through the right abutment, spills directly into the Yakima River. The crest width is 400 feet and is 12 feet below the dam crest. The basalt surface appears to be slightly below the spillway crest elevation, thus requiring a concrete crest founded in the basalt. A concrete training wall is used to contain the spillway flows on the left between the spillway and the embankment.

The reservoir is filled by a 5-foot-diameter concrete cylinder pipeline from an unlined section of the Roza Canal (appendix A figure A-2). The pipeline crosses three parallel railroad tracks, a gravel county road, the Moxee Canal, an 8-inch high-pressure gasline, and the Yakima River. The pipe beneath the dam is cast-in-place, having 21-inch-thick reinforced concrete walls with a steel liner.

The normal reservoir water surface is 12 feet below the canal water surface, so that the reservoir is filled by gravity. The rate of filling could vary with the reservoir stage from a maximum of about 350 cfs when the reservoir is empty to about 150 cfs when near full. The assumed flow available in the Roza Canal for diversion to the reservoir is 200 cfs; therefore, the initial fill rates will have to be controlled by valving.

Three structures are required on the pipeline: an inlet at the Roza Canal with a hand-operated slide gate; the inlet-outlet structure at the upstream toe of the dam with a hydraulically operated slide gate; and the irrigation release structure with two valves capable of discharging 200 cfs each (appendix A figure A-3). The maximum head across these valves is approximately 70 feet. The hardware to control and measure flows is shown in the following schematic.



1. Inlet. Manually operated slide gate, normally open.
2. Control Valve. Remotely operated; modulated to control reservoir fill rate and closed to retain storage or release to river.
3. Release Valve. Remotely modulated for desired release flow.
4. Flow Measurement. Bidirectional, remote readout; provides input for modulating the control and release valves.
5. Inlet-Outlet. Hydraulically operated slide gate, normally open.
6. Reservoir Level. Remotely monitored.
7. Canal Water Surface. Remotely monitored to confirm that water is available for diversion.

East Selah Gravel Pits

Site Conditions

The East Selah gravel pits are located on the flood plain of the Yakima River between the river and Interstate 82. Relief on flood plains is generally negligible, but levees constructed around the gravel pit operations and excavations to mine the sand and gravel have resulted in elevations that vary from about 10 feet above normal river levels to as much as 40 feet below. The river flood profiles at the gravel pit site are shown in appendix A figure A-8.

The Yakima River, with its headwaters on the eastern slopes of the Cascades, at this site drains a 6,155-square-mile, roughly triangular region. The river spans two geologic terranes. On the northeast side of the river, thick flows of Columbia River Basalt are present; on the southwest side is the uplifted area of the Cascade Mountains that has been dissected by erosion. The Yakima River is a classic example of an antecedent river, as can be witnessed in its upstream canyons, that has cut through uplifting folds while maintaining its course.

Though glacial ice did not advance as far as the Yakima area, the effects of the glacial age were still felt. Stream terrace deposits are present at higher levels along the slopes. Though outwash deposits have not been mapped surficially, they might be present at depth in the valley or might have been subsequently eroded away. The existing river deposits are alluvium and flood deposits. The gravels are predominantly basalt that has been eroded to a subangular to a subrounded shape. The alluvium is a well- to poorly graded gravel with a small percentage of fines. The site is being quarried to a depth of 45 feet, where a 2-foot-thick hardpan layer occurs. Material size and compaction increase slightly with depth to about 15 feet. Below that point, the gravel size and amount of compaction are fairly constant, with the material slightly cemented and standing on near-vertical cut slopes in the gravel pits.

Feasibility Analysis and Conceptual Design

Construction of the reregulating facility at this site involves diking along the freeway and improving and/or raising existing levees to store gravity diversions. Releases are made by gravity at the downstream end of the site.

The storage volume is a function of the drop in river gradient across the site (about 20 feet) and the area diked (appendix A figure A-5). The storage volumes can be maximized by excavating the diked area to the elevation of the river at the discharge point. The storage-elevation curves in figure A-5 show the existing and potential storage volumes. Some of the area is now below the discharge elevation and represents storage that would require pumping. This volume is small now, but as quarrying continues, the volume could increase enough to consider pumping in the future.

Gravel Pit Operation. The site is subdivided into three cells so that the gravel pit operation can continue to mine approximately one-third of the area while the remaining two-thirds are used for irrigation reregulation. By rotating the cells that are used for irrigation, the gravel pit operation will have access to all of the pit area except the portion covered by dikes plus a setback from the dikes to ensure their stability.

Groundwater. The gravel pit area is mapped in the U.S. Geological Survey (USGS) Water Supply Paper No. 1595 as an area where there is significant groundwater discharge into the Yakima River from the east. The groundwater flows through a broad, very gently sloping deposit of sand and gravel alluvium. Excavations in the gravel pits reveal about 10 to 15 feet of easily excavated sands and gravels with numerous open-work seams (as shown by seepage patterns along the levee into the de-watered pits). Below this are slightly cemented sands and gravels that stand on near-vertical cut slopes the full depth of existing excavations (about 30 feet high). The excavated faces of the cemented sands and gravels exhibit a very uniform seepage pattern with a much lower coefficient of permeability than the overlying sands and gravels. Several old borrow pits east of the freeway provide an indication of the groundwater levels, but they are influenced by the gravel pit dewatering operations. It appears the normal groundwater depth east of I-82 is about 5 to 8 feet.

Seepage. The gravel pit operations are carried out in the dry, requiring pumps to dewater the excavation. No records on area drained, river stage, or volume pumped are available to define the pumping conditions, but it is known that two 2,500-gallon-per-minute (gpm) pumps are required to dewater approximately 100 acres of the pit during summer river conditions. The area dewatered varies in elevation from about 1100 (approximate original ground) to 1055 where the pumps are located. During periods of high river levels, the pumps are not adequate to keep up with the seepage flows.

River stages during normal spring runoff cause head differentials across the existing levees of one-third to one-half the differential that will be experienced by the cell dikes under normal operating conditions. The head differential between cells and surrounding water levels will cause seepage through the dikes and the dike foundations. Careful construction of the dikes will result in a fairly uniform embankment and uniform seepage through the embankment. The foundation seepage, however, is not predictable. The volume of seepage through the dike foundations will depend largely on the number and size of openwork gravel seams. Seepage volumes in the range of tens to many hundreds of cubic feet per second would not be unusual for this site. Seepage toward the river does not present a problem if it does not affect the stability of the dikes and does not exceed the capacity of the inlets. Seepage toward the east, however, could raise the groundwater table enough to adversely affect septic tank operation, homes, and the production of agricultural lands.

A slurry trench constructed along the freeway into the cemented sands and gravels will provide a partial cutoff to the east. A storm drain collector pipe between the slurry trench and freeway will also serve as a drain pipe to intercept seepage passing beneath the cutoff.

Dikes. The dikes have three functions: to contain the stored water, to exclude damaging flood flows, and to serve as access and haul roads for the gravel pit operation. Materials for dike construction will come out of the gravel pit, except for riprap that must be imported. Handling and placement of the sand and gravels in the embankment must be rigidly controlled to protect against materials segregation that could cause highly permeable lenses. Placement next to structures requires special care to avoid segregation.

All dike slopes are 3 horizontal to 1 vertical. The exterior dikes and the east-west interior dike have a top width of 15 feet. The north-south interior dike, which is expected to be the main haul road for pit operations, is 24 feet wide. All dikes are constructed to elevation 1112 to provide a 2.5-foot freeboard above the spillway crests at elevation 1109.5. The east dike (along the freeway) will be constructed to elevation 1109 before the slurry trench is constructed. The embankment width at this elevation is 33 feet, which is about the minimum width required for construction of the slurry trench.

The native materials will provide adequate wave protection on the interior slopes, but riprap will be placed along the river exposure to protect the exterior dike slope from river flood flows.

Structures. Eight structures are required to regulate flows through the cells. A flood-proofing structure in the inlet canal would have the gate closed in the off-irrigation season to permit the cells to be dewatered for pit operations, to prevent ice damage to the inlet, transfer, and release structures, and to prevent uncontrolled flows through the cells during floods (appendix A figure A-6). Screens to exclude anadromous fish are required at the inlet and outlets. The inlet screens are sized to limit approach velocities to 0.5 foot per second (fps) to prevent passage of fingerlings. The outlets have bar screens to prevent entrance of adult fish.

Cell A and B inlet structures transfer water from the inlet canal to the respective cells (appendix A figure A-7). A weir entrance prevents excessive drawdown and damaging velocities in the inlet canal. Radial gates control flows into the cells.

Transfer structures connect each cell to allow any two cells to operate as irrigation storage while the third cell is dewatered for mining the sands and gravels. The transfer structures are 10-foot-wide chutes controlled by a heavy-duty slide gate. The heavy-duty gate is necessary because normal operations can cause the same magnitude seating and unseating head.

Cells A and C have outlet structures for discharge to the river. The outlet invert elevations are set at the approximate river bottom elevation where they exit to maximize the storage volume. The discharge structures are 10-foot by 10-foot box culverts with heavy-duty slide gates. These slide gates can experience unseating heads also during high river stages when the cells are dewatered.

Operation. Normal operation during irrigation season requires a fully opened flood-proofing structure gate so that the inlet canal can carry water from the diversion point to the cell A and B inlet structures. The canal capacity is 300 cfs at a hydraulic gradient of 0.0001 foot per foot. The capacity increases significantly if the inlet gates are opened to increase the gradient; however, velocity through the inlet fish screens will exceed 0.5 fps with flows greater than 300 cfs. As the cell approaches full, a stable condition will result in which inflow equals seepage or the cell fills to the spillway elevation. The gate should be modulated to allow for seepage flows while maintaining a water surface of about 1109.0, 1/2 foot below the spillway. Otherwise, spillway flows could enter the cell being mined for sand and gravel.

The transfer and release structures allow passage of 200 cfs with very minimal headloss; however, it must be recognized that the 10 by 10 gates are half as high as the cells are deep and that the flow area reduces rapidly as the cells approach empty. Consequently, large flows can be released with a full cell but cannot be maintained as the cells are drawn down.

The first several years' operation will require close observation of the dikes' performance, particularly during periods of large head differentials between cells and between the cells and the river. Openwork gravel seams in the dike foundation or excessively porous zones in the dike embankment can cause damaging seepage pressures. When locations of excessive seepage volumes or seepage damage are noted, the offending cell or cells will have to be emptied and repairs made. The repairs might consist of slurry trench sections or flattening the dike slopes with filter and riprap courses. We anticipate at least two seasons of operation before the majority of the weak zones are found and repaired.

The control elements for the gravel pits are shown in the sketch on the following page.

COST ESTIMATES

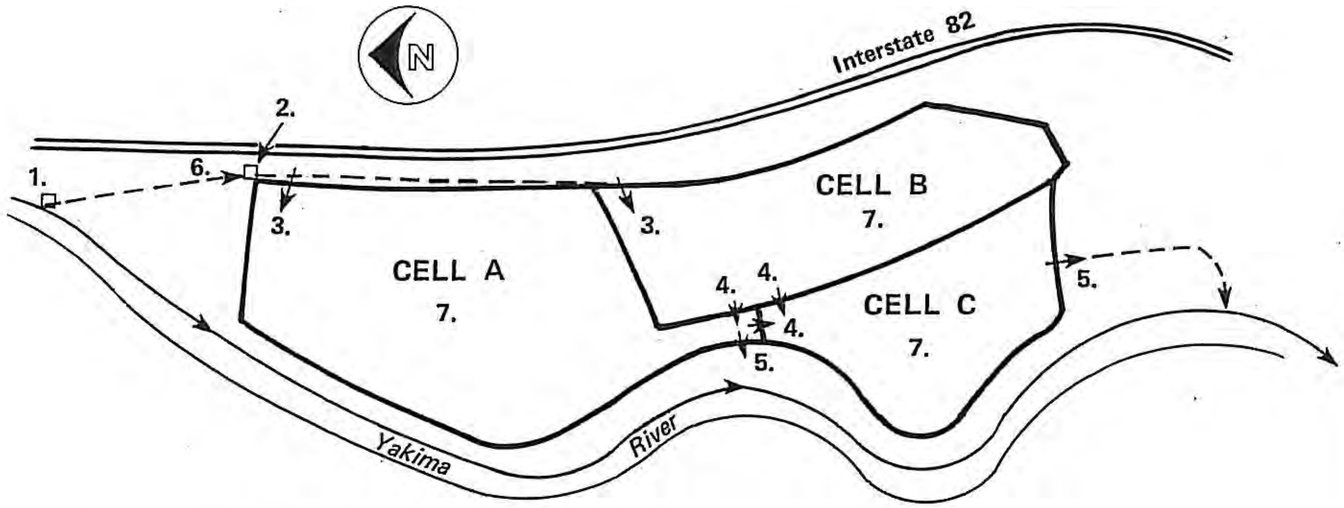
The construction cost estimates are based on conceptual design descriptions and drawings. The estimates were developed by several methods, including use of historical cost data adjusted for project location and time and use of equipment quotations plus installation estimates and definitive material and labor estimates. All costs are based on 1978 price levels.

