Yakima River Basin

Water Enhancement Project, Washington

Damsite and Structure Review Team Report

Bureau of Reclamation

Boise, Idaho

January 1984

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DAMSITE AND STRUCTURE REVIEW TEAM REPORT

YAKIMA RIVER BASIN

WATER ENHANCEMENT PROJECT, WASHINGTON

TRANSMITTAL

Organization of Team and Purpose of Report

The following report was prepared by the Damsite and Structure Review Team established to fulfill the requirements of reclamation Instructions, Part 133, which state in part that "As a part of the plan formulation process, a Damsite and Structure Review Team shall review damsites to be included in the feasibility report. The team will be composed of regional and project personnel, an earth dams designer, a concrete dams designer, and a geologist from the Engineering and Research Center."

A Damsite and Structure Review Team comprised of the following members was formed for this project:

John Doty	E&R Center	Western Geology Branch
Thomas Luebke	E&R Center	Embankment Dams Section
Harold Blair	E&R Center	Concrete Dams, Spillways, and Outlets Section
Dan Magleby	Regional Office	Geology Branch
Al Kennedy	Regional Office	Planning Engineering Branch
Gary Kitterman	Yakima River Basin	Civil Engineer (Study Team Leader)

Warren Dunkin, Plans Coordination and Engineering Branch, Division of Planning Technical Services, E&R Center, accompanied the team.

Travel period (dates): November 1, 1982, through November 8, 1982. E&R Center participants arrived Sunday evening, October 31, 1982, because commercial travel schedules into Yakima are limited.

Places or offices visited: Potential reservoir sites in the Yakima River basin and the Yakima Project Office.

Synopsis of Trip.--Regional and E&R Center personnel met in the conference room of the Yakima Project Office the morning of November 1, 1982. Also participating in the meeting were Steve Mitchell, Department of Ecology, State of Washington, and Onni Perala, Yakima Project Hydrologist.

Gary Kitterman, YRBWEP Study Team Leader, gave a brief history of the Yakima Project and explained the study team's report on Phase 1 of the YRBWEP feasibility study. This report identified 35 potential storage sites on the Yakima River basin. These sites were evaluated and the study recommended 11 sites for further detailed study which are scattered throughout the Yakima basin.

Onni Perala, Yakima Project Hydrologist, discussed the present operations of the Yakima project and explained the water shortages on presently irrigated lands in dry years.

The damsite review team then proceeded to inspect the 11 potential storage sites recommended for further detailed study. The purposes of the review were to:

1. Familiarize the DSRT and the D-700 coordinator with the potential reservoir sites

2. Provide the DSRT an opportunity to evaluate each site

3. Provide the DSRT an opportunity to discuss the data requirements and deficiencies related to site evaluations

4. Provide the DSRT an opportunity to divide up assignments for preparation of the team report

5. Make preliminary recommendations on the subsurface exploration program

6. Make recommendations for topographic and surface geologic mapping

Late Saturday afternoon, November 6, the DSRT returned to Wymer to look at the potential pumping plant site along the Yakima River. This was the last stop on the field inspection trips.

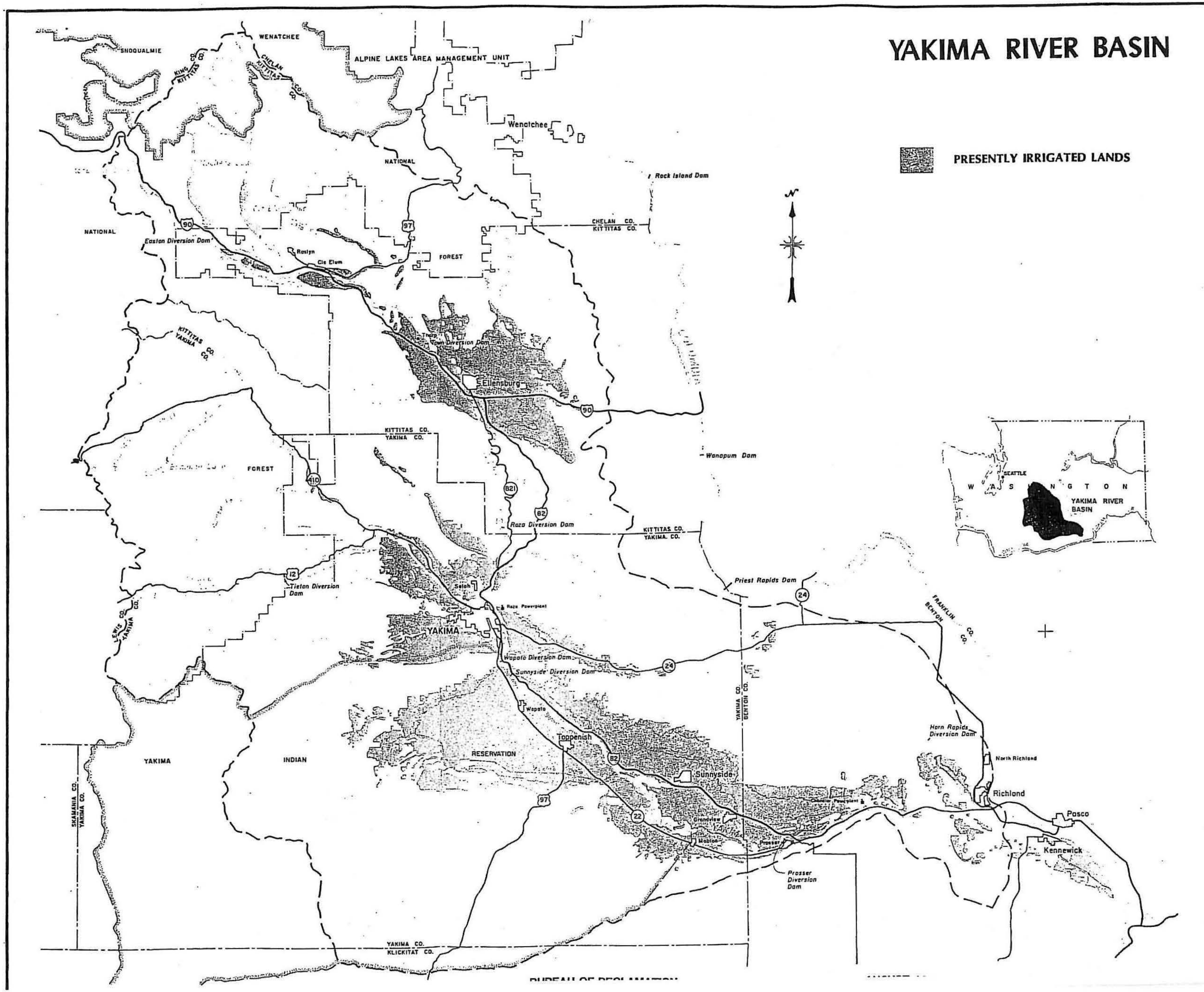
On Sunday, November 7, the DSRT met in the conference room of the Yakima Project Office to discuss the findings of the week's field inspection trips.

This report is a result of the Yakima River Basin Water Enhancement Project Damsite and Structure Review Team reviews.

SUMMARY AND CONCLUSIONS

All 11 sites were visited and following is the type of dam recommended for each site:

1. Bumping Lake Enlargement	Zoned earthfill embankment
2. Cle Elum Enlargement	Earthfill embankment and dikes
3. Devils Table	Eliminate, go to Mile 4 damsite
4. East Selah Reregulating Reservoir	Earth dikes
5. Forks	Earthfill embankment or RCC center section with zoned earthfill dikes


YAKIMA RIVER BASIN
PRESENTLY IRRIGATED LANDS
SNOQUALMIE
WENATCHEE
ALPINE LAKES AREA MANAGEMENT UNIT
Wenatchee
NATIONAL
Rock Island Dam
CHELAN CO.
KITTITAS CO.
Easton Diversion Dam
Roslyn
Cle Elum
FOREST
Town Diversion Dam
Ellensburg
KITTITAS CO.
YAKIMA CO.
Wanapum Dam
Roza Diversion Dam
Tieton Diversion Dam
Priest Rapids Dam
Selah
Roza Powerplant
YAKIMA
Wapato Diversion Dam
Sunnyside Diversion Dam
Wapato
Toppenish
RESERVATION
INDIAN
Sunnyside
Grandview
Mabton
Prosser
Prosser Diversion Dam
Horn Rapids Diversion Dam
North Richland
Richland
Pasco
Kennewick
FRANKLIN CO.
BENTON CO.
YAKIMA CO.
BENTON CO.
SKAMANIA CO.
YAKIMA CO.
KLICKITAT CO.
SEATTLE
WASHINGTON
YAKIMA RIVER BASIN

6.	Horsetail	Thin arch concrete dam and rockfill dike
7.	Tieton Enlargement	Rockfill embankment
8.	Wymer	Concrete-faced rockfill embankment
8a.	Wymer Afterbay	Same as Wymer
9.	Satus	Zoned earthfill or RCC
10.	Simcoe	Zoned earthfill
11.	Tampico	Zoned earthfill or RCC

There are many options for outlet structures and spillway structures, and these options are explained in the report.

CONCURRENCE

This report was prepared in the Planning Branch of the Regional Office under the direction of the damsite review team leader. A copy was sent to each member of the review team and their comments have been incorporated into the final report.

The continuation of planning and design of selected projected features will be in accordance with the findings, procedures, and conclusions contained in this report.

L.W. Lloyd
Regional Director
Pacific Northwest Region

Assistant Commissioner
Engineering and Research

Date

10-15-84
Date

PURPOSE AND AUTHORITY

The purpose of the YRBWEP feasibility study is to ascertain if there are means to alleviate problems and provide for needs related to water resource development and use in the Yakima River basin. The primary objectives of the study are to (1) provide supplemental water to presently irrigated lands, (2) provide water to new lands on the Yakima Indian Reservation, (3) provide water for increased instream flows for aquatic life, and (4) develop a comprehensive plan for the basin to enable efficient management of the existing water supplies. A secondary set of objectives exists which would be addressed only if there are no conflicts with the primary objectives. Secondary objectives include increased hydroelectric power generation, improved municipal and industrial water supplies, new irrigation on non-reservation lands, improved flood control, enhanced water quality, enhanced wildlife, and increased recreational opportunities. If an acceptable plan meeting these objectives can be put together, a recommendation would be made to Congress and to the state legislature to take actions necessary to implement the plan.

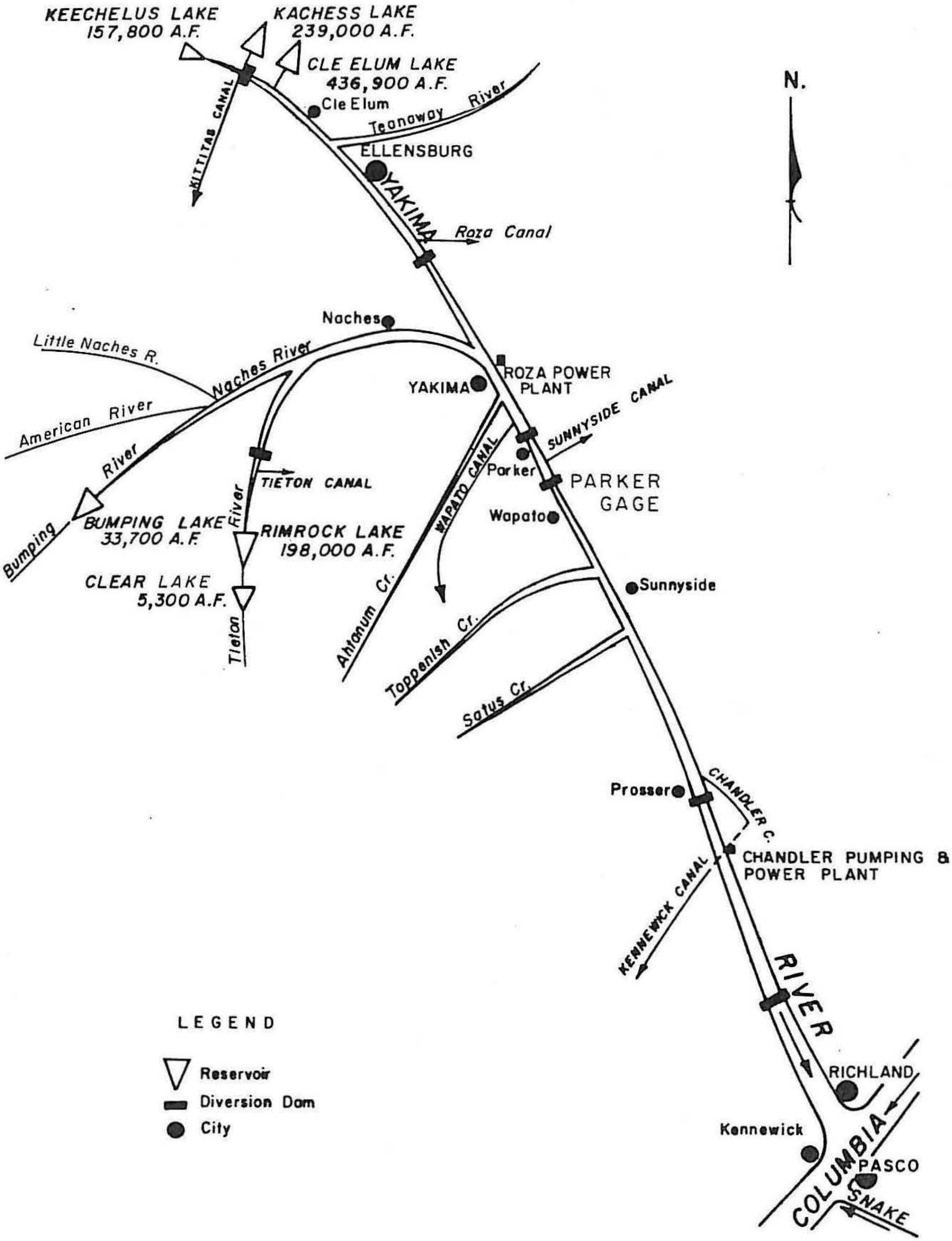
LOCATION

The Yakima River basin, located in south-central Washington, covers an area of about 6,000 square miles or about 4 million acres. The basin centers around the city of Yakima and includes most of Yakima, Kittitas, and Benton Counties. Topography is characterized by a series of long, rather hilly ridges extending eastward from the Cascades and encircling flat valley areas. Elevations in the basin range from over 12,000 feet in the Cascades to about 350 feet at the confluence of the Yakima and Columbia Rivers.

The Yakima River and its tributaries drain the area. The Yakima River heads near the crest of the Cascade Range, above Keechelus Lake at elevation 2517 and flows for 175 miles generally southeastward to its confluence with the Columbia River near Richland. Major tributaries include the Kachess, Cle Elum, and Teanaway Rivers in the north and the Naches River, which has two major tributaries--Bumping and Tieton Rivers. Ahtanum, Toppenish, and Satus Creeks join the river in the lower portion of the basin. Natural runoff for the basin above Parker averaged about 3.5 million acre-feet annually over the period 1940-76. Natural runoff usually peaks May and June and drops to its lowest point in August.

The Yakima Project is primarily an irrigation project with hydroelectric power generation, an associated function. Project reservoirs do provide incidental flood control and recreation benefits, and project operation does provide some flows for fish.

The water supply for the Yakima Project comes from natural flow, storage, and return flows. The six Federal reservoirs in the basin which help regulate this supply have a total storage capacity of 1,070,000 acre-feet--Bumping Lake (33,700 acre-feet), Keechelus Lake (157,800 acre-feet), Kachess Lake (239,000 acre-feet), Cle Elum Lake (436,900 acre-feet), Rimrock Lake (198,000 acre-feet), and Clear Lake (5,300 acre-feet). Other principal



SCHEMATIC
YAKIMA RIVER BASIN

Bureau of Reclamation

August 1982

features include several diversion dams, two hydroelectric generating plants, canals, laterals, and pumping plants. The Yakima River basin schematic shows the major tributaries and diversions.

About three-fourths of the present storage capacity of the Yakima basin is in the upper Yakima drainage (Lakes Keechelus, Kachess, and Cle Elum). One-fourth of the storage capacity occurs in the upper Naches drainage (Bumping, Clear, and Rimrock Lakes). Upper Yakima reservoirs meet water supply needs in the valley above the Yakima-Naches Rivers confluence and are the main suppliers of storage water to the large irrigation districts in the lower valley. The upper Naches reservoirs provide storage releases to irrigation development in the lower Naches Valley and make a small contribution to the irrigation developments in the lower Yakima Valley. Return flows from irrigation developments in the upper valley are major contributors to some lower valley irrigators.

The six project reservoirs are the key to the regulation and utilization of the Yakima basin water supply. Operation of these reservoirs provides the control necessary to meet the basin's irrigation needs by the storage of winter and spring runoffs for subsequent use during the months of July, August, and September when natural runoff is low and irrigation demands are high. The carryover of water supplies in storage from one irrigation season to the next is an essential ingredient in assuring a continued supply in water-deficient years.

The 1945 Consent Decree provides for the allocation of the available water supply in the Yakima Valley to meet the irrigation needs of the parties to the decree. In years of sufficient water supply, it is not necessary to apply the provisions of the decree since there is adequate water to meet the needs of all parties; in water-deficient years the decree is the essential tool in distributing the available water supply. The available water supply for purposes of the decree is defined as the natural flows, stored waters, and return flows. Some of the parties to the decree hold what are referred to as nonproratable rights, others hold proratable rights, and others have a combination of these rights. Under the decree, any deficiency in the available water supply is first assessed against the proratable rights. The amount of water which the holders of proratable rights will receive is thus variable, depending upon the type of water year, while the holders of nonproratable rights receive a consistently firm supply unless the total available supply is not sufficient to satisfy even the nonproratable rights, in which event they too would have less than a full water supply.

In recent years, the Federal Court has ordered instream flows in specific river reaches to protect anadromous fish spawning and rearing. These orders are considered to be an interim action until a more permanent solution is reached. An annual operating plan is developed each year to meet project authorizations and institutional constraints. Some annual changes or modifications based on court or informal agreements are expected to continue in the absence of adjudication or other solutions.

PROBLEMS AND ISSUES

The problems and issues addressed in this study were identified from previous studies, reviewed in newsletters sent to the public, and confirmed at public meetings and by written comments in response to newsletters. Additional detail and quantification of needs were obtained through discussions with basin residents; contact with appropriate Federal, state, and local agencies; and limited fieldwork.

Water Shortage on Presently Irrigated Lands

At present, about 550,000 acres of land are irrigated in the Yakima River basin. Of this total irrigated acreage, about 190,000 acres with proratable water rights and about 20,000 acres of other lands are short of water in varying degrees during dry periods.

The estimate of the need for supplemental irrigation is dependent on the definition of a full-water supply and what shortages would be acceptable. In Phase 1, the full-water supply is defined as the existing or recognized entitlements and water rights in the basin. The State of Washington is at present conducting an adjudication of water rights and may adjudicate water on the basis of beneficial use. In some cases, there is indication that existing entitlements exceed beneficial use. If so, the adjudicated water rights in the future could be less than existing entitlements. The acceptable shortage definition used for Phase 1 is based on what would be economically tolerable for general crops. The Yakima basin, however, includes many specialty crops, so if Phase 2 is initiated, a detailed examination would be made to determine economically tolerable shortages based on actual cropping patterns.

On the basis of the foregoing definitions, it was determined that there is a need for an estimated 150,000 to 200,000 acre-feet of storage to reduce shortages to an acceptable level. A change in these definitions is likely and could lead to a greatly altered estimate of the need for supplemental irrigation water.

New Irrigation Development on the Yakima Indian Reservation

The Yakima Indian Nation is interested in protecting its claims to diversionary water rights and developing new irrigation on the Yakima Indian Reservation. Development of about 36,000 acres is being considered in this study, of which some 24,000 acres are presently drylands. An estimated 200,000 acre-feet of storage would be needed to meet these demands.

Anadromous Fish

Anadromous fish populations in the Yakima basin have declined. Today, annual spawning runs, including spring chinook, fall chinook, coho salmon, and steelhead trout, are estimated at 2,000 fish. Steel head trout account for about one-half the population, spring chinook account for about one-fourth the population, and the remainder is composed of fall chinook and coho salmon. The primary reasons for the decline and continued low populations are inadequate instream flows at times and excessive flows at other times in the Yakima River and tributaries. Minimum and optimum instream flow needs for fishery enhancement were identified for various stream reaches. These preliminary recommendations were developed in cooperation with Federal and state fish and wildlife agencies and are based on existing data and professional judgments. The daily average minimum and optimum flow recommendations for various stream reaches are shown in table 1.