The costs are approximate in that:

- Final design might differ from the preliminary design.
- Subsurface investigations for preliminary design might disclose foundation conditions different from those assumed for this report.

Because of the preliminary nature of the information used in developing costs, a 25-percent contingency has been added to cover miscellaneous unlisted items and to provide a realistic margin. In addition, 15 percent was added for engineering and 10 percent for escalation, based on construction in 1979.

The costs estimated for each site are given in tables 3-1, 3-2, and 3-3.



1. Fish Screen Structure. Traveling screens with automatic backwash and manual gates for ice protection.
2. Flood-Proofing Structure. Manual gate; open during irrigation season and closed during off-irrigation season.
3. Inlet Structure (2 each). Remotely operated radial gates modulated to control inflow to cells A and B.
4. Transfer Structure (3 each). Remotely operated slide gates modulated to control transfer of stored water from cell to cell. Cell B has to be transferred to Cell A or C for release to the river.
5. Outlet Structures (2 each). Remotely operated slide gates modulated to control release rates.
6. Inlet Canal Water Surface. Remotely monitored; indicator of river level and water available to direct into storage. Changes in water surface as inlet gates are opened also indicate inflow volumes.
7. Cell Water Surface Elevations (3 each). Remotely monitored.

Table 3-1. SELAH DAM ESTIMATED COSTS

Item	Quantity	Unit Cost ($)	Subitem Cost ($)	Item Cost ($)
1. Bonds & Insurance	LS[a]			57,300
2. Mobilization	LS			250,000
3. Diversion & Care of Water	LS			50,000
4. Stripping				
Damsite	14,000 cy	0.75	10,500	
Spillway	7,800 cy	0.75	5,850	16,350
5. Foundation Excavation				
Common	46,850 cy	0.90	42,170	
Rock	7,100 cy	8.00	56,800	98,970
6. Foundation Preparation	13,800 sf	2.00		27,600
7. Foundation Grouting	5,000 cf	25.00		125,000
8. Embankment				
Rockfill	256,900 cy	3.10	796,190	
Random fill	160,000 cy	1.60	256,000	
Impervious select backfill	5,050 cy	5.00	25,250	
Drains	LS		25,000	
Select AC base	28,200 cy	6.50	183,300	
Asphalt concrete membrane	150,000 sf	1.80	270,000	
Slurry trench	40,000 sf	20.00	800,000	2,355,940
9. Spillway Excavation				
Rock - waste	65,750 cy	3.90	256,430	
Rock - usable	197,250 cy	-		
Common - waste	66,650 cy	1.10	73,320	
Common - usable	160,000 cy	-		329,750
10. Inlet Structure				
Concrete	17 cy	350	5,950	
Misc. fabricated metal	LS		2,000	
Gate & Operator	LS		4,900	
Modifications to existing flume	LS		1,500	14,350
11. Irrigation Release Structure				
Concrete	94 cy	300	28,200	
Ported sleeve valve & operator	LS		90,000	
Misc. piping and fittings	LS		12,000	
Two structures @			130,200 =	260,400
12. Inlet-Outlet Structure				
Concrete	54 cy	250	13,500	
Misc. fabricated metal & vent	LS		3,500	
Gate, operator, tubing, & pump	LS		35,000	52,000
13. Pump Station				
Pumps and motors	2 ea	240,000	480,000	
Valves	4 ea	30,000	120,000	
Piping and fittings	LS		12,000	
Building	3,300 sf	40	132,000	744,000
14. Pipeline				
Concrete cylinder pipe	3,400 lf	170	578,000	
Encased pipe under dam	400 lf	560	224,000	
Highway crossing	LS		11,900	
Railroad crossing	LS		17,000	
River crossing	LS		184,000	
Valves, flowmeters, & fittings	LS		60,200	1,075,100
15. Access Road	.4 mi	50,000		20,000
16. Electrical (includes $210,000 for transmission)	LS			272,200
17. Instrumentation and Control				
Local	LS		10,000	
Remote	LS		50,000	
Computer hardware & software	LS		120,000	180,000
Subtotal				$5,928,960
25% Contingency				1,482,240
Total Estimated Construction Cost				7,411,200
15% Engineering				1,111,680
10% Escalation				741,120
Total Estimated Project Cost				$9,264,000
Annual Operation & Maintenance Costs				$51,000
Pumping at $1.00/ac-ft (est. 15,000 ac-ft/yr)[b]				15,000
Total				$66,000

[a] LS = Lump sum.
[b] Power cost estimated at $.04 kWh.

Table 3-2. WENAS DAM ESTIMATED COSTS

	Item	Quantity	Unit Cost ($)	Subitem Cost ($)	Item Cost ($)
1.	Bonds & Insurance	LS			$ 40,000
2.	Mobilization	LS			250,000
3.	Diversion & Care of Water	LS			75,000
4.	Clearing & Stripping				
	Damsite	13,500 cy	0.75	10,130	
	Spillway	20,000 cy	0.75	15,000	25,130
5.	Foundation Excavation	2,300 cy	8.00		18,640
6.	Foundation Preparation	12,100 sf	2.00		24,200
7.	Foundation Grouting	2,850 cf	25.00		71,250
8.	Embankment				
	Core	63,000 cy	1.50	94,500	
	Shell	158,000 cy	2.10	331,800	
	Rock slope protection	46,800 cy	3.10	145,080	
	Select filter material	45,200 cy	10.00	452,000	
	Drain	LS		35,000	
	Slurry trench	60,000 sf	20.00	1,200,000	2,258,380
9.	Spillway				
	Common Excavation				
	Usable	150,000	-		
	Waste	127,000	1.10	139,700	
	Concrete weir & wall	462 cy	250	115,500	255,200
10.	Inlet Structure				
	Concrete	35 cy	250	8,750	
	Misc. fabricated metal	LS		2,000	
	Gate & operator	LS		4,500	15,250
11.	Irrigation Release Structure				
	Concrete	94 cy	300	28,200	
	Sleeve valve & operator	LS		20,000	
	Misc. piping & fittings	LS		12,000	
	Two structures @			$60,000 =	120,000
12.	Inlet-Outlet Structure				
	Concrete	50 cy	250	12,500	
	Misc. fabricated metal & vent	LS		3,000	
	Gate, operator, tubing, & pump	LS		27,000	42,500
13.	Pipeline				
	Concrete cylinder pipe	1,680 lf	140.00	235,200	
	Encased pipe under dam	360 lf	430.00	154,800	
	Road crossing	LS		10,000	
	Railroad crossing	LS		30,000	
	River crossing	LS		126,000	
	Canal dike crossing			6,000	
	Valves, flowmeter, & fittings	LS		56,000	618,800
14.	Access Road	1.9 mi	45,000		85,500
15.	Relocate Gas Pipeline				110,250
16.	Electrical	LS			5,000
17.	Instrumentation & Control				
	Local	LS		4,700	
	Remote	LS		26,000	
	Computer hardware & software	LS		108,000	138,700
	Subtotal				$4,153,800
	25% Contingency				1,038,450
	Total Estimated Construction Cost				$5,192,250
	15% Engineering				778,840
	10% Escalation				519,220
	Total Estimated Project Cost				$6,490,310
	Annual Operation and Maintenance Costs				$31,000

Table 3-3. GRAVEL PIT ESTIMATED COSTS

	Item	Quantity	Unit Cost ($)	Subitem Cost ($)	Item Cost ($)
1.	Bonds & Insurance	LS			$ 47,500
2.	Mobilization	LS			20,000
3.	Diversion & Care of Water	LS			10,000
4.	Clearing & Stripping				
	Exterior dikes	28.4 ac	900	25,560	
	Interior dikes	12.1 ac	900	10,890	36,450
5.	Inlet Channel				
	Excavation	20,500 cy	-		
	Embankment	34,600 cy	1.20	41,520	
	Liner	126,000 sf	.90	113,400	154,920
6.	Dike Embankment				
	Exterior dikes	281,000 cy	1.50	424,500	
	Interior dikes	167,000 cy	1.50	250,500	
	Filter	22,200 cy	5.00	111,000	
	Riprap	55,400 cy	10.00	554,000	1,340,000
7.	Slurry Trench Cutoff Along Fwy	186,000 sf	2.00		372,000
8.	Drain Collector System				
	4' diameter pipe	1,200 lf	75.00	90,000	
	5' diameter pipe	1,100 lf	105.00	115,500	
	5.5' diameter pipe	1,100 lf	115.00	126,500	
	Trench excavation	117,500 cy	1.00	117,500	
	Road crossing	LS		120,000	569,500
9.	Floodproofing Structure				
	Concrete				
	Slabs on grade	64 cy	120	7,680	
	Walls	127 cy	250	31,750	
	Bridge	150 cy	30	4,500	
	Gate & operator	LS		15,000	
	Backfill	450 cy	3	1,350	60,280
10.	Intake Structure & Fish Screen	LS			930,000
11.	Inlet Structures, Cells A & B				
	Concrete				
	Slabs on grade	122 cy	120	14,640	
	Walls	134 cy	250	33,500	
	Bridge	125 sf	30	3,750	
	Gate & operator	LS		13,200	
	Backfill	300 cy	3	900	
	Two structures @			$65,900 =	131,980
12.	Transfer Structure, Cells A to C, B to A, and B to C				
	Concrete				
	Slabs on grade	98 cy	120	11,760	
	Walls	183 cy	250	45,750	
	Bridge	150 cy	300	45,000	
	Gate & operator	LS		67,000	
	Backfill	300 cy	3	900	
	Three structures @			170,410 =	511,230
13.	Discharge Structure, Cell A to River				
	Concrete				
	Slabs on grade	90 cy	120	10,800	
	Walls & structural slabs	262 cy	250	65,500	
	Gates & operator	LS		67,000	
	Backfill	550 cy	3	1,650	144,950
14.	Discharge Structure, Cell C to River				
	Concrete				
	Slabs on grade	95 cy	120	11,400	
	Walls & structural slabs	274 cy	250	68,500	
	Gate & operator	LS		67,000	
	Backfill	600 cy	3	1,800	148,700
15.	Spillways				
	Base rock	140 cy	3.50	490	
	Asphalt concrete	167 tons	30.00	5,010	
	Riprap	350 cy	6.00	2,100	
	Three spillways @		5,600	7,600 =	22,800
16.	Electrical	LS			8,000
17.	Instrumentation & Controls				
	Local	LS		7,300	
	Remote	LS		33,000	
	Computer hardware & software	LS		124,000	164,300
	Subtotal				$4,700,610
	25% Contingency				1,175,150
	Total Estimated Construction Cost				$5,875,760
	15% Engineering				881,360
	10% Escalation				587,580
	Total Estimated Project Cost				$7,344,700
	Annual Operation & Maintenance Costs (plus $300,000 Allowance to correct dike leakage problems during the first 2 years of operation)				$44,000

Chapter 4
OPERATIONAL EFFECTIVENESS

To adequately evaluate the effects of reregulating the Yakima River with the three proposed structures, a computer program was developed. Using daily historical flow rate data at Sunnyside Dam, the computer program simulated the required operations of the proposed reregulation facilities. On the basis of the historical flow data, the computer decided when to store or release water from the reregulation structure. It also decided how much water to store or release. After the flow at Sunnyside Dam had been reregulated, the computer decided how much water could be saved by cutting back releases from the mountains and still provide the desired target flows at Sunnyside Dam.

The need for this computer model became evident when evaluation of the large amount of daily data was considered. Hand calculation of water saved by reregulation for just one site, one target flow, and one irrigation season proved time consuming. With a carefully designed program, a large number of alternatives could be considered accurately and quickly. The computer program, within certain limitations, could actually model the daily operations of each site and evaluate the effectiveness of the reregulation of the Yakima River for various past years. A detailed description of the modeling procedure is given in appendix B.