Table 1.--Recommended Daily Average Minimum and Optimum Instream Flows (Listed in Approximate Order Going Downstream)

Stream Reach	Minimum Flow	Optimum Flow
	ft³/s	*ft³/s*
Yakima River near Martin	50	100
Kachess River near Easton	30	90
Yakima River near Easton	150	285
Cle Elum River near Roslyn	95	280
Teanaway River below Forks 1/	65	125
Yakima River at Cle Elum	210 2/	625
Yakima River near Umtanum	250	730
Bumping River 1/	60 3/	120 3/
Little Naches River 1/	30	90
Rattlesnake Creek 1/	15	45
Naches River above Tieton River Confluence	120	365
Tieton River below Tieton Diversion Dam	55	170
Naches River below Tieton River Confluence	180	530
Yakima River at Parker	400	1,355
Yakima River at Prosser	560	1,680
Yakima River at Kiona	560 4/	1,680

1/ Can be provided only if storage is constructed on the drainage.
2/ 400 ft³/s from October 15 to March 1.
3/ Without enlargement of Bumping Lake the flows would be 30 ft³/s minimum and 90 ft³/s optimum.
4/ From April 15 to June 30 and October 1 to November 15, the minimum flow would be 1,200 ft³/s.

The storage required to meet the minimum recommendations totals 300,000 acre-feet. Approximately 450,000 acre-feet of storage could provide instream flows midway between minimum and optimum recommendations for about three-fourths of the time. The amount of storage needed to provide flows midway between minimums and optimums all the time or for optimum flows all the time would be much greater and was not calculated.

Other problems include high fishing pressure; poor, lacking, or improperly maintained fish passage facilities; and unscreened or inadequately screened diversions. If minimum instream flow needs and adequate fish passage and protective facility needs are met in the basin, it is estimated that an annual spawning run of 68,000 fish could be realized. Spawning runs of about 100,000 could be expected if enhanced flows (flows midway between recommended minimums and maximums for about three-fourths of the time) were substituted for minimum flows. Annual addition of about 715,000 pounds of hatchery produced smolts to the Yakima River system combined with enhanced flows and fish passage facilities would provide a potential spawning run of 138,000 fish. Total harvest including sport, Indian, and commercial fisheries would be 2.6 million pounds for 68,000 spawners, 3.7 million pounds for 100,000 spawners, and 5.1 million pounds for 138,000 spawners.

Resident Fishery

The resident fishery of the basin generally is considered poor. Present conditions are largely the result of inadequate instream flows to maintain game fish and aquatic invertebrate populations. Other factors include large fluctuations of flows below reservoirs and diversions, very low drafts and lack of minimum pools in some reservoirs, degraded water quality, and unscreened diversions.

Hydroelectric Power

Although projections of the growth rate in electric power demand have declined, power deficits continue to be predicted for the Pacific Northwest power system in 1990's and beyond. Also, power self-sufficiency continues to be a national objective. A need exists to develop renewable resource power facilities, such as hydroelectric powerplants, especially where environmental effects would be minimal.

Municipal and Industrial Water Supplies

Water supplies for all communities in the basin, except for the city of Yakima, are considered adequate for the present and estimated future expansions. In Yakima, the existing supply is considered adequate to meet a present average daily demand of 9,960,000 gallons but too small to meet future growth. By 1990, municipal and industrial requirements of Yakima are expected to surpass the existing supply and capacity of the system. The increase in average daily water use above 1980 levels is projected to be 1,100,000 gallons in 1990, 2,440,000 gallons in 2000, and 4,520,000 gallons in 2010. An additional water supply of about 3,400,000 gallons per day would be needed to meet 2010 needs.

During low flow periods, the city of Yakima is unable to divert its full water right because of physical limitations. This problem can be solved by maintaining sufficient instream flows for use of present facilities or by redesigning new facilities capable of diverting the full water right at lower flows.

Flood Control

Average annual flood damages in the Yakima basin are estimated by the Corps of Engineers at $3,888,000 and occur primarily in the low-lying lands below Yakima (see table 2). Cost-effective methods of reducing flood losses are needed.

Table 2.--Average Annual Flood Damages Anticipated in the Yakima River Basin

River Reach	Damages
	dollars
Easton to Thrall (Ellensburg)	192,000
Thrall to Selah Gap (Selah)	28,000
Selah Gap to Union Gap (Yakima, Union Gap)	2,220,000
Union Gap to Mabton	640,000
Mabton to Columbia River (Benton City, Richland, and West Richland)	112,000
Teanaway River Valley	132,000
Naches River Valley	282,000
Ahtanum Creek Valley	42,000
Toppenish Creek Valley	120,000
Satus Creek Valley	120,000
Total	3,888,000

Water Quality

Water quality in the lower reaches of the Yakima River and tributaries is severely degraded. Standards set for acceptable levels of fecal coliform, temperature, turbidity, nitrates, and orthophosphates are exceeded at times in all reaches of the river below the towns of Cle Elum and Naches. The most severely affected reaches are below Sunnyside Dam where recommendations and standards on dissolved oxygen, nitrites, and ammonia concentrations cannot be met. Nonpoint source pollution appears to be the major factor causing reduced water quality.

There is a need to improve agricultural practices and water management to reduce pollution from agricultural sources. In addition, the treatment plants at Prosser, Snoqualmie Pass, West Richland, Ronald, and Roslyn need to to be improved to meet 1983 effluent limitations.

Wildlife

The most significant wildlife problem is the loss of habitat. While irrigation originally increased habitat for pheasants and Hungarian partridges and some other species, urban and suburban growth and intensive farming practices have reduced the amount and value of that habitat. Also, improvements in irrigation systems in recent years which are intended to conserve water have further depleted habitat by reducing canal seepage and waste water that supported riparian vegetation. Large canals can also affect wildlife by blocking migration. Attempts to cross canals can result in injury or death of the animals.

In addition to these general problems, the water supply for the Toppenish National Wildlife Refuge is inadequate and needs to be supplemented.

The primary need in the basin is to protect and preserve existing wildlife habitat. Also, enhancement of existing habitat where possible would be desirable.

Recreation

Although the recreational resources of the Yakima basin are extensive, the demands on the resource are also large because of proximity to the Puget Sound metropolitan area. Projections show recreation demand will increase 28 percent in the next 20 years. A demand of this magnitude would indicate a need for a substantial increase in campsites, picnic tables, and boat launch lanes.

New Irrigation Development of Nonreservation Lands

An extension of the existing Kennewick Division has been identified as a potential for new land development. The Kennewick Irrigation District is independently studying the development of lands located between Benton City and Richland.

There are other tracts throughout the basin that may have irrigation development potential, but their scattered nature and location makes many of these lands unsuitable for project-type development because of water supply and economic considerations. The need for new irrigation off the Yakima Indian Reservation would be further evaluated if Phase 2 proceeds.

RESOURCE CAPABILITY

With existing water resource development, operated under present institutional constraints, irrigation needs of the basin cannot be fully met about 30 percent of the time, and instream flows for fish are inadequate in some reaches in most years. In good water years, the water supply with present development is sufficient for most if not all irrigation and instream flow needs. In drier years, present storage is inadequate to provide the needs of those with proratable rights, and streamflows in many reaches fall below recommended minimum levels. During the driest years, or during a series of dry years, water supply becomes critical because the basin reservoirs provide very little carryover storage from one year to the next.

Conservation measures including lining canals, addition of control structures, and onfarm improvements could reduce shortages for irrigators and could also improve water supplies for instream flows. Institutional changes, including adjudication or reallocation of water supplies, could also help. However, improving resource use through conservation measures and institutional changes would not meet all irrigation and instream flow needs with the present level of storage development.

The undeveloped water resources of the basin, if developed, appear capable of meeting all existing and future needs. Use of the undeveloped resource requires development of additional storage to control runoff and provide carryover for dry years. To meet all irrigation and instream flow needs, additional storage would need to be developed in the upper Naches River drainage. A minimum of 450,000 acre-feet of storage would be needed to meet supplemental irrigation needs and minimum instream flow recommendations--150,000 acre-feet for irrigation, and 300,000 acre-feet for instream flows. An additional 150,000 acre-feet for a total of 600,000 acre-feet would be needed to meet supplemental irrigation needs and provide enhanced flows for fish (midway between minimums and optimums for about three-fourths of the time). Greater operational flexibility would be achieved if more than one new reservoir was developed and if part of the new storage was located on the upper Yakima River drainage.

The total amount of storage needed to meet supplemental irrigation and instream flow objectives could be reduced by 50,000 to 60,000 acre-feet if the East Selah reregulating reservoir was constructed. The total storage need could be reduced an additional 60,000 to 80,000 acre-feet if water conservation measures were instituted that would improve irrigation efficiency by 4 percentage points.

New irrigation development on the Yakima Indian Reservation could be served from storage developed in any part of the basin upstream from the reservation or by development of storage on the reservation. On the basis of economics and the physical position of reservation lands in relation to water courses, development of water supplies on the reservation would be preferable. Development of about 200,000 acre-feet of storage within the reservation would provide an adequate supply for about 36,000 acres. The potential for ground-water development to meet irrigation needs on the reservation is limited and is not capable of meeting the needs entirely. Integrated use of ground water and storage would increase the amount of land that could be served from reservation resources. Development of new irrigation on the reservation would not conflict with other study objectives related to instream flow improvement and supplemental irrigation water.

MEASURES TO MEET NEEDS

Identification

A variety of potential measures were identified including storage and stream reregulating reservoirs, facilities such as fish screens and ladders, instream flow improvements, recreation facilities, water conservation measures, and other measures to improve efficiency of water use and control. These potential measures were identified from previous studies and through public participatiuon in the study process. A list of potential measures including 35 storage sites was eventually compiled.

Because the list of potential storage sites was large and many of the sites appeared to lack real potential, a two-step screening process was used to evaluate the sites and eliminate those with the least potential for development. In the first step of the process, sites were screened on the basis of four evaluation factors--(1) economic aspects, (2) legal/institutional aspects, (3) social aspects, and (4) environmental aspects. Potential storage sites not compatible with these evaluation factors were discarded.

In the second step, storage sites that were considered to be alternatives were arrayed together and ranked. The highest ranked alternative site was kept and the other alternatives discarded. Eleven sites remained after the screening process was completed.

A further evaluation of storage sites and other potential plan elements was made following public workshops. Five sample plans were developed to be presented to the public for comment on the potential plan elements and means of meeting basin needs. The five plans were formulated so that accomplishments related to supplemental irrigation, new irrigation, and fish enhancement would be nearly the same for each; instream flows and hydropower generation of one plan were considerably less than for the other four plans. The primary difference among the plans was the way supplemental irrigation water supply needs would be met. In four of the plans, supplemental irrigation needs would be met through various combinations of new storage using 9 of 11 sites that emerged from the screening process. The fifth plan would use water conservation measures and various nonstructural means to meet some of the supplemental irrigation needs. These plans were presented at public workshops held in Ellensburg, Yakima, and Prosser, Washington.

As a result of public expressions during and following the workshops, one storage site was eliminated, and one site discarded if the screening process was reinstated. Table 3 shows the storage sites that were eliminated from further consideration and the reason for elimination.

Table 3.--Potential Storage Sites Discarded During Phase 1

Name	Stream	Reason for Elimination
Bakeoven	South Fork Tieton River	Cost
Casland	North Fork Teanaway River	Cost
Cooper Lake	Cooper River	Cost, wilderness impacts
Cowiche	South Fork Cowiche Creek	Cost
Dog Lake	Clear Creek	Cost
Hole in the Wall	Dry Creek	Cost
Horseshoe Bend	Naches River	Cost, geological problems, anadromous fish passage problem
Hyas Lake	Cle Elum River	Cost, wilderness impacts
Little Rattler	Rattlesnake Creek	Cost, inundates big game winter range and resident fishery
Lost Meadow	Little Naches River	Cost
Lower Canyon	Yakima River	Cost, anadromous fish passage problem
Manastash	Manastash Creek	Cost
Mile Four	Rattlesnake Creek	Inundates big game winter range and resident fishery
Minnie Meadows	South Fork Tieton River	Cost
Naneum	Naneum Creek	Cost
Pleasant Valley	American River	Inundates anadromous fish habitat, recreation area loss
Rattlesnake	Naches River	Anadromous fish passage problem, social effects problem
Soda Springs	Bumping River	Alternative to Bumping Lake enlargement
Swauk	Swauk Creek	Wildlife impacts
Toppenish	Toppenish Creek	Cost
Upper Canyon	Yakima River	Anadromous fish passage problem
Wapatox	Naches River	Anadromous fish passage problem
Waptus Lake	Waptus River	Cost, wilderness impacts
Wenas	Wenas Creek	Under construction

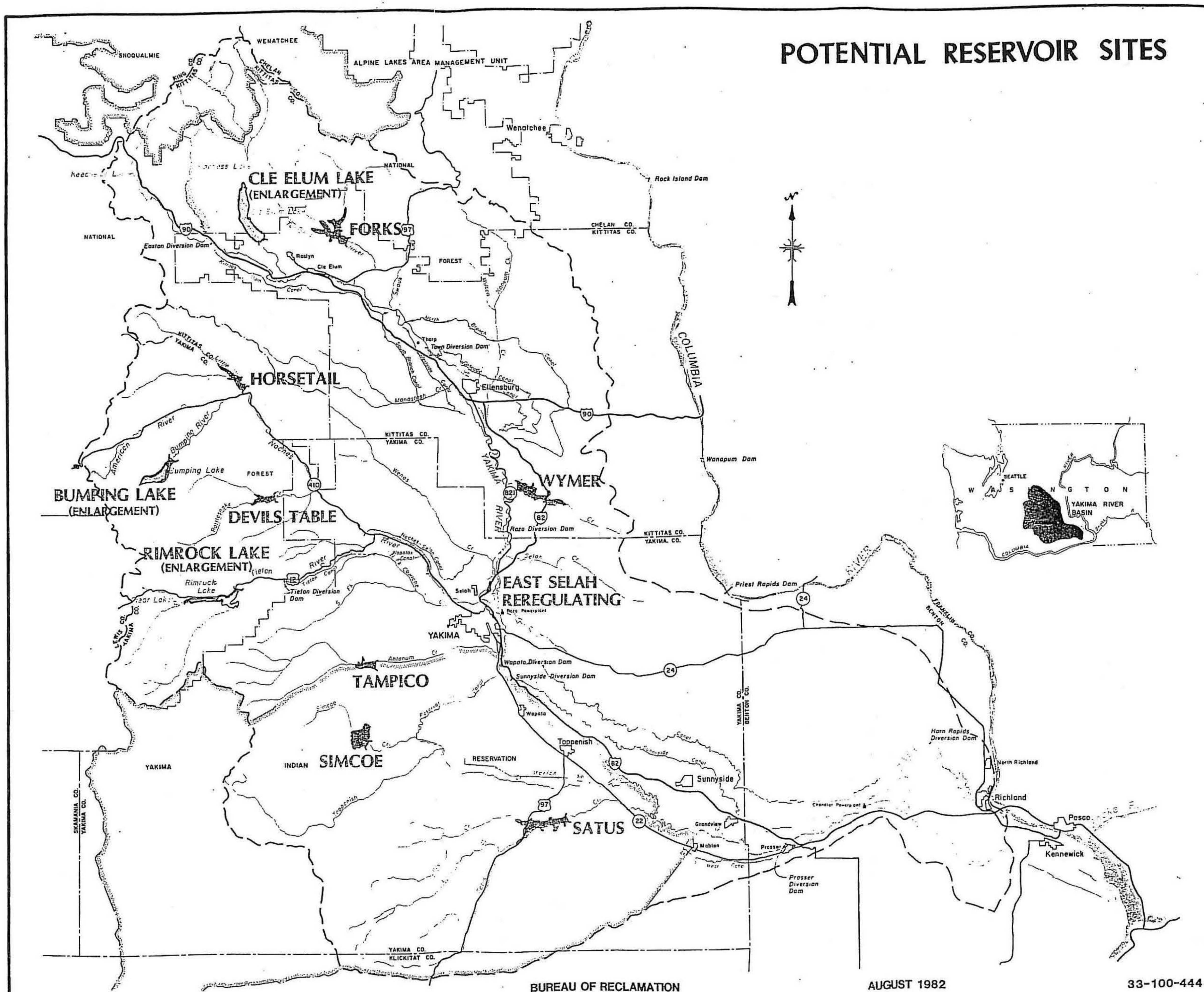
The potential plan elements including 11 storage sites proposed by the study team for further consideration and evaluation if Phase 2 studies are initiated, are listed in table 4. Some of the plan elements listed in table 4 could be eliminated and other elements identified in Phase 2.

Table 4.--Potential Plan Elements for Consideration in Phase 2

Plan Elements
Reservoirs
Bumping Lake enlargement
Cle Elum Lake enlargement
Devil's Table
East Selah reregulating
Forks
Horsetail
Rimrock Lake enlargement
Satus
Simcoe
Tampico
Wymer
Hydroelectric powerplants
Water conservation measures
Reallocation of water
Waterbank
Irrigation facilities
Fish passage and protective facilities
Fish hatchery
Wildlife protective and enhancement measures
Recreation facilities
Flood control measures
Municipal and industrial water supply
Water quality improvement
Water management plan

Reservoirs and Hydroelectric Powerplants

The 11 reservoir sites identified for further detailed study are scattered throughout the Yakima basin (see Potential Reservoir Sites map). Four sites (Bumping Lake and Rimrock Lake enlargements and Devil's Table and Horsetail Reservoirs) are located in the Naches River drainage, three sites (Cle Elum Lake Enlargement and Forks and Wymer Reservoirs) are located in the upper Yakima River drainage, three sites (Satus, Simcoe, and Tampico Reservoirs) are located on the Yakima Indian Reservation, and the single reregulating site is located near Yakima (see East Selah Reregulating Reservoir map). Hydroelectric generation facilities are included at all sites except East Selah reregulating, Satus, and Tampico. Hydrologic data including hydroelectric potential at the 11 reservoir sites are shown in table 5. Specific functions were not identified with individual reservoirs, as any reservoir added to the Yakima system would be operated as an integrated facility with the existing reservoir system to accomplish project objectives.



POTENTIAL RESERVOIR SITES
CLE ELUM LAKE (ENLARGEMENT)
FORKS
HORSETAIL
BUMPING LAKE (ENLARGEMENT)
DEVILS TABLE
RIMROCK LAKE (ENLARGEMENT)
WYMER
EAST SELAH REREGULATING
TAMPICO
SIMCOE
SATUS
ALPINE LAKES AREA MANAGEMENT UNIT
Wenatchee
Rock Island Dam
Easton Diversion Dam
Roslyn
Cle Elum
Ellensburg
Wanapum Dam
Roza Diversion Dam
Priest Rapids Dam
Selah
Yakima
Wapato Diversion Dam
Sunnyside Diversion Dam
Wapato
Toppenish
Sunnyside
Grandview
Mabton
Prosser
Prosser Diversion Dam
Horn Rapids Diversion Dam
North Richland
Richland
Pasco
Kennewick
COLUMBIA
YAKIMA RIVER BASIN
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AUGUST 1982
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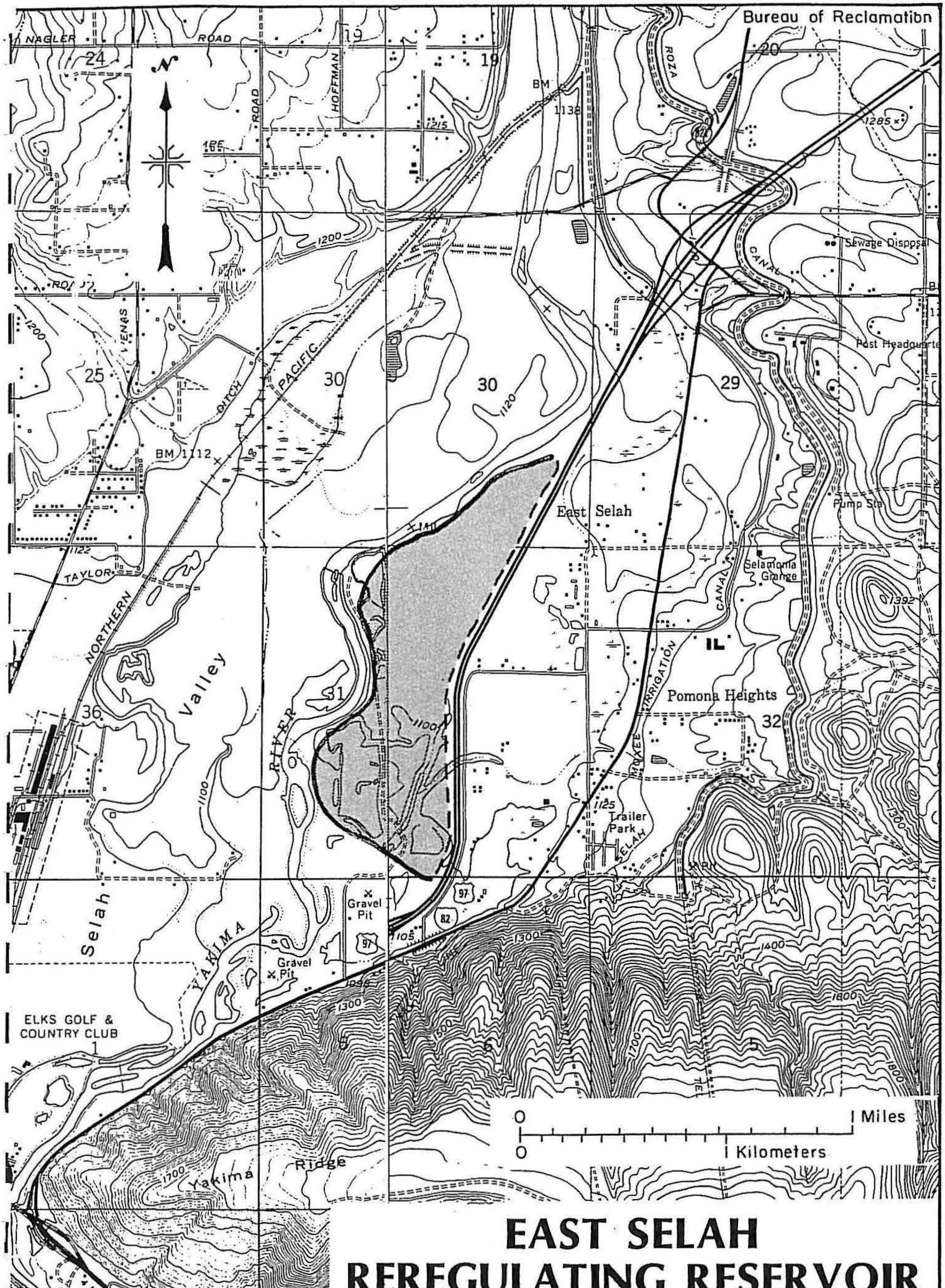