The goals of the modeling were to determine the extent to which the various sites would:

- Conserve water when possible by cutting back water releases from the five mountain reservoirs

- Minimize the number of water-short days by providing no less than a minimum target flow over Sunnyside Dam

Experimentation with the model parameters (reservoir size, for example) showed the importance of each feature toward achieving these goals.

TARGET FLOWS

The minimum target flows over Sunnyside Dam were selected on the basis of irrigation needs and instream flows that might be required under institutional agreements. For irrigation purposes only, the minimum legal flow over Sunnyside Dam is zero. Return flows from the Sunnyside and Roza Districts as well as the Wapato Project make up the majority of the flow in the river below Parker during the last half of the season. Enough return flow enters the river between Sunnyside Dam and Prosser Dam 56 miles downstream to meet the needs of downstream users.

A range of target flows over Sunnyside Dam was tested with the computer model. These target flows are 0, 50, 100, 150, 200, 250, and 300 cfs. For each of the three sites and for each of five historical irrigation seasons, an operations test was performed to see how much water could be saved or how much additional water would be required to maintain these target flows.

SEASONS TESTED

Five irrigation seasons were selected for the operations tests. Three representative years of low water supply were chosen, 1977, 1973, and 1968. To represent normal water years, 1969 and 1970 were selected. The input data to the operational test were the mean daily flows recorded at USGS's Parker gage just below Sunnyside Dam. In addition, the mean daily flow that was requested, but not delivered, to Sunnyside Canal was subtracted from the river gage readings. (The daily amounts of flow shortage were available for 1977 only.) The hydrograph that resulted is shown in figure 2-1.

An analysis was performed of the 6-month (April to September) runoff values recorded at Sunnyside Dam. The years 1946 to 1977 were used as the data base. Table 4-1 ranks the years from driest to wettest on the basis of total seasonal runoff in acre-feet. As a result of the analysis, 1977 was determined to be the driest year on record.

Table 4-1. SEASONAL RUNOFF BY YEAR, SUNNYSIDE DAM

Year	Runoff (acre-feet)	Year	Runoff (acre-feet)
1977*	68,876	1959	746,860
1973*	87,490	1957	946,682
1968*	194,070	1976	976,010
1966	319,690	1951	983,548
1952	353,518	1946	1,022,280
1963	394,810	1975	1,031,050
1962	402,420	1961	1,077,910
1970*	417,550	1954	1,078,550
1964	499,330	1969*	1,104,220
1953	515,404	1971	1,197,320
1960	577,142	1949	1,257,542
1967	581,730	1948	1,485,672
1958	599,968	1950	1,508,002
1947	642,478	1974	1,910,640
1965	692,230	1956	2,037,096
1955	734,504	1972	2,058,820

* Years used in model study.

ASSUMPTIONS OF OPERATIONS TESTS

Several assumptions were required to make the operations tests simulate the real-time reregulation reservoirs. These are:

- The proposed gages at 16th Avenue on the Naches River and at Harrison Bridge on the Yakima River (see figure 1-1) can be used to develop an accurate prediction of the flows at Sunnyside Dam 6 to 8 hours later.

- No lag time exists between Parker and the three proposed reregulation sites. This assumption is valid for the prototype facility if the proposed gaging stations at the Harrison Bridge and Nelson Bridge sites are established.
- With the assumption of no lag time, historical mean daily flows can be read as input to the operational test at the beginning of the day. Reregulation reservoir status is monitored at the end of the day.
- For the purpose of the study, it is assumed that the natural runoff into the reregulation reservoirs equals the water lost to evaporation and leakage.
- Only the months of April through September are of concern.
- All reregulation reservoirs are full at the beginning of April.

OPERATIONS RULES

The following are the rules under which the reregulation reservoir will operate:

- Stream gages located at 16th Avenue on the Naches River and at Harrison Bridge on the Yakima River telemeter streamflow data to a computer located at the USBR office in Terrace Heights. The stream gage data indicate the adequacy of flow in the river at Sunnyside Dam.
- On the basis of the actual measured flows in the river compared with the target flows and the quantity of storage in the reregulation reservoir, the computer makes a decision to open or close the valves on the outlet works at the reregulation reservoir.
- The decision to release from the reregulation reservoir is made upon detecting a river flow that is less than the target flow. The amount to be released is selected by computer to be the closest 100-cfs increment of flow greater than or equal to the deficit. The maximum release is 400 cfs.
- A gage in the reregulation reservoir telemeters information to the computer. From this information, the volume of storage in the reservoir is computed. The rate at which water can fill or empty the reservoir is also calculated at this time as a function of reservoir storage.
- If the gage indicates that the reregulation reservoir level is less than half full, the computer indicates a need for water to be released from the major reservoirs to meet the demands for river flow and to help refill the reregulation reservoir.

- If the gage indicates a full reregulation reservoir and a flow in excess of the target flow over Sunnyside Dam, the computer indicates a need to cut back release from the major reservoirs. Cutbacks from the major reservoirs can be made only if the controlled releases are being made and adequate storage exists to hold this water. For example, if all major reservoirs and the reregulation reservoir are full and excess flow occurs at Sunnyside Dam, a cutback in release from the major reservoirs is impossible.

SITE-SPECIFIC OPERATIONAL CHARACTERISTICS

Each of the three reregulation reservoirs has specific physical characteristics that affect its function. These characteristics are the travel or lag time from the site to Sunnyside Dam, the useful storage volume, and the fill and discharge rates.

The travel time to Sunnyside Dam is strictly a function of the distance to the dam and the hydraulics of the river. If the reregulation reservoir were at Sunnyside Dam, there would be no lag time. The farther upstream the site is from Sunnyside Dam, the longer the lag. The effects of long lag time can be somewhat lessened by the proposed gages at 16th Avenue on the Naches River and at Harrison Bridge on the Yakima.

The available storage volume and fill and draw rates, which are functions of storage, limit the extent of reregulation. For example, the maximum volume is 3,000 acre-feet in the reservoir. The present volume is 2,600 acre-feet, limiting the 24-hour fill rate to 200 cfs even though the hydraulic capacity of the inlet is greater. In addition, as storage is depleted, the reregulation reservoir is limited, in the same fashion, to maximum release rates.

Filling rates vary as a function of reservoir characteristics and inlet pipe size. A 5-foot-diameter pipe was chosen for the Wenas site, to be filled by gravity head. A 6-foot-diameter pipe and pumping plant were selected for Selah Creek, and 10-foot box culvert gravity inlet-outlet pipes were selected for the Selah gravel pits.

Discharge rates are independent of head behind the reservoir because of short pipes and relatively low discharge rates required. If a shortage was detected in the river, a decision was made to release water from the reregulation reservoir. Discharges are made in blocks. For the purposes of the study, discharges were made in blocks of 100 cfs to a maximum of 400 cfs. For example, if Sunnyside Dam were short 123 cfs, the reregulation structure would release 200 cfs. If the shortage were 750 cfs, however, the structure would only release up to 400 cfs.

The operational tests were limited to the physical reservoir characteristics described in chapter 3. The final design of any of the three sites would require a detailed investigation of physical characteristics most desirable for meeting the operational goals.

Selah Creek Site

The Selah Creek site has the longest lag time of the three sites, 9.9 hours. The storage volume is 3,000 acre-feet. The fill rate is limited by the storage volume in the reservoir at any particular time and the characteristics of the two 900-horsepower axial pumps and piping. Release rates of up to 400 cfs are not a problem because of the high differential head between the reservoir and the river. The long lag time is the only physical constraint that limits the site's operational ability, although it is comparable with the Wenas Creek site.

Wenas Creek Site

The Wenas Creek site has a 9.3-hour lag time and a 2,250-acre-foot storage volume. Because the reservoir is filled by gravity, the fill rate, especially when the reservoir is nearly full, is a constraint on the operations. The site also has the lowest storage volume. Differential heads are not as great as at Selah Creek, so that discharge rates are limited to 250 cfs at low reservoir volumes.

Gravel Pit Site

The East Selah gravel pit site has the shortest lag time, 7.5 hours. In fact, it is closer to Sunnyside Dam than is the proposed Harrison Bridge gage. Depending on which of the three cells (or combinations) are used, storage can vary between 1,320 and 2,750 acre-feet (all three cells). The operations test used 2,000 acre-feet. Because of the configuration of the gates and the available head, the fill and draw rates were considered unlimited. However, the operations tests did not consider the effect of fish screens on the intake. If fish screens are required, the inflow capacity will be limited to approximately 300 cfs.

RESULTS OF OPERATIONS TESTS

The reregulation water savings identified by the operations tests are shown in table 4-2 for all three reregulation reservoirs for five seasons and seven target flows at Sunnyside Dam. For example, 30,900 acre-feet of water might be saved at the Wenas Creek site for 1977 with 0 cfs target flow over the Sunnyside Dam. For the same year and same site but a 300-cfs target flow over Sunnyside Dam, 84,500 acre-feet of water would have been required in additional releases from the mountain reservoirs.

A graphic representation of the results of reregulation for Wenas Creek in 1977, with 0 cfs passing Sunnyside Dam, is given in figure 4-1. The solid line hydrograph, which is the same as presented in figure 2-1, represents the recorded 1977 flow over Sunnyside Dam and the shortages in the Sunnyside Canal for the 1977 irrigation season. The dotted line represents the reregulated flow hydrograph.

Table 4-2. HYPOTHETICAL WATER SAVINGS AS A RESULT OF REREGULATION

		Water Saved in Major Reservoirs[a] (ac-ft/Irrigation Season)						
	Year	0 cfs Target Flow	50 cfs Target Flow	100 cfs Target Flow	150 cfs Target Flow	200 cfs Target Flow	250 cfs Target Flow	300 cfs Target Flow
Selah Creek	1968[b]	103,300			51,000			-7,700
	1969	121,400	108,700	98,300	86,800	79,700	73,500	57,300
	1970	126,400	119,200	107,500	96,500	88,000	67,100	51,900
	1973[b]	47,300			-7,000			-58,700
	1977	35,200	17,500	3,800	-19,200	-35,800	-55,300	-75,000
Wenas	1968[b]	93,500			37,300			-15,700
	1969	113,400	105,800	91,300	79,800	70,100	61,100	51,200
	1970	123,100	115,500	101,100	93,300	79,900	65,000	43,600
	1973[b]	34,400			-19,800			-71,800
	1977	30,900	10,900	-6,200	-30,400	-47,500	-67,400	-84,500
Selah Gravel Pits	1968[b]	100,300			47,300			-2,400
	1969	120,700	106,700	96,800	87,100	74,300	66,300	56,900
	1970	124,200	118,000	105,000	95,100	85,300	68,900	55,600
	1973[b]	45,800			-10,100			-60,500
	1977	33,300	14,400	1,000	-19,600	-37,100	-55,100	-73,300

[a] Plus = water saved; minus = water released.
[b] The years 1973 and 1968 were studied for target flows of 0, 150, and 300 cfs; only 1977, 1973, and 1968 were critical water years; 1969 and 1970 were normal water years.

MODELING LIMITATIONS

Limitations of the operations tests are mainly in the area of mountain reservoir control. The computer program monitors the total of daily controllable releases from the mountain reservoirs but does not monitor the ability of each mountain reservoir to accept the release cutbacks as additional storage. Thus any claim of water saved is contingent on available mountain storage capacity.

To adequately address the question of mountain reservoir control, a study of the water management for the entire Yakima Basin is needed. The carryover effects from one year to the next of this added mountain storage must be assessed. The existing computer model can easily be altered to encompass this additional factor.