EAST SELAH
REREGULATING RESERVOIR

Table 5.--Hydrologic and Hydroelectric Power Data for Potential Reservoirs

Reservoir	Water Source	Maximum Storage Capacity	Average Annual Runoff	Power-plant Capacity	Hydro-electric Power
		acre-feet	*acre-feet*	*kilowatts*	*average annual kilowatt-hours*
Bumping Lake Enlargement	Bumping River	458,000 (424,000 new)	213,000	6,000	23,000,000
Cle Elum Lake Enlargement	Cle Elum River	482,000 (45,000 new)	680,000	18,000	49,100,000
Devil's Table	Rattlesnake Creek	50,000	69,000	3,200	12,100,000
East Selah Reregulating	Yakima River	3,000 (offstream)	Not Applicable	None	Not Applicable
Forks	Teanaway River	400,000	260,000	10,800	40,700,000
Horsetail	Little Naches River	143,000	177,000	7,400	27,600,000
Rimrock Lake Enlargement	Tieton River	220,000 (22,000 new)	370,000	19,000	51,700,000
Satus	Satus Creek	80,000	105,000	None	--
Simcoe	Simcoe Creek Toppenish Creek	80,000	21,000 39,000	1,780	6,300,000
Tampico	Ahtanum Creek	55,000	65,000	None	--
Wymer	Squaw Creek Yakima River	300,000	25,000 100,000	21,000 1/	67,800.000 2/

1/ Includes two powerplants, a 16,800-kW plant at Wymer Dam, and a 4,200-kW plant in the carriage system at potential Manastash tunnel.

2/ Net power production is 34,800,000 kWh; about 33,000,000 kWh would be required to operate Swauk pump used to fill Wymer Reservoir.

PROJECT AREA

Regional geology and seismicity are discussed in this section because of their possible impact on design. Environmental considerations and topography are more site specific and will be discussed in a subsequent section addressing sites examined.

Regional Geology

The Yakima River Basin is situated astride Yakima Fold Belt Subprovince of the Columbia Plateau Physiographic Province; and immediately to the west, the Northern and Middle Cascades Subprovinces of the Cascade Range Physiographic Province. The Cascade Range Physiographic Province defines the region of tectonic uplift forming the Cascade Mountain Range.

The Yakima Fold Belt Subprovince is characterized by a series of folds that extend eastward through the Yakima River Basin from the eastern flank of the Cascade Range. The folds dissect the basin into a number of subparallel anticlinal ridges and synclinal subbasins developed by the crustal stresses associated with the tectonism in the birth of the Cascade Range.

Prior to development of the folding and associated faulting, large voluminous floodflows of basalt erupted from fissure systems tens of miles long and covered 55,000 square miles of Washington and Oregon to form what is known as the Columbia Plateau Physiographic Province.

The Yakima Basalt Subgroup, the most recent flood basalt flows collectively termed the Columbia River Group, occurred during the Middle and Upper Miocene Epoch. This subgroup covered the area of the Yakima River basin in its entirety. The thickness of the Yakima Basalt Subgroup has been found to reach 3,000 feet in some areas of the Yakima Fold Belt Subprovince. This basalt Subgroup has been studied sufficiently enough to classify the basalt flows into the following three formations (from youngest to oldest): The Saddle Mountains Basalt Formation with 10 distinguishable members, the Wanapum Basalt Formation with 4 distinguishable members, and the Grande Ronde Basalt.

As the period of floodflows was coming to an end and development of the subparallel anticlinal ridges and synclinal subbasins was nearly completed, pyroclastic and sedimentary deposits from the Cascade Range began accumulating in the depressions of lakes and streambeds. These deposits of clay, silt, sand, and gravel were deposited during the Pliocene Epoch and have since been classified as the Ellensburg Formation. Much of this material was deposited before the close of the basalt outpourings as these sedimentary units conformably underlies, overlies, and intertongues with the upper members of the Saddle Mountains Basalt Formation. Deposition of this material was also large and extensive as thicknesses of the Ellensburg Formation have been found to exceed 1,500 feet as deposited in some synclinal subbasins.

More recent deposits of the Pleistocene period have been identified as fluvial, lacustrine, and eolian deposits indicative of a time when molding of the terrain features was dominated by glacial activity. Holocene alluvial deposits are products of the earlier glacial activity (e.g., stream reworking of glacial moraine and glacial outwash) coupled with more recent stream activity which is continuing to the present day.

Four sites believed to rest within the boundary of the Cascade Range Physiographic Province are Cle Elum, Forks damsite, Bumping Lake, and Tieton Dam. The terrain has been strongly influenced by glaciation. Considerable quantities of alluvium and glacial outwash overlie the bedrock in the valley sections. The abutments at most sites are commonly underlain by basalt.

The terrain features of the damsites studies in the Yakima Fold Belt Subprovince is the end result of what has occurred in geologic history; the folding and associated faulting; floodflows of the Yakima Basalt Subgroup, and the sedimentary deposition of the Ellensberg Formation.

The damsites which have been subjected to these features throughout Geologic time include Horsetail, Devils Table, Wymer, Tampico, Simcoe, and Satus damsites.

Even though it can be concluded that these features are identifiable in respect to each site, the examination and identification of these features have been limited to a cursory review of their presence and their influence on the feasibility of each site as an acceptable location for a dam and reservoir.

Seismicity

The Yakima Basin is located within Zone II on Algermissen's Seismic Risk Map. The western border of the basin is near the boundary with Zone III. Zone II corresponds to expected "Moderate" damage (coeff. of 0.05) and Zone III corresponds to "major" damage (coeff. 0.10).

No site-specific seismotectonic studies have been made for the individual damsites in the Yakima Basin. However, considerable information has been assembled by the Washington Public Power, in their nuclear powerplant siting studies, that can be used for background information for any site-specific studies. This background information includes:

1. Geologic mapping of the basin with detailed studies of the major fault systems.

2. Research of all past reports and recordings of earthquakes.

3. Monitoring and interpretation of a large seismograph network.

At the present time, there are no recognized serious seismic hazards that would preclude further studies of any of the damsites.

It is recommended, in the preconstruction stage, that a seismotectonic study be made of each considered damsite in the study.

A study should also be made of the potential hazards from possible volcanic eruptions. Since some of the damsites are near volcanic eruption centers having historic records of activity, the study should involve the problems of lava flows as well as ash flows and ash falls.

SITES EXAMINED

The 11 reservoir sites identified for further detailed study as previously described (MEASURES TO MEET NEEDS, Reservoirs and Hydroelectric Powerplants) were examined by the Damsite and Structure Review Team from November 1, 1982, through November 6, 1982. A discussion of each of the sites follows.

BUMPING LAKE ENLARGEMENT

Introduction

Bumping Lake enlargement was visited Thursday morning, November 4. The weather was miserable--rain, snow, and sleet with temperatures in the 30's. The DSRT visited this site Thursday morning, November 4, 1982.

Description

The site for the enlarged dam is on Bumping River about 4,500 feet downstream from existing Bumping Lake Dam and about 60 miles via paved highway northwest of the city of Yakima, Washington. The dam would be a rolled earthfill structure with a maximum height above streambed ranging from 154 to 223 feet and a crest length ranging from 3,058 to 3,300 feet.

A concrete chute-type spillway with a capacity of about 36,030 cubic feet per second (ft^3/s) would be constructed on the left abutment. The spillway, in combination with a reservoir surcharge storage ranging from 20,000 to 26,900 acre-feet and an outlet works capacity of 3,470 ft^3/s, is provided to protect against the routed inflow design flood which has a peak discharge of 39,500 ft^3/s and a 5-day volume of 131,000 acre-feet. Controlled releases of water from the reservoir would be through outlet works located in the left abutment of the dam. Dam maintenance facilities consisting of a combination garage-maintenance building would be on the left abutment above the spillway. A roadway along the crest of the dam and a bridge across the spillway would provide access to the right abutment for operation and maintenance purposes. As safety measures, the spillway structure would be fenced, and the outlet works would not be accessible.

The final design of the dam which would be made during advance planning studies would be modified to include means to provide minimum continuing flow to sustain fish life during a closure. Also, any closure of the dam would be coordinated with the Washington Department of Ecology, Department of Game, and other appropriate agencies to minimize any adverse effects on the resident fishery and anadromous fish runs.

Bumping Lake Reservoir

Bumping Lake Reservoir would be enlarged to a capacity of 458,000 acre-feet at elevation 3560 as compared to the present capacity of 33,700 acre-feet at elevation 3426. The present dam would be breached following construction to insure full use of the existing pool.

The enlarged reservoir, with a total capacity of 458,000 acre-feet, has a very low ratio of inflow to capacity. Refill after severe droughts may take several years with low water levels during that period. The added storage would have to be treated as long-term carryover storage because of the poor refill capability and as such would only be used during drought conditions. Even with a smaller Bumping Lake enlargement (250,000 total acre-feet), the refill capacity would not be as good as Cle Elum Lake enlargement, Horsetail, Devil's Table, or Tieton enlargement. The location is excellent within the basin. The upper Naches requires additional storage or the presently recommended instream flows cannot be met except in good runoff years.

The enlarged reservoir would inundate 4,120 acres of land, of which 1,300 acres are in the existing reservoir and 2,820 acres would be newly inundated. The new reservoir would have about 17 miles of shoreline, an increase of about 7 miles over the existing reservoir. All required right-of-way is within the Snoqualmie National Forest. The present reservoir and a substantial part of the area needed for enlargement are national forest lands under Reclamation withdrawal, and the additional lands needed for the enlarged lake would be placed under Reclamation withdrawal.

Stumps would be removed from the existing pool and timber, including stumps, cleared from the enlarged reservoir area. Some trees and snags would be retained for wildlife purposes. The Forest Service would administer and be reimbursed by the Bureau of Reclamation for the administrative costs of the sale of merchantable timber resulting from reservoir clearing.

Stumpage value of the timber in and near the reservoir area is estimated by the Forest Service to be about $64,200 (1978 price).

The May 1975 Forest Service report shows the land area in the unit (between enlarged lake and Cougar Lakes Management Unit) contains an estimated 7,570 acres of timberland, of which about 2,300 acres are noncommercial timberland and 5,270 acres are commercial timberland. Annual growth that could be harvested is estimated at 800,000 board-feet per year. Based on logging restrictions and methods, average annual harvest is estimated at 60 percent of annual growth, or 480,000 board-feet per year.

About 134 jobs would be lost with reduction of the timber in and around the enlarged reservoir.

Estimated value of the timber in the reservoir area was updated by the Forest Service in 1978 from a range of $10-$25 per thousand board-feet to $40-$90 per thousand board-feet. No changes were made in the estimated volume of timber.

Relocations

In establishing the low density recreation use concept around the enlarged lake to be compatible with the existing wilderness experience, road access above the dam would be eliminated and the Forest Service land use permits around the lake terminated. The plan provides for relocating a portion of the Forest Service road downstream from the dam. The new permanent access road would accommodate traffic to the enlarged lake. During construction, logging traffic in the reservoir area would be routed over the existing dam to connect with the north side road.

The new reservoir would inundate about 8.8 miles of Forest Service road, and 16.9 miles of road would be closed and abandoned with termination of all vehicle traffic above the damsite. In addition to the roads, 4.2 miles of trails would be inundated. Termination of the vehicle traffic would result in a change in resource use to either boaters or hikers.

Existing road, outside of the proposed reservoir and upstream from the damsite, would be closed off, scarified, seeded, and culverts removed such that the area would soon blend with the adjacent forest. Plant species to be seeded would be determined during advance planning and in cooperation with the Forest Service.

Goose Prairie residents are interested in a temporary road south of Bumping River to bypass the community during the construction period. Construction of such a road would be physically feasible, and an alinement and cost estimate have been prepared. The Forest Service has some concerns about using this bypass route, largely because of the fragile environmental setting and the potential conflict with the adjacent proposed Cougar Lakes Wilderness Study Area and RARE II Roadless Area #6032. If the project is authorized, discussions would be made with the Forest Service and the appropriate local transportation agency to decide whether to include the bypass road.

The existing Bumping Lake Road from S.R. 410 to the construction area is not adequate to accommodate additional traffic expected during construction. Based on information provided by the Yakima County Public Works Department, costs are included in the plan for 9.72 miles of improvement, principally improvement of the shoulders and installation of the guardrails in hazardous areas.

The public campgrounds and public boat-launching facilities would be replaced as a part of the new recreation plan. New trail heads would be developed. Recreation traffic would not be permitted on or near the construction areas. Bumping Crossing Campground would not be available during construction, and the Forest Service does not anticipate operating it as a campground after the project is completed.

The summer homes and cabin permits now existing with the Forest Service would be terminated[1/] with construction of the reservoir, and the structures would have to be removed without cost to the Federal Government. The project would provide funds to survey and lay out substitute sites for summer homes and to construct an access road (0.4 mile) to that site as replacement for the existing sites and road access developed by the Forest Service. The tentative replacement site is on the north side of Bumping Lake Road, just downstream from the community of Goose Prairie.

The commercial boat launch and rental under permit from the Forest Service would be eliminated and not relocated[1/]. With the exception of water base services, most services or supplies such as gas and oil, fishing tackle, etc., are available on private land at nearby Goose Prairie. Since the project will construct a boat launch with floating dock, most of the necessary water base facilities will be provided by the Government.

There are two existing hydrometeorological stations that would require relocation if Bumping Lake is enlarged.

1. Bumping Lake Snow Course No. 21C8 is a Soil Conservation Service station; however, readings are taken by Bureau of Reclamation personnel. In 1966 a second course was established downstream--the Bumping Lake New, No. 21C36. The purpose was to have concurrent readings for a number of years so that data correlation could be established between the two stations if the old station was inundated.

2. Bumping Lake Climate Station, No. 450969, originally a National Weather Service station, is located, adjacent to the existing storage building. In 1976 the Bureau replaced the equipment at the station with a fully automated weather station, including air temperature, precipitation, and snow-water content sensors. The Bureau of Reclamation would assume the responsibility of moving the station.

Breaching of Existing Dam

The existing Bumping Lake Dam would be breached. Complete removal of the old structure is not believed to be necessary because of infrequent exposure. Reservoir operation studies show that over the period of study (52 years) the embankment would have been exposed in only 1 year for a period of 7 months. Adequate posting would locate the old structure and alert reservoir users during low water periods.

Environmental Considerations

Enlargement of Bumping Lake will make a noticeable change in the clarity of the lake, with more clear water. Fish production will increase due to

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1/ *See Appended Material, Provisions Regarding Termination of Forest Service Land Use Permits at Bumping Lake* increased habitat, but the fish will be more dispersed within the lake which will have an adverse impact on angler success. The reservoir should provide a significant amount of cool water for instream flows.

Anadromous fish enhancement potential is excellent because of the good location and storage potential. The present fishery is only moderate and would likely stay that way or decrease slightly from enlargement. Wildlife use of the area in the spring and fall is significant and some appropriate mitigation would be necessary. No significant environmental quality problems are present at this site.

Geology of the Site

Data Reviewed

Reconnaissance Geologic Report on the Bumping Lake Enlargement Damsite, Yakima Project, Washington, by R. G. Anderson, July 1952.

Design Request Data for the Feasibility Design of Bumping Lake Enlargement Dam, Yakima Project, Washington, 1963.

Preliminary Findings Report, Yakima River Basin Water Enhancement Project, October 1982.

Field Review of Potential Reservoir Site, by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington.

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington, November 1981.

Damsite and Reservoir Geology.--The dam and reservoir site is on the eastern side of the Cascade Range in south-central Washington. Bumping River valley is a typical erosional valley which has been modified by the action of alpine glaciers. At the damsite, the 2,500-foot-wide valley floor is covered by glacial deposits known to be more than 250 feet thick. The glacial deposits consist mostly of an unsorted mixture of boulders, cobbles, gravel, and sand with some layers of silt. Exposures of hard, sound volcanic flow rocks occur at various places along the canyon walls. On the left abutment of the damsite, hard andesite occurs in steep cliffs above the river; on the right abutment dacite occurs beneath a thin veneer of talus and slopewash.

At the damsite the elevation of the valley floor is about 3350 feet near the left abutment and about 3425 feet near the right abutment. From the valley floor, the right valley side rises on a slope near 30° or 63 percent to approximate elevation 5500.

The left valley side rises on a slope from vertical to 55° to approximate elevation 3450, continues at a slope of about 14° to elevation 3475, and then steepens to a slope of about 26° to elevation 3600 where the slope begins to descend into a gully. Two small gullies exist near elevation 3585 to 3550 after which the slope continues to rise at about 5° to elevation 3800 and then continues to elevation 6000 at about 16°.

No surficial deposits exist on the left abutment below elevation 3450. In this reach, a nearly vertical cliff has a gradient too steep to allow soil or rock debris to accumulate. Above 3450 feet the abutment is mantled with glacial till to about elevation 3475, and with the slope wash and talus from elevation 3475 to 3575. This overburden is estimated to be less than 15 feet thick.

The right abutment is completely covered with slope wash and talus accumulations of silt, clay, sand, and rock fragments. One large talus slide exists on this abutment near the axis and should be avoided if a dam is built. Better foundation conditions exist 100 feet farther downstream.

Bedrock, as exposed in numerous outcrops on the left abutment, consists of one basalt flow which is fine-grained, highly jointed, massive, and dark gray to light red. The color and texture is not consistent from place to place within the flow. Joint systems in the upper portions have broken the basalt into platy fragments while the lower portions exhibit columnar jointing. No vesicular basalt has been found in this lava flow.

No bedrock crops out on the right abutment, but rock fragments in the talus covering part of the abutment indicate andesite porphyry exists under the overburdens.

In 1940 the Corps of Engineers churn-drilled two exploration holes to depths of 100 and 102 feet in the valley floor at the Bumping Lake Enlargement damsite.

The Bureau of Reclamation drilled two foundation exploration holes at the site to 200 feet and 111 feet in 1951 and 1952. A topographic reservoir map on a scale of 1 inch equals 500 feet of Bumping Lake was prepared in 1940. A topographic map of the damsite was prepared on a scale of 1 inch equals 100 feet with a contour interval of 5 feet, and a geologic map of the site was prepared in 1952.

Much of the alluvial material encountered in earlier explorations at the site is permeable. Gravity water tests were made at intervals of 5 feet in the overburden by using a 5-foot length of 3-inch pipe perforated with 725 1/4-inch holes on the end of 3-inch casing. The water level was held from 2 feet to 13 feet above the perforated pipe of water table during the test depending on the depth of section being measured.

Water losses ranged from 0 to 15.5 gal/min per minute. Gravity water tests were, also, performed as the casing was withdrawn from the hole. Losses ranged up to a maximum of 166 gal/min under an 80-foot head. At the considered axis, the water table is 25 feet to 22 feet below river level, indicating a permeable valley fill and a silted river channel which prevents rapid recharge of ground water from this source.

Bedrock in the left abutment is jointed, fresh, dense, hard, and would not leak excessively if the joints were grouted. Although bedrock on the right abutment is not exposed, rock fragments on the talus slopes indicate a tight, sound foundation can be expected at shallow depth.

In the left abutment, 500 feet and 900 feet northwest from Bumping River near the considered axis, two gullies trend northeast and southeast and intersect the damsite axis. These gullies have been eroded along highly jointed zones in the basalt by moving ice and water. Since glaciation, rock fragments weathered from the gully sides have accumulated along the floors. Since these talus-filled gullies might furnish seepage paths through the left abutment, exploration will be necessary to determine the thickness of talus accumulation and the permeability of these conduits.

Overburden along the valley sides in the reservoir basin is rather thick but probably does not exceed 30 feet. Most of the valley slopes are covered with slope wash and coarse talus composed of lava rock fragments. Alluvial fans have accumulated at the mouths of the small tributary valleys entering the reservoir basin but the alluvial debris does not extend for a great distance onto the floor of Bumping Valley.

Overburden along the valley floor exceeds 200 feet and consists of glacial till and small deposits of river gravel and sand.

Although most of the valley overburden is till, some of the material is stratified, indicating that glacial melt water sorted portions of the deposit at the time of deposition or shortly thereafter.