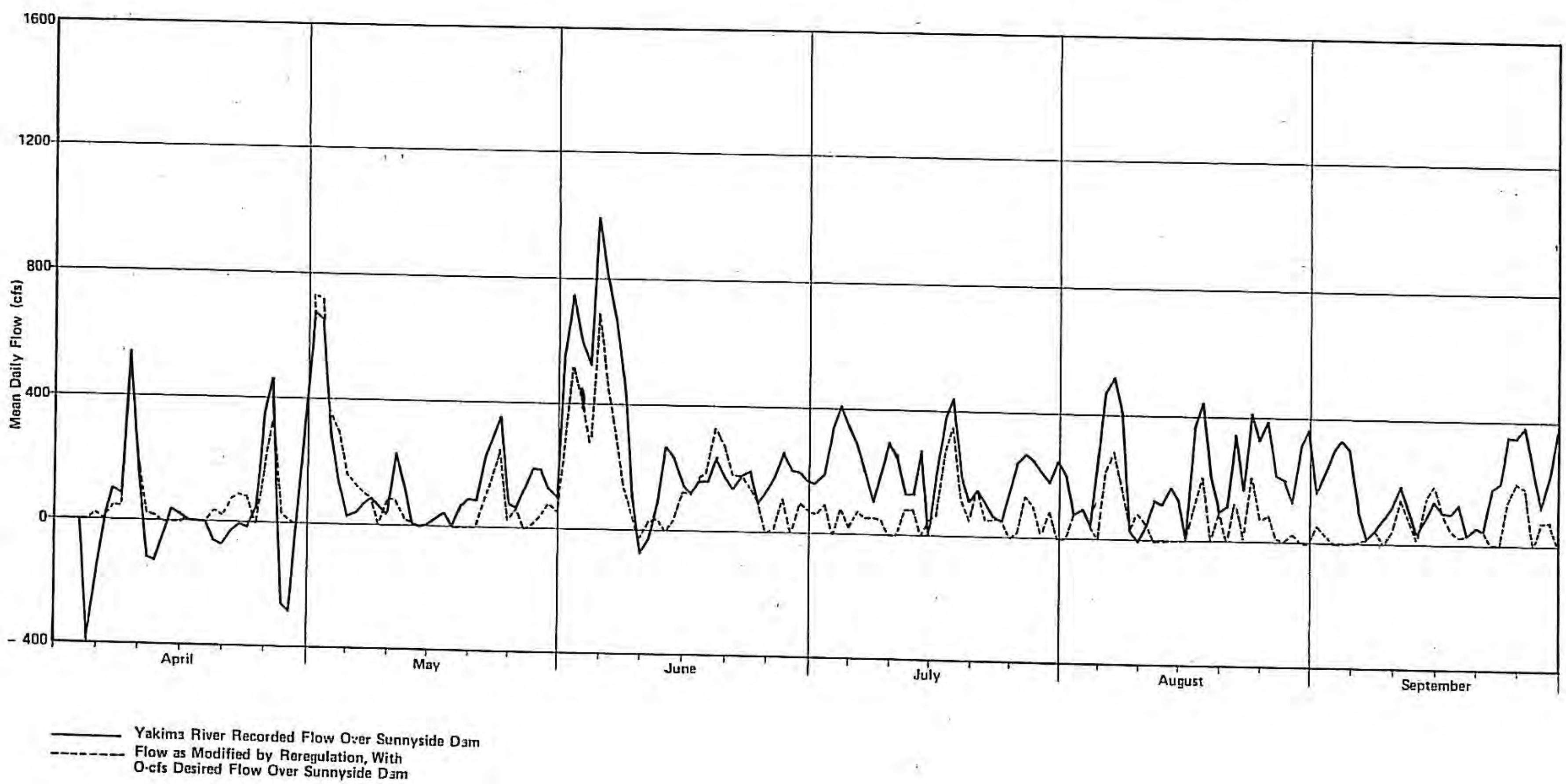


Figure 4—1

HYPOTHETICAL REREGULATION EFFECT OF WENAS CREEK SITE, 1977

Chapter 5
ECONOMIC AND FINANCIAL FEASIBILITY

PROJECT BENEFITS

The proposed reregulation facility would stabilize flows in the Yakima River near Sunnyside Dam and would provide water savings for most hydrologic conditions considered in this study. The principal value of the water savings is as drought insurance. The potential benefits and beneficiaries of the project are:

Benefit	Beneficiary
Reduced operating costs	Sunnyside Irrigation District
Increased crop production	Yakima Basin Project farmers
Fishery maintenance	Commercial and sport fishermen
Recreation enhancement	Area residents

In this study, benefits from reduced operating costs and increased crop production are considered to be the principal measurable benefits. Benefits of a smaller magnitude might exist for fishery maintenance and recreation enhancement. Methods for estimating benefits of reduced operating costs and increased crop production are clearer than methods for valuing fishery and recreation benefits. The latter two types of benefits require many assumptions and simulation of market forces.

As part of the benefit evaluation, the distribution of benefits from the proposed facility was estimated. The benefit of the saved water would generally accrue first to irrigation and to irrigators with the newest (proratable) water rights. Irrigators with the newest water rights incur water shortages most often and of the greatest magnitudes. Water was allocated in water-short years in accordance with the 1945 "consent decree."

Reduced Operating Costs

The inability of the present Yakima Valley irrigation system to "fine tune" flows at Sunnyside Dam results in periodic water shortages at that point. For example, 15 shortages were reported in the drought year 1977. Data are not available on the number of water shortages in other years. However, few, if any, shortages would be expected under current management practices in normal years.

In water-short years, a shortage of water in the Sunnyside Irrigation District Canal requires removing and resetting boards in one or more of 36 check structures to maintain water levels. If the shortage occurs outside regular working hours or during a busy time, employees of the district must work overtime to adjust the levels of the check dams.

In addition, water users must reschedule irrigations and, if the duration of the shortage is sufficiently lengthy, crops could be damaged. In any case, sprinklers are shut down when the shortage occurs, and siphons must be reset in gravity systems. Farmers are inconvenienced and can incur monetary damage.

The proposed reregulation facility would stabilize flows at Sunnyside Dam. The hydrologic model shows that 14 of the 15 shortages in 1977 could have been prevented by the proposed Wenas and Selah facilities, and 13 could have been prevented by the proposed facility at the gravel pits (see chapter 4).

Placing a monetary value on fewer average numbers of water shortages requires an estimate of the cost of a water shortage and the expected frequency of shortages over time. Information is not adequate to do this in a precise way, but data have been provided for 1977. Government and district managements estimate that the Sunnyside District incurred about $10,000 of labor overtime and related overhead costs each time a shortage occurred.* These additional costs occurred because considerable fluctuations in streamflows necessitate close monitoring and manipulation of water control equipment. Using a cost of $10,000 per shortage, the total savings from reregulation in 1977 would have been about $140,000 for the Wenas and Selah sites, and $130,000 at the gravel pits.

A frequency analysis indicated that the 1977 water conditions will recur, on the average, once every 20 years. For this recurrence frequency, the expected extra annual operating cost due to shortages would be $7,000 for Wenas and Selah and $6,500 for the gravel pits. This analysis does not take into account added farm costs resulting from water shortages.

Increased Crop Production

During water-short years, the proposed facility would provide water to supplement the limited irrigation supply. The value of this water in terms of benefit to crop production depends on the frequency of years of short water supply, the quantity of water available, and the expected response of farm production in water-short years. The response and its value depend on many factors, including type of crop, type of soil, management practices, and the distribution of these factors among water right holders. Information is incomplete for all these factors.

Benefits due to increased crop production would accrue in water-short years when water available was less than that required for full irrigation. Available water could come from water savings in the current year or from stored water carried over from the previous year. Production of crops can be reduced in water-short years in two ways:

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* Based on a discussion with Onni Perala, hydrologist for the USBR in Yakima, and Clayton Gould, watermaster for the Sunnyside Valley Irrigation District.

1. Less water is applied and yields per acre are reduced

2. Fewer acres are planted, although full irrigation is practiced on the acres planted.

Case 1 is likely to be expected in a slightly short water year, case 2 in a year of greater shortage, and perhaps both in very short water years. Use of water to merely save perennial plants is another possibility, but the likelihood of a shortage this severe is considered quite remote.

To indicate the severity and frequency of dry years, runoff of water in the Yakima River near Parker is shown in table 5-1 for the period 1 April to 30 September, 1946 to 1977. The data are in acre-feet and arrayed from smallest to largest for the last 32 years.

Table 5-1. SUMMER RUNOFF, YAKIMA RIVER AT PARKER

Year	Runoff (acre-feet)	Year	Runoff (acre-feet)
1977*	68,876	1959	746,860
1973*	87,490	Average	895,500
1968*	174,070	1957	846,682
1966*	319,690	1976	976,010
1952*	353,518	1951	983,548
1963*	394,810	1946	1,022,280
1962*	402,420	1975	1,031,050
1970*	417,550	1961	1,077,910
1964*	499,330	1954	1,078,550
1953*	515,404	1969	1,104,220
1960	577,142	1971	1,197,320
1967	581,730	1949	1,257,542
1958	599,968	1948	1,485,672
1947	642,478	1950	1,508,002
1965	692,230	1974	1,910,640
1955	734,504	1956	2,037,096
		1972	2,058,820

* Water-short years.

The year 1977 had the lowest runoff and 1972 had the highest runoff (some 30 times as large as 1977). Seventeen years (53 percent of the total) had less than average runoff, which is one definition of a water-short year. However, it is reported (Tukey, *The Goodfruit Grower*, 15 March 1977) that little or no reduction in crop yields is likely to occur with a reduction of 25 percent in water applied. If we assume that 75 percent of average runoff is adequate for full irrigation, then 14 out of the last 32 years were water short. In addition, it is known that efficiency of water use is improved in water-short years, so that it was assumed that crop production might be adversely affected by low runoff in 10 of the 32 years illustrated, about one-third of the time.

Other factors besides current year runoff also affect the availability of water for irrigation. A minimal factor is the level of storage in the upper reservoirs at the beginning of the irrigation season. As explained below, the proposed facility would be capable of making more water available both from current-year runoff and from carryover storage.

The relationship between runoff and expected water saved by the proposed facility is such that the lower the runoff, the lower the current-year water savings. As shown in table 4-2, the year 1977 had very low runoff and low potential water savings. The relationship apparently does not hold throughout all runoff levels, however, because 1970 (a lower-than-average runoff year) had a higher water savings potential than 1969 (higher-than-average runoff).

The number of acres that might be affected by water shortages of various magnitudes can be only roughly approximated. In 1977 persons in the Yakima districts reported that 31,100 acres that normally would have been irrigated and cropped were left fallow. Acres idled, by district, were:

Irrigation District	Acres Idle in 1977 Because of Water Shortage
Wapato	11,700
Roza	11,600
Kittitas	7,800
	31,100

Because 1977 was a drought year, acreages are probably the maximum to be expected. In 1977 the proposed Selah Creek facility could have saved about 35,200 acre-feet of water (table 4-1); therefore, assuming an application rate of 4 acre-feet per acre, 8,800 of these fallowed acres could have been irrigated. In the water years better than 1977, savings of water would allow more acres to be irrigated, but fewer acres would be water short.

Figure 5-1 illustrates the potential for irrigating lands from the water savings of a reregulation facility. The line for acres idled by drought was estimated, with an actual data point for 1977 only. The horizontal axis is based on table 5-1. The 1977 runoff was 8 percent of average, while 60 percent of average is equivalent to 515,700 acre-feet of runoff at Sunnyside Dam. Acres potentially irrigable increase as runoff and water savings increase. Because of greater natural flow, acres idled by insufficient water decline as runoff increases.

The amount of land actually irrigated as a result of current-year savings would follow the dotted line in figure 5-1. In an average water-short year, about 10,000 acres would be irrigated that otherwise would be left idle for lack of water. The average would be expected to be greater than 8,800 acres because 1977 conditions were very unusual.

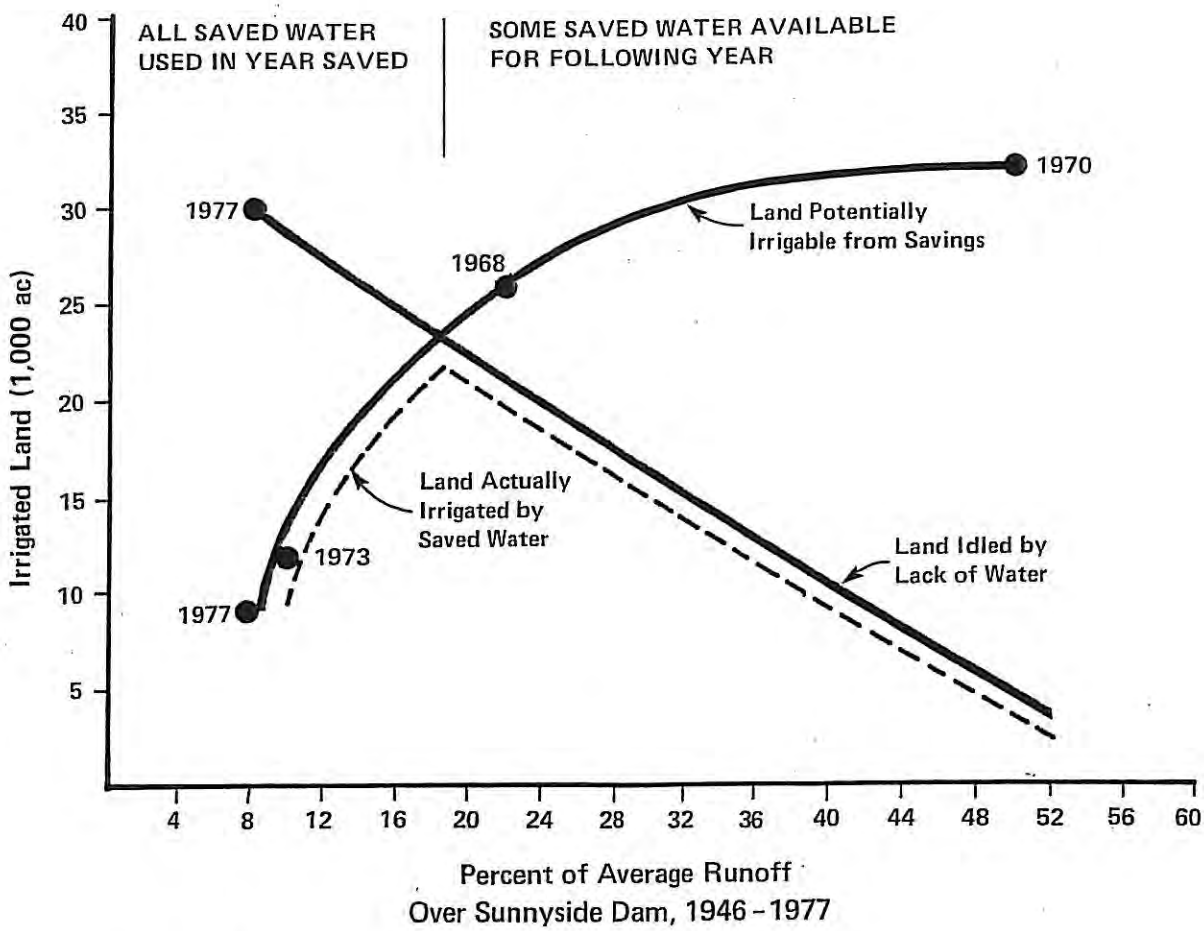

Figure 5–1

POTENTIAL IRRIGATION
FROM SAVED WATER

In addition to irrigation from current-year water savings, additional irrigation would be possible in many years because of water carried over from the previous year in the upper watershed reservoirs. As shown in figure 5-1, it is approximately true that any year better than 1968 would have a potential for providing carryover water for the subsequent irrigation year. This occurs when the amount of water required for land idled by the water-short conditions is less than the water saved by the reregulation facility.

Carryover water could occur in about 8 out of 10 years (every year except 1973 and 1977 in the 32-year historical period). The amount of potential carryover varied from a negligible quantity up to an amount sufficient for at least 30,000 acres. (See table 4-2. The maximum potential for water savings occurred in 1970 and was about 126,000 acre-feet, equivalent to 31,500 acres at 4 acre-feet per acre.) It appears doubtful that more than 20,000 added acres could be irrigated with carryover water in the worst conditions. (For 1977, perhaps 31,100 acres were idled by the drought, and 8,800 could have been irrigated with current year water savings; therefore, 22,300 acres might have used carryover water had it been available).

Net Value Based on Water Rights

To determine the net value of irrigating additional acres in water-short years, the following prices were documented for water rights in 1977:

Irrigation District	Price Per Acre $	Price per Acre-Foot (approx.) $
Roza 1[a]	100	70
Roza 2[b]	175	180
Sunnyside	50-175[c]	50
Wapato 1	250[d]	65
Wapato 2	150-300	--

[a] A 50-percent water supply was predicted for the year.
[b] A 30-percent water supply was predicted for the year.
[c] Most at $150.
[d] For hops and mint.

This information was obtained from people in the Yakima Valley who were involved in sales or had personal knowledge of transactions made in the spring of 1977. The total number of acres of rights involved in the sales is unknown.

On the basis of a water price of $200 and the other information above on water savings and their likely frequency, an approximate annual benefit can be calculated. This benefit is proportional to the annual number of acres benefited, which was estimated as follows:

- For current-year savings, an average quantity of water sufficient for 10,000 acres would be expected to be used in 10 of 32 years, or 31.25 percent of the time, so that the average annual number of acres benefited is 3,125.

- For carryover water, the most that might be used, in very short years like 1977 or 1973, would be water for around 20,000 acres. This amount of added land would be irrigated in less than 1 in 10 years. For a frequency of use of 6 percent (2 in 32 years), the average number of annual acres benefited is about 1,200.

For a value of water of $200 per acre, the average annual benefit from an additional 4,325 acres would be $865,000. The logic of this method is that if a buyer is willing to pay a certain price for a water right, then it has that much benefit to him. Because it might be expected that water values in 1977, a very short water year, would be inflated, another method for valuing water is given below.

Net Return in Crop Production

An alternative approach to estimating the crop production benefits of added irrigation water (water saved) is by evaluating the net return to water in irrigated crop production. In this method, gross returns are estimated from irrigated production, and all costs of farm production are deducted except costs of developing the water supply.

Recently, two major studies using this approach were conducted for the State of Washington by Washington State University.* The emphasis in these studies was on developing new lands for irrigation, but much of the information is applicable to the present proposal. As emphasized in the WSU reports, the economic feasibility of irrigation developments is heavily dependent on crops grown, their prices, and their costs of production. Although the WSU reports are a few years old, prices used, as well as yields, are considered to be still valid. Costs of production might well have increased. As stated in the 1975 report (page 36): "Current wisdom would indicate that the present profit margins are the best to be expected for the next few years." The longer term is much less certain.

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* Washington State University, Department of Agricultural Economics. *A Planning Study for Irrigation Development in Washington*. Prepared for the House of Representatives and the Legislative Transportation Committee. October 1976.

Whittlesey, Norman K. *Irrigation Development Potential in Washington*. Washington State University College of Agriculture Research Center, Pullman. February 1975.

For new development lands (1976 study), the returns to water and management varied from $72.50 to $410 per acre (table 5-2). Returns to water, assuming management costs of 5 percent of gross income (our estimate), vary from $55.60 to $346.75 per acre.

Table 5-2. RETURNS PER ACRE TO IRRIGATION ON NEW DEVELOPMENT LANDS IN WASHINGTON

	Return to Water and Management	Return to Water*
Apples	$352.00	$268.00
Potatoes	410.00	346.75
Sugar Beets	236.00	198.50
Alfalfa	135.00	114.00
Wheat	72.50	55.60
Dry Beans	144.00	122.00

* Estimated by CH2M HILL.

SOURCE: WSU, October 1976, page 38.

As concluded in the 1976 study, for planned rotations in the Horse Heaven Hills and East High project areas, the returns are insufficient to cover costs of water development and provide adequate returns to management. However, the present project is already developed, the cost of the added water is different, and crop rotations differ.

In the 1975 WSU report, the returns to water were estimated for the following areas in the Yakima Valley:

Simcoe, Satus, and Toppenish
Moxee, Roza, and Black Rock
Black Rock, Cold Creek, and Dry Creek near Hanford

The estimated return to water in each of these areas is $291 per acre.

The crop rotation assumed for these estimates of water return is (page 13, 1975 report):

Alfalfa (pasture, silage, etc.)	30%
Sugar beets	10%
Potatoes and other vegetables	10%
Dry beans and other seed crops	12%
Wheat and other grains	38%
	100%

The crop rotation for the Roza Irrigation District in 1976 was as follows (U.S. Bureau of Reclamation, Crop Production Report 1976):

Forages	19%
Miscellaneous field crops (sugar beets)	25%
Vegetables	7%
Nursery and seeds	2%
Fruits	31%
Cereals (including wheat)	16%
	100%

This rotation would return more to water than would the Yakima Valley rotation assumed for the returns in the 1975 WSU report. However, using the somewhat lower 1976 WSU water returns (table 5-2) gives a water return to the Roza rotation of $188 per acre. This estimate is made by weighing crop returns for each type of crop by the percentage of acres in each crop. As indicated earlier, this return might be somewhat high for this rotation because costs of production have increased since the 1976 WSU study was made. At $188 per acre, the 4,325 added annual acres irrigated has an annual value of $813,100.

Fishery Maintenance

The proposed facility could be operated to provide a minimum river flow to benefit fish. The water for the minimum flow would come from water that is saved in storage reservoirs in the upper part of the watershed and is not used for irrigation. On the basis of the estimated water saving potential at various target flows (table 4-1) and the distribution of water runoff (table 5-1), there would be sufficient water to provide for both irrigation and 200-cfs fish flows in all years except the very water-short ones.

To obtain information for the benefit evaluation, personnel of the Washington State Department of Fisheries were consulted relative to the nature of the benefits, if any, and the populations of anadromous fish that would be affected by the proposed facility. In addition, the following two reports were of particular significance for this investigation:

U.S. Bureau of Reclamation. *Environmental Statement, Bumping Lake Enlargement, Yakima Project, Washington.* 1977.

U.S. Department of Commerce, National Marine Fisheries Service. *Partial Net Economic Values for Salmon and Steelhead for the Columbia River System.* Prepared by Merritt E. Tuttle, Jack A. Richards, and Roy J. Wahle. 1975.

It is estimated that, prior to 1880, about 600,000 salmon and steelhead migrated annually into the Yakima River system (USBR, 1977). By 1905 salmon and steelhead populations had declined to about 10 percent of their 1880 number, principally because of irrigation development and appropriation of water rights for that purpose. Populations of migrating fish continued to decline until about 1920, when a rehabilitation program was initiated that has caused a gradual increase in number of fish since that time. Estimates by the Washington State Departments of Fisheries and Game place current migration populations at 1,000 spring chinook, 750 coho, and 2,500 steelhead trout. A large enough increase in minimum streamflows over Sunnyside Dam could improve opportunities for juvenile or adult fish to pass through the river system.

Under current management practices, supported by law, irrigation demands for stored water take precedence over fisheries flows. During the summer irrigation season, flow of the river below Sunnyside Dam is at or approaching zero in many years. Low summer minimum streamflows recorded in several years are shown below.

Year	No. of Days at Zero Flow	No. of Days Below 100 cfs	No. of Days Below 200 cfs
1977	26	75	125
1973	8	68	105
1970	-	-	11
1969	-	-	17
1968	-	8	37

According to information received from the Washington State Department of Fisheries, 100 cfs of flow over Sunnyside Dam is inadequate for adult migrating fish to move up above Sunnyside Dam, but this quantity of water might allow some movement of juvenile fish down the river. It is estimated by the same source that 240 cfs is the minimum flow at Sunnyside Dam for adult fish movement up the river.

In extremely water-short years, the fisheries agencies trap and haul fish around water-short areas of rivers. In 1977, for example, juvenile fish were trapped above Suunyside Dam and moved downstream by truck. Without this action, it is likely that the 1980 run of spring chinook would have been destroyed. Migrating adult fish were also hauled from downriver to above Sunnyside Dam. The cost of these actions is estimated at $50,000 by the Washington State Department of Fisheries. It was estimated that 75 percent of the fish that otherwise would have moved naturally were moved by truck.

The National Marine Fisheries Service study mentioned above provides some estimates of the net economic value of spawning fish that escape the sport and commercial catches. The annual value of the current fishery is estimated as follows:

Spring chinook: 1,000 at $144 = $144,000
Coho: 750 at $107 = $80,250
Steelhead: 2,500 at $100 = $250,000
Total: $474,250

By providing an improved and more stable flow in most years, the proposed facility might aid in avoiding a potential loss in the fishery. However, even in a very dry year like 1977, it is likely that the fisheries agencies could trap and move fish during the critical time of migration.

Through proper regulation, it is possible that the proposed reregulation facility could reduce the cost of fish trapping and transportation by providing some flow for the juvenile fish.

These factors lead to the following conclusions:

- In very short water years like 1973 and 1977, it is not possible to provide more than 100 cfs of fish flows with the proposed facility and meet existing irrigation water rights.
- Disregarding water rights, in most years (approximately 90 percent of the time) fish flows of 100 to 200 cfs could be provided on a stable basis at some reduction in water available for irrigation. In many years no reduction in irrigation water would be necessary with careful management.
- Fisheries experts indicate a sustained flow rate in April to June would provide sufficient water for movement of juvenile anadromous fish downstream. A flow of 240 cfs is required for migration of adults upstream. Information is inadequate to specify a monetary benefit to fisheries.