The only known source of impervious and semipervious material in the vicinity of the damsite is the glacial till along the valley floor. This material is an unsorted mixture of boulders, cobbles, sand, silt, and clay. Much of the material is oversized and some method of sorting would be necessary before using the embankment in various sections of the dam.

No large deposits of sand and gravel exist along Bumping River in the vicinity of the damsite. Large deposits of gravel exist downstream from the site along the Naches River but would require a 20- to 30-mile haul to the site. Large quantities of rock fragments of sand and gravel size exist in the overburden along the valley floor and might be recovered by processing the glacial till.

No riprap or rockfill areas have been defined at the present time, but very likely riprap and rockfill could be obtained from the basalt flow along the left valley side. The lower portions of this flow are hard, durable, less jointed, and would be the most suitable. Many boulders exist in the valley fill and would be suitable for riprap provided they were separated from the rest of the glacial debris.

Three geologic problems have been identified:

1. Excessive reservoir seepage losses may occur through the deep glacial till deposit in the foundation.

2. There may be liquefiable materials in the glacial deposits underlying the damsite.

3. The close proximity of Mt. Rainier raises questions of seismicity and associated volcanic eruptions.

Design

Data Reviewed.--The data reviewed by the designers included:

SEED Data Book

SEED Evaluation Report dated September 1982 (for existing dam)

Bumping Lake Enlargement - Preliminary Estimate Drawings (November 1953)

Bumping Lake Enlargement - Feasibility Estimate (January 1955)

Bumping Lake Enlargement - Feasibility Estimate (July 1963)

Draft Environmental Statement - Bumping Lake Enlargement (February 1977)

Embankment Dams Section (D-222) Correspondence File

Preliminary Findings Report October 1982

Draft Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project (November 1981)

Structural Features Embankment Dam.--The proposed dam for the Bumping Lake Enlargement Plan is currently based on a 1963 feasibility design performed by the Bureau. The dam would be a rolled earth and rockfill structure with a maximum height above streambed of 223 feet and a crest length of 3,300 feet. The damsite investigation (based on drilling prior to 1952) has revealed bedrock on both abutments and glacial deposits at least 200 feet in depth in the bottom of the valley section.

Permeability testing of the glacial deposits indicate very high permeability rates (35,000 ft/yr) in certain zones of the foundation. The dam design includes a pressure relief well system to reduce the anticipated seepage under the dam as well as upstream blanketing to reduce the flow gradient. Still, under the present design, up to 100 ft^3/s of seepage losses may be expected. It is important to note, however, that the drill holes in the bottom of the valley section did not reach firm formation. Flow samples were obtained and permeability values were estimated from open-end pump-in tests of questionable validity. Consequently, the extent and cost of the design features to handle seepage may vary considerably from the present feasibility design based on final design data collection. It does not appear that a slurry trench or chemical grouting would be practical solutions to reduce those large levels of seepage. Since the seepage can be safely handled and is not detrimental to the safety of the structure, there are three alternatives to examine:

Accept large seepage losses under the present design

Explore the river valley upstream and downstream of the present site (possibly by geophysical methods) to determine if a site exists with lesser depths of glacial deposits that can be economically treated to reduce seepage

Lower the reservoir elevation sought for the enlargement

The large seepage losses under the present design may be found acceptable since much of the water development is for stream enhancement for fish. While topography for an alternate site may indicate greater above-ground quantities are required for the embankment, a net savings may be found by eliminating or reducing the extent of features for seepage control. A smaller dam with less reservoir head may be found acceptable since Bumping Lake alone may not satisfy the objectives of water development within the Yakima basin. If other reservoir development is required anyway, it may be more economical not to develop Bumping Lake Reservoir to the extent indicated by the present design.

The major unknown with regard to the present design is the potential for seismic activity within the area of the damsite. There are indications of potentially liquefiable sands in the dam foundation. If required, the foundation materials can be treated by some means of densification to withstand the earthquake load but this will add to the total cost of construction and is not currently addressed in the feasibility design.

Spillway and outlet works.--The recent maximum probable flood is predicted to have a peak of 39,500 ft^3/s and a 5-day volume of 131,000 acre-feet. This is in excess of twice the peak of the flood which was designed for in the 1963 feasibility estimate. This would require a wider spillway, but the location and type of spillway would be the same as in the 1963 feasibility. The location would be on the left abutment and the crest structure would be uncontrolled with an open-cut chute and type II stilling basin. The spillway would be founded on andesite, which would provide an excellent foundation for the structures. If a lower dam were considered more feasible, the alinement may be changed slightly. More spillway excavation could result in this situation because of lowering of the spillway crest.

The outlet works should be a tunnel alined as shown on the 1963 feasibility drawing. The trashracked outlet works intake structure would have a circular upstream tunnel, a gate chamber with an access shaft and house, a free-flow downstream tunnel and a stilling basin. Additional information will be required for designs related to fish facilities needed.

Additional Data Required

For Elimination Process.--None.

For Appraisal Design.--Pending the results of the elimination process and the requirement for full reservoir development, the present design may serve as adequate to account for known conditions. However, significant changes in design features may occur during the final design process if alternate sites are found or reductions in reservoir development are sought. In any case, a preliminary assessment of the potential for seismic activity should be conducted and the present design evaluated to determine if additional features are required to reduce liquefaction potential of foundation materials. A preliminary assessment should be conducted to evaluate the Bumping Lake lineament. Also, the following data should be provided:

Verification of maximum probable flood

Diversion floods

Outlet works discharge and head requirements

CLE ELUM ENLARGEMENT

Introduction

Cle Elum Dam and Lake Enlargement was visited late afternoon, Tuesday, November 2. The weather was still clear but cool, about 40° F. The DSRT talked with the damtender, Robert Crosier, to discuss the problems associated with this site.

Previous Studies

Cle Elum Dam is on the Cle Elum River, a tributary of the Yakima River, approximately 8 miles northwest of the city of Cle Elum.

This site has been identified in several previous studies. A memorandum from the Chief, Planning Technical Services, dated June 20, 1980, regarding the enlargement of Cle Elum and Tieton Dams and the Formulation Working Document, Cle Elum and Tieton Powerplants, Yakima Project, Washington, June 1981, are the most recent studies identifying the structure.

Description

The existing Cle Elum Dam, a zoned, roller compacted earthfill structure, rises a maximum of 134 feet above the bed of the Cle Elum River to a crest elevation of 2250 feet. The structural height is 165 feet, and the hydraulic height is 124 feet. The crest of the dam is 750 feet long and 30 feet wide; a 3-foot-high parapet extends along the upstream edge of the crest. A main dike with a crest width of 30 feet, a crest elevation of 2253 feet, and a maximum height of 40 feet extends 750 feet to the west at an angle from the left abutment of the dam. Three small dikes with a total crest length of about 200 feet are located in low spots or saddles to the northeast of the dam. The dam and dikes contain approximately 1,410,000 cubic yards of material.

The spillway is a concrete-lined open channel on the right abutment of the dam. Five electrically operated 37-foot- by 17-foot-high radial gates control flows into the spillway, which has a design capacity of 40,000 ft^3/s. The stilling basin at the lower end of the spillway is a concrete structure with vertical sidewalls and a dentate lower sill.

The outlet works for the dam consist of a concrete-lined tunnel through the right abutment of the dam and four hydraulically operated gates. The tunnel is 2,108 feet long and 14 feet in diameter. A gate chamber and 250-foot section immediately upstream of the gate chamber are lined with 3/8-inch steel plate. The inlet structure is located about 765 feet upstream of the dam axis, and the conduit terminates about 880 feet downstream of the dam axis in the spillway near the left wall just above the stilling basin.

An outlet control tower is adjacent to the spillway immediately upstream of the dam axis. Four hydraulically actuated 5-foot by 6.5-foot gates were installed in 1980 to replace original cylinder gates. Discharge capability after the rehabilitation is projected to be 4,900 ft^3/s at full pool and 4,250 ft^3/s at 70 percent of full pool. This capability is sufficient to meet existing release requirements of the project.

Hydrology

The reservoir water surface could be raised 2 to 3 feet to increase active capacity without raising the dam and dike embankments if the inflow design flood for the dam is assumed correct. However, the inflow design flood was reviewed in March 1980 as part of the SEED (Safety Evaluation of Existing Dams) program, and from that review it was determined that the inflow design flood should be reanalyzed to recognize additional hydrologic and meteorologic data.

Raising the embankments and constructing new dikes to accommodate moderate increases in the reservoir water surface (10 to 15 feet) would not cause major problems with seepage, settlement, or stability. Cle Elum Dam was conservatively designed, and the embankments have performed very well. Available topography indicates that more than 2,000 feet of new dikes would be necessary for a 10-foot increase in embankment crest elevation. Reservoir blanketing upstream of the existing dikes and any new dikes would probably be required to insure adequate seepage control. The existing freeboard from maximum water surface to crest of dam is 10 feet.

The spillway structure could accommodate, without major modifications, an increase in active storage elevation of 2 or 3 feet. Increases in excess of those elevations would require replacement of the spillway. The outlet works could satisfactorily accommodate a higher water surface elevation with only modest modifications. However, the outlet works, which are presently undergoing rehabilitation which includes new gates, will only marginally meet project delivery requirements. In addition, its capacity is required for emergency reservoir evacuation. For these reasons, the addition of power features should not affect the discharge capabilities of the outlet works.

Hydrologic data available indicates a very good ratio of inflow to capacity even for the driest years, indicating a very good refill capability. The reservoir would be expected to completely fill in almost all years and at least substantially (70 percent full) fill in all years. The drainage area is about 201 square miles, and the average annual runoff is 680,000 acre-feet. Based upon reconnaissance level data, the inflow design flood at the damsite is estimated to have peak flow of 86,200 ft^3/s and a 5-day volume of 276,000 acre-feet.

Environmental Considerations

Cle Elum Lake is a relatively sterile, nonproductive lake. A limiting factor may be the availability of phosphorus, which is present in a very low concentration compared to nearby reservoirs. Whether low productivity is due to a lack of phosphorus or the absence or presence of some other factor is not known at this time. Little change in water quality is expected from the existing conditions. A small amount of additional cool water for instream flow would be available.

Anadromous fish enhancement potential is minor because of the small amount of new storage; however, location is good. Any impacts to fish and wildlife resources would be very minor. The dead storage provides an adequate minimum pool.

Cle Elum Lake, the impoundment formed by Cle Elum Dam, has an active storage capacity of 436,900 acre-feet. The total storage capacity is estimated at 709,900 acre-feet, and at full pool the lake has a surface area of 4,800 acres.