Thus, examination of available evidence suggests that the proposed reregulation facility, through proper management, could provide some benefits to the Yakima River anadromous fishery through higher streamflows.

Recreation Enhancement

Opportunities for recreational enhancement resulting from the proposed facility include:

- A possible improved resident fishery in the Yakima river as a result of higher and stablized flow
- Improved water-related recreation activities in the river due to higher and stabilized flow
- Recreational opportunities at the reservoir sites (see chapter 6). At Selah Creek, there is potential for recreational development of view land adjacent to the reservoir and of developing a resident fishery in the reservoir. The recreational potential at Wenas Creek is similar to that at the Selah Creek site. There is also the potential for some depreciation of view and loss of some stream fishing in Wenas Creek. At the gravel pits there is opportunity for expansion of the present resident fishery, for more water surface, and for improved recreation facilities on land adjacent to the reservoir.

Land acquisition plans include access at the Selah and Wenas Creek sites. Information available at this time concerning state plans for development is inadequate to estimate the value of potential benefits.

PROJECT COSTS

The costs of the reregulation reservoirs for the three alternative sites have been analyzed in two ways. First, the present value of costs for each site was determined. Second, for purposes of financial planning, annual cash costs were calculated as the sum of debt service (principal and interest) and operation and maintenance costs. The latter cost estimates are given in a later section, titled Financial Feasibility.

The costs of the proposed facilities are summarized in table 5-3.

Table 5-3. COSTS OF REREGULATION FACILITIES

Cost Category	Cost[a] ($ x 1,000) Selah	Wenas	Gravel Pits
Capital (Nonland)	9,264	6,490	7,345[b]
Land Acquisition	59	317	324
Total project	9,323	6,807	7,669
Operation & Maintenance	66[c]	31[c]	44[c]

[a] 1978 dollars.
[b] Includes $300,000 for dike repairs during the first 2 years of operation.
[c] See chapter 3 for some operation and maintenance costs.

The calculation of present value is necessary for comparative purposes when expenditure flows differ over time. For each site, 1979 was assumed to be the year of construction and 1980 the first year of operation. The life of the structures and period of operation was assumed to be 50 years.

The present value of the costs is shown by component in table 5-4. The present values of the costs of constructing and operating the three facilities (in 1978 dollars) are lowest for the Wenas Creek site and highest for Selah Creek. The cost of Wenas Creek site development is 27 percent less than the cost at the Selah site and 11 percent less than at the gravel pit site.

Table 5-4. PRESENT VALUE OF COSTS OF REREGULATION FACILITIES

	Present Value[a] ($ x 1,000)		
	Selah	Wenas	Gravel Pits
Capital Cost	8,688	6,087	6,889[b]
Land Acquisition	55	297	304
Subtotal	8,743	6,384	7,193
Operation & Maintenance	897	421	598
Total	9,640	6,805	7,791

[a] Operation period equals 50 years. Discount rate assumed is 6-5/8 percent (Water Resources Council discount rate for water resource projects).

[b] $300,000 of the capital costs at the gravel pit site occur in the second and third years ($150,000 each year).

ECONOMIC FEASIBILITY

Economic feasibility has been determined by the relationship of benefits of the proposed facility to its costs. Benefits and costs were both discounted for the 50-year evaluation period to the present for the appropriate comparison.

Benefits and Costs

Benefits were estimated above for reduced operation and maintenance costs and for increased crop production. Although benefits exist for fisheries, present water right allocations apply only to irrigation, and water-short years could exclude fish flows. Recreation benefits are also likely at the gravel pits and perhaps at the other sites, but plans for recreation development and management are incomplete.

On the basis of the benefits and costs shown in table 5-5, the Wenas Creek and gravel pit sites are clearly economically feasible. Benefit-to-cost ratios are about 1.6 and 1.4 to 1, respectively. The feasibility of the Selah Creek site is somewhat marginal at 1.2 to 1.0. Benefits to anadromous fisheries and to recreation when plans are complete will likely improve the economic feasibility of all sites. The feasibility of the Selah Creek site would still be the least favorable.

Table 5-5. BENEFITS AND COSTS OF REREGULATION FACILITIES

	Present Value[a] ($ x 1,000		
	Selah	Wenas	Gravel Pits
Benefits			
Reduced Operation and Maintenance[b]	95.1	95.1	95.1
Crop Production[c]	11,144.9	11,044.9	11,044.9
Fishery Maintenance	d	d	d
Recreation Enhancement	d	d	d
Total	11,140.0	11,140.0	11,140.0
Costs	9,640.0	6,805.0	7,791.0
Benefit/Cost Ratio	1.16	1.64	1.43

[a] Annual values are discounted at 6-5/8 percent for development and 50 years of operation.

[b] Estimated annual savings of $7,000.

[c] Crop production benefit based on $188 net value of water per acre and 4,325 acres benefited per year. Annual benefit $813,100.

[d] Benefit likely but not estimated.

The crop production benefits used in this analysis are based on the following:

- Present crop production costs and prices
- Additional irrigation from current savings of water in water-short years averaging 10,000 acres, and water-short years occurring 31.25 percent of the time
- Additional irrigation from carry-over water with a potential of 20,000 acres, but being used only 6 percent of the time.
- A cropping pattern on the additional irrigated acres approximately the same as presently exists in the Roza Irrigation District.

Distribution of Benefits

Benefits of reduced operation and maintenance costs will be received by the Sunnyside Irrigation District. The district will also benefit to an undetermined extent from more timely water service and, therefore, from likely increased returns from crop production. The principal benefits to crop production, however, will accrue to the holders of proratable water rights. Information from the U.S. Bureau of Reclamation indicates that nonproratable water rights are always met, so that the benefits of the proposed facility will go entirely to proratable water right holders and will be distributed in proportion to the amount of their right.

The amounts and distribution of water rights in the Yakima project, and the resulting shares in the benefits, are shown in table 5-6. As indicated, irrigators in three districts (Kittitas, Roza, and Wapato) would receive the bulk of the benefits, 83 percent of the total.

Table 5-6. WATER RIGHT HOLDINGS AND BENEFIT DISTRIBUTION

District	Water Right (acre-feet) Nonproratable	Water Right (acre-feet) Proratable	Percent Distribution of Benefits
Kittitas	0	336,000	26.4
Roza	0	375,000	29.4
Sunnyside	315,836	142,684	11.2
Wapato	305,613	350,000	27.5
Yakima-Tieton	75,869	38,131	3.0
Cascade	54,585	0	0
Westside	31,128	8,200	.6
Selah-Moxee	27,508	4,281	.3
Union Gap	20,763	4,642	.4
Naches-Selah	49,645	4,486	.4
City of Yakima			
M&I	4,860	4,500	.4
Irrigation	8,802	1,500	.1
Congdon	23,767	4,300	.3
Total	918,376	1,273,724	100.0

SOURCE: U.S. Bureau of Reclamation, private communication.

FINANCIAL FEASIBILITY

The financial feasibility of the proposed project depends upon whether sufficient revenues can be generated from use of the saved water in water-short years to pay the cost of the project. Stated differently, it depends on whether the beneficiaries are likely to be willing to pay the annual costs of the project.

Aside from reduced operation and maintenance costs and fishery and recreation benefits, the project can be viewed as a form of income insurance for irrigation. Benefits are collected in water-short years although project costs, like insurance premiums, must be paid every year.

In the following financial analysis, the Wenas site is used in most examples. Selection of another site would increase the costs.

Annual Costs

The annual costs of the reregulating reservoirs for the three sites are given in table 5-7. The debt service costs shown are the annual payments (interest plus principal) required to retire a debt that might be incurred to build the facility, assuming a 30-year state loan at 5-1/2 percent interest. The operation and maintenance costs are the annual costs necessary to operate and maintain the facility at a desired quality. The annual revenues required to meet costs, without considering inflation of operation and maintenance costs, are $499,000 for Wenas Creek, $572,000 for the gravel pits, and $707,000 for Selah Creek.

Table 5-7. ANNUAL COST REQUIRED TO FINANCE, OPERATE, AND MAINTAIN REREGULATION FACILITIES

	Annual Costs[a] ($ x 1,000)		
Cost Category	Selah	Wenas	Gravel Pits
Debt Service[b]	641	468	528
Operation and Maintenance	66	31	44
Total Annual Cost	707	499	572

[a] 1978 dollars.

[b] Assumes state loan at 5-1/2 percent for 30 years.

The costs illustrated in table 5-8 for the first 10 years of operation have an assumed inflation factor of 6 percent per year applied to operation and maintenance costs. The costs are for the Wenas Creek site only. The annual cost for the added irrigation (4,325 acres) is $501,000 to $524,000 for the 10-year period.

Table 5-8. ANNUAL FINANCIAL COSTS ASSUMING INFLATION AT 6 PERCENT ON OPERATING COSTS, WENAS CREEK SITE, 1979-1988

Year	Cost ($ x 1,000)
1979	501
1980	503
1981	505
1982	507
1983	509
1984	512
1985	515
1986	517
1987	520
1988	524

An alternative view of financial feasibility can be obtained by assuming that the annual cost of the project would be added to the cost of all water provided in a normal year for irrigation in the Yakima system. For Wenas Creek site costs, the "add-on" would be $.23 per acre-foot in year 1 and $.24 in year 10 (assuming 2,192,100 acre-feet). At the normal acreage irrigated (462,000 acres), the added cost per acre would be $1.08 to $1.13.

Cost Allocation

In this study, all costs have been allocated to reduced operation and maintenance (1%) and crop production (99%). This is also the distribution of benefits, disregarding fishery and recreation benefits. The total annual cost was assumed to be $500,000 (Wenas Creek site), with $5,000 allocated to Sunnyside Irrigation District for reduced operation and maintenance costs, and $495,000 distributed to proratable water rights. The allocation is shown in table 5-9. The annual cost per acre-foot of proratable water right is $.39. The annual benefit per acre-foot is about $.64. Thus, financial feasibility of the Wenas Creek site is indicated.

The average annual crop production benefit is estimated to be $1.76 per acre ($813,100 divided by 462,000 acres). Thus the annual revenue, on the average, would appear to exceed the annual cost and again indicate financial feasibility.

Table 5-9. ALLOCATION OF ANNUAL COSTS OF WENAS CREEK SITE

District	Annual Cost
Kittitas	$130,680
Roza	145,530
Sunnyside	60,440[a]
Wapato	136,125
Yakima-Tieton	14,850
Others[b]	12,375
Total	$500,000

[a] Includes $5,000 for operation and maintenance benefit.

[b] See table 5-6 for distribution.

Chapter 6
ENVIRONMENTAL FEASIBILITY

This environmental feasibility assessment briefly describes the physical and socioeconomic environments of each of the three sites and assesses the potential impacts on these environments. The potential impacts at each site are compared in a matrix to facilitate site evaluation.

Additional environmental information is provided in appendixes C, D, and E. Data are presented for terrestrial biology, aquatic biology, and archeology.

EXISTING ENVIRONMENT

Selah Creek

The Selah Creek valley bottom is approximately 800 feet across, and the valley entrance is framed with sheer rock cliffs. The south wall of the valley is a cliff that is 100 feet high at the mouth. Talus slopes are evident on both sides of the valley. A few lateral valleys also intersect the main valley along the north wall, providing a generally more weathered condition on that side of the Selah Creek site. The valley bottom is composed of alluvial soils that are shallower and rockier than those at the Wenas site.

The dominant vegetation is big sagebrush with occasional spiny hopsage and horsebrush. Various grasses and weeds such as filaree make up much of the sparse ground cover. No riparian (streamside) vegetation is found along the creek, although squaw currant, golden currant, and western chokecherry are found at the base of the south wall not far from the creek bed. The area has been heavily grazed and thus supports rather sparse and simple flora.

The wildlife of the site consists of desert-oriented species, particularly those adapted to the sheer rock walls and talus slopes. Most noticeable are nesting birds and a variety of raptors. Red-tailed Hawks, including a nonactive nest, and Sparrow Hawks were observed, although the potential exists for Prairie Falcons, Golden Eagles, and other broad-winged hawks to nest on the cliffs. The bottom area is used by Black-billed Magpies, Western Meadowlarks, Starlings, Robins, and other birds. Evidence of mule deer and coyote use of the area was noted, and there are reports of a high population of rattlesnakes.

In general, the Selah Creek site offers a moderate diversity of habitats, highlighted by the extensive cliff-face environment for birds, mammals, and reptiles. However, the extensive grazing has somewhat reduced an already limited plant productivity and associated wildlife. No endangered or threatened species are known or suspected of occurring on the site.

The intermittent nature of the stream precludes its being able to support much aquatic life. The water in the stream at the time of the site visit was clear and cool. The stream bottom is composed primarily of coarse sands and gravels. During the site visit, the stream disappeared altogether about 100 yards before reaching SR-821.

The area has experienced little development. There are a vacant older ranch home and a mobile home at the mouth of the valley and a more substantial ranch development between the valley mouth and the river itself. Interstate 82 borders the upper end of the reservoir, and a highway rest area situated on the south rim of the valley overlooks the entire site. This same rest area marks the westernmost boundary of the U.S. Government's Yakima Firing Range. Under current plans, the upper reaches of the reservoir would extend approximately 1/4 mile into this military reservation.

In regard to archeological resources, the potential reservoir at this site would lie between a burial site (45YK14) near the mouth of the canyon and a group of petroglyphs (45YK125) located on the north side of the canyon under the Interstate 82 highway bridge. The reservoir plan would not affect either of these sites.

A very cursory examination of the floor of the canyon revealed a number of cryptocrystalline silica flakes that were produced by the activities of a stone-tool maker. No concentration of flakes was found, but the inspection consisted of a single walk down the canyon. An exposure of what appeared to be redeposited volcanic ash, probably of Mt. Mazama origin (about 6,700 years B.P.), was noted in the canyon.

No attempt was made to evaluate historic resources at Selah Creek, but no structures or foundations were observed in the study area.

Wenas Creek

The mouth of the Wenas valley is framed by 40- to 50-foot-high cliffs of Pomona basalt. These sheer basalt cliffs show the effects of the past erosion activities of the stream, which is fast flowing and turbid and delivers an appreciable volume of water to the Yakima River during the spring. The cliffs diminish and disappear within a short distance upstream.

The valley fans out and is just over 800 feet across at its widest. The valley bottom is used almost exclusively for grazing. Grazing has been a contributing factor in maintaining a limited diversity in both plant and animal life in the area. There are few trees or shrubs on the site other than at the mouth and, although several varieties of birds were observed in the area, there was little evidence of use by wild mammals or amphibians.

The habitat is primarily a well-grazed pasture consisting of various grasses, clover, filaree, and other forbs. The meadow covers nearly the entire site. There is no riparian vegetation along the stream except for a 1-acre patch of cattail marsh near a turn in the creek. A small cottonwood and willow thicket is found on the south perimeter near the mouth.

Few wildlife were recorded at Wenas Creek. Birds included Mallards, Ring-necked Pheasants, Red-winged Blackbirds, Killdeer, Western Meadowlarks, Rock Wrens, and Black-billed Magpies. Other wildlife such as raccoon (tracks) and a garter snake were also noted. No other mammal tracks were observed along the mud stream border.

Wenas Creek is relatively low in habitat diversity, although it could be fairly high in plant productivity. This is attributed to the rather simple structure of the habitat, which is dominated by grass and is maintained in that state by grazing. No endangered or threatened species are known or suspected for the site.

Although the stream has a limited riparian vegetation, the aquatic habitat is quite diverse. The stream provides a spawning habitat for steelhead, coho, and chinook salmon, rainbow trout, and whitefish. Spawning success is only moderate due to the greatly decreased flows late in the summer caused by irrigation diversions. However, fish are present throughout the year, and the area near the mouth of the stream is a popular fishing spot, especially in the early summer.

Four relatively new and well-constructed permanent homes have been built on the east bank of the river directly across from the mouth of Wenas Creek. Approximately 600 feet east of these homes the terrain begins to rise substantially, and at the top of this rise the Roza Canal is located. The view up the Wenas valley from the homes is pleasant.

Some residential development has occurred along Wenas Road at the head of the potential reservoir. There are a few homes scattered on the west side of the road, and a few are located on the east side of the road just north of the limits of the project area.

A Northwest Pipeline Company 8-inch high-pressure natural gas line runs diagonally across the alignment of the potential dam at a depth of approximately 5 feet.

Archeological sites 45YK16, 45YK17, and 45YK18 are located at the mouth of Wenas Creek. These sites were partially excavated by Claude Warren (1968) in 1956 as part of a salvage program for a natural gas pipeline. A later test of the main occupation site at the mouth of the creek at site 45YK16 was made by David Rice (1969) (Rice lists the site as 45YK51). This site was reported by both excavators to have been badly damaged by relic collectors. The cultural deposits are quite rich and are relatively recent by current archeological chronologies.

Little evidence of past excavations by relic collectors or archeologists can be seen at the site today. A lush green pasture covers the area and the pits are hardly discernible.

There probably are data yet to be gained at this site. Warren's excavations were confined to the route of the pipeline, and Rice dug a square of only 2 meters by 2 meters.

Gravel Pits

The gravel pits are the least natural of the three sites. The area has been the scene of extensive gravel mining over the years. The proposed design at this site would involve an approximate doubling of the area already excavated. Of the three potential sites, the gravel pit site possesses the most productive aquatic habitat. Some of the various mined-out pits that been allowed to fill with water have been stocked with fish by the Washington Department of Game. While there is no trout reproduction, various spiny-ray fish (yellow perch, largemouth bass, crappie, bluegill, and pumpkinseed) do reproduce and are a self-sustaining fishery. Public access is available, and these ponds are a popular fishing area.

Cattail-bulrush habitat has formed around the edges of some pits (especially the northern ones), and this serves as a nursery for young fish and provides good waterfowl cover. Water quality in these ponds is generally good, and they are expected to continue to provide a mixed warm- and cool-water fishery. The natural topography of the area is relatively flat. The area lies on the flood plain of the river, bounded by the river on the west and by Interstate 82 on the east.

The geology of the site is a mix of river and flood plain deposits ranging from very fine silts to coarse gravels underlain by a hardpan layer at a depth of approximately 45 feet.

Terrestrial habitats are fairly diverse, both in distribution and in kinds of vegetation. Scattered willows and cottonwoods line many of the older ponds and the river dike. Most of these trees appear to be dead. An area of large cottonwood snags is found at the northern edge of the site. A number of the upland areas between the northern ponds have sparse grasses and weeds.

A considerable variety of wildlife occurs in the habitats of the gravel pits. Waterfowl observed include Canada Geese, Whistling Swans, Mallards, American Wigeon, Wood Ducks, and Coots. Other water-oriented wildlife include gulls, Belted Kingfishers, Long-billed Marsh Wrens, Red-winged Blackbirds, and Killdeer. A pair of Bald Eagles was recently recorded in the area. A muskrat lodge was observed in a well-developed cattail marsh in the northern portion. The stand of large cottonwood snags is probably used for nesting by Wood Ducks, Magpies, Starlings, and Common Flickers.

The gravel pit site appears to have diverse habitat and wildlife. This has been brought about by major modifications of the terrain as part of the gravel operations and is accentuated by the natural productivity of the flood plain and the extended time certain areas have had to develop.

The Bald Eagle is now officially designated a threatened species by the U.S. Fish and Wildlife Service. Its use of the area appears to be sporadic and might occur only during migration periods. No other endangered or threatened species are known for the site.

The area is owned almost entirely by the Yakima Asphalt Paving Company. There are, however, two private homes built on a narrow strip of land between the gravel pits and Interstate 82. There is little other development in the area.

The gravel pits appear to have no potential archeological or historical resources. Extensive disturbance to the original ground surface has precluded the possibility of undisturbed cultural resources.

ENVIRONMENTAL IMPACTS

At this feasibility level of study, many environmental impacts are not quantifiable. Additional detail will be provided if a preferred alternative is selected and an environmental assessment or impact statement is required.

Impacts are discussed below in relative order of importance for each of the two major categories of environment: physical and socioeconomic.

Physical Environment

Hydrology

The primary positive impact of the project at any of the sites would be the ability to even out present fluctuations in the flow of the Yakima River at Sunnyside Dam. This will provide more efficient use of stored water, with direct benefits to agricultural users, particularly in a drought year. The more constant river flow could also offer benefits to the Yakima River fishery downstream.

At both the Selah and Wenas sites, the retention of water at elevations higher than at present could raise the groundwater tables. With the lack of development around the potential Selah reservoir, this possibility is of little consequence. A change in the groundwater table at the Wenas reservoir, however, could have an effect on septic tank drain fields and individual well water supplies. If the Wenas site is selected, the exact nature and extent of these effects would have to be determined.

Enlargement of the gravel pit ponds to the proposed reservoir is not expected to cause any significant hydrologic impacts. Protective measures are proposed to prevent erosion of the highway embankment along the east boundary of the site. Seepage from the reservoir to the river will have to be controlled adequately for the facility to function efficiently. Seepage from the reservoir during low river flows could substantially increase downriver flow because of increased head differential. However, because a "flow through" concept is planned at this site, the leakage would be offset by the diversion and the net flow past the reservoir would be stable.

Wildlife and Vegetation

Development of water storage facilities at any of the three sites would eliminate most or all of the existing habitat and displace its wildlife. The full extent of the losses can only be roughly estimated because of the limited data available at this time. At Selah Creek all the bottomland and some of the lower talus slopes would be inundated and the sheer cliffs would be retained. At Wenas Creek all of the bottomland and most of the cliff faces would be lost. Some shallow areas would be created. At the gravel pits most of the riparian and marsh vegetation would be lost, and various aquatic communities would be exposed and lost if cells were used to mine selected portions.

The opportunity to mitigate these losses is low at Selah Creek, moderate at Wenas Creek, and high at the gravel pits. The water surface adjacent to high cliffs at Selah Creek could actually improve the area for cliff-nesting raptors and other birds. This might be further enhanced if a fishery could be established. However, it is unlikely that emergent vegetation can be established. Relatively shallow areas left in places at Wenas Creek could be developed into marsh or riparian habitat. This would substantially improve the area for waterfowl and other marsh species. Because the riparian habitat at the gravel pits was created by major terrain modification, it could be replaced and enhanced by a similar approach. Shallow areas could be engineered to encourage the development of marsh vegetation. Contours of the cells could be created to maximize the perimeter for riparian habitat. In all areas plantings could be used to accentuate vegetative development.

Each site has advantages and disadvantages regarding habitat and wildlife diversity, plant productivity, and mitigation potential. Selah Creek has moderate diversity, low productivity, and low mitigation potential. Wenas Creek has low diversity, high productivity, and moderate mitigation opportunity. The gravel pits have high diversity, moderate productivity, and high mitigation potential.

The result of this comparison is that no site proves to be substantially more acceptable than the other for development. Further, none of the sites appears to be especially valuable from a terrestrial biology point of view. This may well be related to their heavy use by man, which has significantly modified their natural vegetation and wildlife. We conclude that terrestrial biology should not play a further role in site selection. Once a prime site is chosen, however, a better understanding of the terrestrial impacts should be gained and more precise mitigation measures determined.

Fish/Aquatic Life

Construction of a dam at the Selah Creek site would have little or no negative impact on aquatic communities. Instead, new aquatic habitat would be created, with the potential for some year-round habitat. The extent of a permanent pool would depend on irrigation demands, and it is anticipated that the pool level would fluctuate throughout the reregulation season. However, there is potential for management of aquatic and riparian habitat. At all of the sites the Washington Department of Game has expressed concern about the possibility of increased siltation and turbidity in released waters and increased water temperatures as a result of solar radiation during storage. These higher temperatures could cause a migration block downstream when the stored water is released. In the case of Selah and Wenas Creek sites, the department is concerned about possible impacts from the required river crossing of the water pipeline serving the facility.

Construction of a dam at the Wenas Creek site would block anadromous fish runs unless a fish ladder or other fish conveyance mechanism is incorporated in the project design. In addition, more than 2 miles of spawning habitat would be inundated. The water level fluctuations behind the dam might preclude effective management of the reservoir for the species of fish now present in the affected reach of the stream.

It is anticipated that the Washington Department of Game might require mitigation for project effects on aquatic resources at the Wenas Creek site. The extent of the mitigation would depend on the productivity of the area affected and would probably require studies specific to the affected reach of the stream.

Inundation of the gravel pits would not greatly alter the deeper portion of the existing ponds, and the present fish species would probably remain. Water quality, however, might suffer as continually changing water levels would increase disruption of bank sediments, which could in turn lead to increased turbidity. In addition, it is likely that the majority of the existing cattail-bulrush habitat would be lost, and that this would lead to a short-term reduction of fisheries and waterfowl productivity. The Department of Fisheries has expressed concern about possible anadromous fish loss due to diversion into the gravel pit reservoir from the river; this will require the addition of fish screens at the inlet and possibly at the outlet of the facility. Costs for screening are included in the estimate.

Another concern raised at the public meeting in Yakima on 27 April 1978 was whether the reservoir facility might adversely affect fish migration through diversion of freshets. The concern is that these cold-water freshets, which trigger fish migration, could be diverted and retained in storage long enough to raise the temperature and prevent migration. This possible impact will require additional study if the gravel pit alternative is selected.

Possibilities for mitigation of loss of aquatic resources appear to lie mainly with development of an appropriate bottom contouring and water level management plan based on preferred depths and times of spawning. The existence of a large residual water supply and pre-established "cells" makes such a plan more possible at this site than at the Selah or Wenas sites. Some cutting and filling might be necessary to ensure the success of such a program.

Geology and Soils -

In addition to the basic change in the topography of the flooded area at the Selah Creek and Wenas Creek sites, fluctuation of the water level within the reservoir could hasten erosion of the sideslopes. Because of the greater soil development at the Wenas site, the impact would be greater there.

The nature of the rock cliffs at the two valley sites presents the possibility of seepage from the dams. This appears to be especially true at the Selah site, where rock fracturing is more evident on the cliff faces and drainage through the underlying conglomerates appears to be more rapid. More extensive geologic investigations would be required to determine the magnitude of this impact and the basic suitability of the geologic structure for dam construction.

The geology of the gravel pit site would be little altered because it has already been heavily impacted by mining activity. More rock, gravel, and soil would be excavated, and the overall topography of the roads, dikes, and water surfaces would be raised, but actual impacts would be minimal.

The potential for archeological resources in the project area of Selah Creek Canyon is very high. There is a recorded site at each end of the proposed reservoir and a lithic scatter between them. A thorough survey of the proposed project area is recommended if the plan for Selah Creek Canyon continues. This survey would aid in planning because mitigation of impacts to archeological resources can become an important consideration if such resources are present. Only a thorough survey can determine if significant archeological resources are within the project area.

Careful consideration must be given to any plan that would damage the Wenas Creek archeological sites. The proposed dam would probably impact a portion of the site, but it would also serve to protect what might be the main segment of 45YK16 from eventual destruction by the erosion from Wenas Creek. The latter possibility should be explored if the plan for Wenas Creek remains viable.

Water Quality

The two major water quality considerations in the proposed projects are temperature increases and turbidity. The magnitude of temperature impacts is not known at this time, because water storage duration has not been established. Related considerations are time of year (for solar radiation and air temperature) and volume of stored water. The concern is that overly warm stored water that is released into the river could cause a temperature block downstream, which would prevent fish migration.

With regard to turbidity, the concern is that water discharged from the storage reservoir would be taken from the bottom of the pool and could carry silt with it into the river. This would be particularly harmful during low flow, when water quantities are insufficient to carry the silt away. This would be harmful to spawning beds and invertebrate organisms. It appears that this impact can be avoided or substantially minimized through design of the discharge structure and development of operational procedures that consider this potential problem.

A minor contribution to erosion and turbidity would occur as a result of the changing water levels within the reservoirs and the consequent disruption of bank or bottom sediments.

Air Quality

Adverse impacts to air quality would be minor and temporary. The impacts would primarily involve dust stirred up during construction and exhaust emissions from earthmoving equipment. No significant air quality deterioration due to operation of the facility is anticipated. Permanent pumps would be electrically powered, which would theoretically involve some slight increase in air pollutants at the site of power generation (if fossil fueled). No increase in population is involved, so that consequent secondary air quality impacts (due to automobile emissions and heating fuel combustion) would not be involved.

Natural Resources

No impacts to natural resources are anticipated other than those discussed under the preceding heading.

Socioeconomic Environment

Dwellings and Businesses Dislocated

No dwellings would be dislocated through use of the Selah Creek site.

Use of the Wenas Creek site could involve dislocation of up to four homes, which are sited just above the elevation of the maximum pool height. These homes are located in the flood plain, however, and could be lost in a major (probable maximum) flood even if the dam is not built. Properties other than the homes would be required for the reservoir site.

One and possibly two dwellings would be dislocated by the siting of the facility at the gravel pit. These homesites, which are along the eastern boundary of the property, have already been severely impacted by the construction of I-82. The concept of the proposed facility at this site would allow the continued gravel extraction operations by Yakima Cement Company.

Dam Failure

Although the probability of catastrophic dam failure would be extremely low, the threat of failure and resultant damage is a major consideration. For the persons potentially affected, the threat alone might be perceived as a significant impact.

Dam failure is a consideration only at the Selah and Wenas Creek sites. The low profile and segmented arrangement of the gravel pit levee offers no real threat to persons or property downstream in the event of a failure.

Of the two sites, the Wenas Creek site presents the most concern. The homes located across the Yakima River and in front of the Wenas damsite are substantial and would be vulnerable *in the event of a catastrophic dam failure only*. At the Selah site, the old ranch house and mobile home immediately downstream of the damsite could be affected. The ranch located on the west side of the highway between the damsite and the river is in a relatively protected position and at a considerable distance and, therefore, would not be seriously affected.

Because of the seriousness of this factor, more detailed study would be required in the event of selection of either of the creek sites. Normal dam inspection and monitoring measures would help to mitigate any real or perceived danger.

Archeology/History

As noted in the Existing Environment section, no undisturbed cultural materials remain at the gravel pit site, and no adverse impacts are anticipated from construction of the project. This site needs no further consideration from the standpoint of cultural resources.

Selah Creek and Wenas Creek seem to be equal in possible archeological importance. Selah Creek has indications of archeological resources; but it has not been systematically surveyed, and its potential will remain unknown until such a survey takes place. Wenas Creek, on the other hand, has been surveyed and has archeological sites somewhat known from partial excavation; these sites could be partially destroyed and partially protected by the construction of a dam.

Further study is required to provide information at Selah Creek and Wenas Creek. A survey at Selah Creek would be the logical first step in research. Test excavations along the dam axis and consultation among archeologists, hydrologists, and construction engineers would be recommended at Wenas Creek.

No impacts to historically important resources are anticipated. None of the three sites is known to contain any historic structures or foundations, and no historically significant events are known to have occurred on the sites.

Land Use

Land use at the Selah Creek site would shift from grazing to reservoir, with some potential for recreational use of the adjacent reservoir lands. The Wenas Creek site would change from grazing and homesites (although in the flood plain) to reservoir, with the same potential for recreational development at the periphery. Land use at the gravel pit site would remain substantially unchanged. Although the water surface area would increase, mining and fishing could continue at the site.

Land Ownership

Impacts to land ownership would primarily involve a shift from private ownership to public. The major exception to this would be in the upper reaches of the Selah Creek site, where a parcel of federally owned land (Yakima Firing Range) would be inundated. Special arrangements such as a letter of agreement with the Department of the Army could be required at this site.

Aesthetics

The only site to suffer a depreciation of view would be the Wenas site. The view up the valley toward the mountains would be lost to the homes at the mouth of the creek and to the approach road to these homes. The view from almost any other vantage point in the valley would be either high or distant enough to preclude any serious loss of scenery.

The view of the Selah valley from the rest area along I-82 and from the freeway itself would improve if the reservoir were built at that site. The view lost from the mouth of the valley is not critical.

The view of the gravel pit site would not change substantially. The water surface would be considerably larger, but similar to the present view. Some vegetation would be lost in construction, but this could be mitigated through new plantings and attention to visual consideration in the design of the facility. The dikes would be too high to offer a continuous water view from I-82 at the southern portion of the site but are not high enough to appear above the horizon.

Recreation

No adverse impacts to recreation would be experienced at the Selah Creek site. In fact, development of a reservoir at this site could offer some potential for recreational development. Because of the fluctuation of the reservoir pool, the maintenance responsibility, and possible objections by adjacent landowners as a result of access, parking, and litter problems, the recreational potential should be formally developed through creation of a state park. Objections were raised at one of the project public meetings in reference to present conditions at the gravel pit fishing area and the other borrow pit ponds across I-82.

Some stream fishing opportunities would be lost at Wenas Creek. This could be supplanted by reservoir fishing, but the same concepts noted above should be taken into consideration. Reservoir-related recreational benefits will depend on management decisions made during the design phase.

Use of the gravel pit site would allow expansion of the public fishing areas at that site. In addition, design of a reservoir could allow an opportunity to mitigate some of the present problems by providing better parking and sanitary facilities and landscaping screening.

Energy Use

At all the sites, energy would be expended during construction. The least construction-related energy requirement would be at the gravel pits, because less material would need to be moved. All dikes and access roads would be constructed of locally extracted materials. Construction energy requirements would be comparable at the Selah and Wenas sites.

For operations the Selah site would require the most energy because water would need to be pumped from the Roza Canal to fill the upper level of the reservoir. Both the Wenas sites and the gravel pits would be filled by gravity.

Utilities

The only known disruption to any existing or planned utility lines would be the required relocation of the Northwest Pipeline Company's high-pressure natural gas pipeline that runs diagonally across the approximate midway point of the Wenas Creek damsite.

Noise

Noise would be a consideration only during construction, and this would be at levels and durations normally associated with earthmoving activities. This impact would be expected to be most noticeable at the Wenas site and least noticeable at the gravel pit site.

Economics and Employment

Economic costs and benefits are discussed more completely in chapter 5. In terms of total annual cost only, the most expensive alternative would be Selah Creek. Wenas Creek and the gravel pits have about the same costs.

Impacts to tax rolls are not considered significant but would be expected to be slightly less in the case of the Selah Creek site because of the inclusion of some federal- and state-owned property.

Some temporary increase in employment would occur as a result of dam construction, but the impact on the local work force would be small.

Health

No health impacts are expected to occur, except the possibility of leachate from adjacent septic tanks entering the reservoir at Wenas Creek.

Light and Glare

No significant light or glare would occur from the projects.

ENVIRONMENTAL EVALUATION

The potential impacts at each site are presented in figure 6-1.

SITE	WILDLIFE AND VEGETATION	FISH	HYDROLOGY	GEOLOGY AND SOILS	WATER QUALITY	RECREATION	LAND OWNERSHIP	LAND USE	DWELLING UNITS/ BUSINESSES AFFECTED	ENERGY USE	ARCHEOLOGY/ HISTORY	AESTHETICS	UTILITIES	ECONOMICS/ EMPLOYMENT	DAM FAILURE
SELAH CREEK	Loss of habitat	Possible creation of lake fishery	Better flow control downstream Possible change in groundwater	Possible problem with dam leakage Elimination of valley topography	Possible increase in water temperature Possible increase in turbidity	Dependent on state management of reservoir	Nine landowners involved; 5 private, 4 public	Shift from marginal grazing to reservoir	No dwelling units dislocated	Requires some pumping to fill	Possible archeological significance (two sites at either end) No historical sites	Could improve view from Interstate 82		Highest annual cost (by a small margin) Some temporary local employment benefit	Moderate potential damage
WENAS CREEK	Loss of habitat	Loss of spawning habitat Possible creation of lake fishery	Better flow control downstream Possible change in groundwater	Elimination of valley topography	Possible increase in water temperature Possible increase in turbidity Possible effects on septic system drainfields (rise in water table)	Partial loss of stream fishery Dependent on state management of reservoir	Eleven landowners involved; all private	Shift from grazing and homesites to reservoir	Four dwelling units might be dislocated; other partial takes	Can be filled by gravity flow	Three archeological sites No historical sites	Loss of view up Wenas Valley	NW gas line crosses site	Some temporary local employment benefit	Highest potential damage
EAST SELAH GRAVEL PITS	Loss of riparian habitat	Temporary adverse impacts Expansion of fishing opportunities	Better flow control downstream Possible change in groundwater	Possible leakage through levee	Possible increase in water temperature Possible increase in turbidity	Temporary disturbance to existing fishing site Potential expansion of fishing	Five landowners involved; 4 private, 1 public	Land use basically (gravel mining) unchanged; larger water area	One dwelling unit dislocated; one partial take	Can be filled by gravity flow	No archeological or historical significance	No significant change		Some temporary local employment benefit	Least potential damage

PHYSICAL ENVIRONMENT (Wildlife and Vegetation through Water Quality) — SOCIOECONOMIC ENVIRONMENT (Recreation through Dam Failure)

NOTE:
No measurable long-term impacts on transportation, noise, light and glare, natural resources, air quality, public services and health

Figure 6—1

ENVIRONMENTAL IMPACT MATRIX