Geology of the Site

Data Reviewed

Draft Report on Safety of Dam and Appurtenant Works

Feasibility Geologic Report, Cle Elum Dam Powerplant, USBR, J. B. Buehler, January 1982

Preliminary Findings Report, Yakima River Basin Water Enhancement Project, October 1982

Notes on the Site Team Examination of Cle Elum Dam for the Yakima River Basin Water Enhancement Project, November 1982

Site Geology.--The dam and reservoir are on the eastern slopes of the Cascade Range that is composed mostly of Tertiary volcanic and sedimentary rocks. Cle Elum Lake was once a naturally impounded glacial trough lake situated within a large glacial valley trending north-northwest. Glaciation spanned the valley and deposited glacial moraine and outwash material at the site of the dam. The exact classification as to moraine versus outwash has not been reached.

The geologic units identified at the site consist of Glacial Drift (Glacial Till with interbedded Glacial Outwash) and Recent River Alluvium. The Glacial Drift is composed of Glacial Till characterized by a heterogenous mixture of mostly subrounded to rounded igneous and metamorphic cobbles and gravel with sand, fines, and scattered boulders. This unit lacks stratification. Glacial Outwash is typified by well-sorted, stratified sand and gravel layers and/or lenses.

The Recent River Alluvium consists of the same materials as the glacial material. The water action has removed much of the fine-grained components from the boulders, cobbles, and gravel.

Drill holes at the damsite show glacial materials well over 100 feet deep. A well near the town of Cle Elum about 7 miles south of the dam penetrated 649 feet of unconsolidated material above bedrock.

The Roslyn Formation constitutes most of the valley exposures and underlies the glacial materials beneath the damsite. The Roslyn Formation consists of interstratified light-colored arkose, lithofeldspathic sandstone, siltstone, minor conglomerate, and coal beds of the Eocene Epoch.

During rehabilitation of the outlet works, lenticular and bulbous voids of about 3 to 8 feet in length and 1 to 3 feet in diameter were encountered in the glacial materials. No investigation of the nature, extent, and cause of these voids has been made.

An assessment of this situation in the foundation is necessary before enlarging this reservoir is considered. This problem could conceivably influence seepage of a large reservoir as well.

Considering the length of the glacial materials of over 100 feet at this dam, a potential for liquifaction may exist.

Design

Data Reviewed.--The data reviewed by the designers consisted of:

SEED Data Book

SEED Evaluation Report (dated November 1982)

Embankment Dams Section Correspondence File

Preliminary Findings Report, October 1982

Structural Features

Embankment Dam.--A review of the above data revealed that the information in the Preliminary Findings Report accurately summarizes the position of the designers in adding embankment material to the existing dam and dikes for the purposes of the elimination process. Pertinent information is restated here for completeness.

The existing Cle Elum Dam, a zoned, roller compacted earthfill structure, rises a maximum of 134 feet above the bed of the Cle Elum River to a crest elevation of 2250 feet. The structural height is 165 feet, and the hydraulic height is 124 feet. The crest of the dam is 750 feet long and 30 feet wide; a 3-foot-high parapet extends along the upstream edge of the crest. A main dike with a crest width of 30 feet, a crest elevation of 2253 feet, and a maximum height of 40 feet extends 150 feet to the west at an angle from the left abutment of the dam. Three small dikes with a total crest length of about 200 feet are located in low spots or saddles to the northeast of the dam. The dam and dikes contain approximately 1,410,000 cubic yards of material.

An increase in reservoir water surface of approximately 10 feet is sought for Cle Elum. The reservoir water surface could be raised 2 to 3 feet to increase active capacity without raising the dam and dike embankments if the inflow design flood for the dam is assumed correct (the IDF was revised recently but no routing to determine maximum water surface was found). Raising the embankments and constructing new dikes to accommodate moderate increases in the reservoir water surface (10 to 15 feet) would not cause major problems with seepage, settlement, or stability. Cle Elum Dam was conservatively designed, and the embankments have performed well. Available topography indicates that more than 2,000 feet of new earthfill dikes would be necessary for a 10-foot increase in embankment crest elevation. Reservoir blanketing upstream of the existing dikes and new dikes would probably be required to ensure adequate seepage control.

The preceding assessment of the feasibility in raising Cle Elum Dam and dikes by 10 feet is suitable for the elimination process without additional data. However, an appraisal study to enlarge the facilities should only be conducted based on following through with the recommendations on the recent SEED study. Of particular concern is the potential for seismic activity at the site and the performance of the dam and foundation under seismic loading. Apparently, zones of potentially liquefiable materials are present in the foundation. Also, important to the appraisal design will be location of adequate borrow sources (thought to be in the reservoir area). Also, a cursory subsurface investigation of foundation materials underlying the new dike would be in order.

<u>Spillway and outlet works</u>.--Raising the dam and dikes to accommodate an increase of 10-foot rise in reservoir water surface would probably require a complete rebuilding of the spillway. It is obvious that the gate size will have to be increased and the hoists and bridge raised. It will also be necessary to raise the walls and probably lengthen and deepen the stilling basin. Further study will be required to determine the extent of modification or if the entire spillway would have to be replaced. Under the Safety Evaluation of Existing Dams Program, the Cle Elum probable maximum flood was updated and subsequently approved in November 1982. The probable maximum flood is a rain-on-snow event with a peak discharge of 77,330 ft^3/s and a 15-day volume of 339,500 acre-feet. Preliminary routings indicate the new probable maximum flood will not impact the decision concerning modification of the spillway, however, the E&R Center has not completed the final routing.

The outlet works has been recently rehabilitated. Capacity and operation of the outlet works would be adequate with the 10-foot increase in water surface. However, the outlet works control house would have to be raised.

Previously discovered voids around the existing outlet works conduits should be located and appropriate repairs made.

Additional Data Required

For Elimination Process.--None

For Appraisal Design.--

1. Preliminary assessment of the potential for seismic activity at the dam.

2. Studies to determine the performance of Cle Elum Dam and dike under seismic loading.

3. Borrow investigations

4. Subsurface investigation of foundation materials for the new dike

5. Topography (1 inch = 100 feet scale and 2 feet contours) in areas of the new dikes

6. Foundation exploration to examine voids?

DEVIL'S TABLE DAM AND RESERVOIR

Introduction

Devil's Table was visited Friday afternoon, November 5. The weather was cloudy with intermittent showers and temperatures in the 30's. The DSRT visited this site Friday afternoon, November 5, 1982.

Devil's Table damsite is located on Rattlesnake Creek about 6-1/2 miles upstream from the Naches River, in section 11, T. 15 N., R. 14 E., W.M., in the Snoqualmie National Forest. Reservoir sizes in the 43,000- to 58,000-acre-foot range are being studied.

Description

An embankment dam is anticipated for this site. At a crest elevation of 2845 the dam would be about 315 feet high, have a crest length of 1,130 feet, and contain about 4.9 million cubic yards of embankment material. The capacity of the reservoir would be about 58,000 acre-feet and would inundate about 580 acres of land (about 240 acres bottomland and the remainder in forested or dry grazing land). County roads in the reservoir would be relocated.

Hydrology

Hydrologic data available indicate a good ratio of inflow to capacity, much better than Forks or Bumping Lake enlargement. The size is small and the location within the basin is poor. This site cannot help meet the needs of the upper Naches and is not low enough to achieve any significant benefits for reregulation of streamflows. The drainage area is about 97 square miles, and the average annual runoff is 69,000 acre-feet. Based on reconnaissance level data, the inflow design flood at the damsite is estimated to have a peak flow of 55,000 ft^3/s and a 5-day volume of 174,000 acre-feet.

Environmental Considerations

Devil's Table will offer some cool water for instream flows, but it will be a rather small amount. Primary production will be low, and the reservoir fishery will be rather poor, similar to Cle Elum.

Anadromous fish enhancement potential is only fair because of the limited amount of new storage possible and poor location on the Naches system. Rattlesnake Creek sustains a natural population of cutthroat and rainbow trout. The remoteness of the area and presence of naturally produced fish results in a highly valued fishery because of the scarcity of such fisheries in the Yakima basin. Impacts of a reservoir on this fishery would be highly significant. Elk and deer use of the reservoir area is also substantial, and wildlife impacts and mitigation would also be highly significant. A reservoir at this site would be oligotrophic with only a fair potential for establishing a fishery. Some potential anadromous fish spawning and rearing habitat would be inundated.

The preliminary area-capacity curve and reservoir map were developed using Geological Survey 7-1/2 minute-quadrangle map, Meeks Table, Washington.

Geology of the Site

Data Reviewed

Washington Public Power Supply System Preliminary Safety Analysis Report, Amendment No. 23, dated April 18, 1977

Preliminary Findings Report, Yakima River Basin Water Enhancement Project, October 1982

Field Review of Potential Reservoir Site, by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington, November 1981

Site Geology.--The geology of the Devils Table site has not been examined in the detail that would identify the existing units, although a surface geology map has been prepared by Shannon and Wilson, Inc., in a Preliminary Safety Analysis Report, Amendment 23, for the Washington Public Power Supply System.

According to this map, the surface unit on the right abutment is identified as the lower member, the Grande Ronde Basalt of the Yakima Basalt Subgroup and the surface exposures on the left abutment exhibit the upper unit of the Ellensburg Formation. Conceivably, the left abutment therefore is expected to contain the Ellensburg Formation, sedimentary rocks conformably underlying, overlying, and intertongued with the Yakima Basalt Subgroup. The sedimentary rocks of the Ellensberg Formation range from arkosic sandstone to laharic breccia and airfall tuffs derived from the Cascade eruptions. The basalt of the underlying group, the Yakima Basalt Subgroup, is black to light gray, dense, fine to very fine grained, and sparsely porphyritic. Further discussion of the geology at this site is not attempted without an onsite geologic reconnaissance.

Immediately upstream of the right abutment is a massive landslide of the Grande Ronde Basalt Formation whereby the basalt exhibits closely spaced fracture patterns, often conchoidal in nature and parallel with the surface topography as features of foliation. These characteristics as exhibited by the surface exposures are believed to have been contributory to the instability of rock mass and hence the occurrence of the slide.

Instability of the right abutment as shown by the characteristics of the basalt coupled by the local relief, would tend to rule out this site as a potential site for a dam.

Design

Data Reviewed.--The data reviewed by the designers consisted of Preliminary Findings Report, October 1982.

Structural Features.--As described in the section on Geology, the large landslide area just upstream of the right abutment is of great concern, not only for reservoir rim instability, but also with regard to the right abutment where the rock mass characteristics are very similar. Based on existing data, we would recommend against construction of a dam at this site.

An alternative site has been located downstream of Devil's Table known as Mile 4 damsite. The damsite review team did not visit the Mile 4 damsite and no data is currently available. If the site itself proves suitable, reservoir rim instability will still exist as a major problem to be addressed.

Additional Data Required

For elimination process

None required for Devil's Table - eliminate it

Conduct a damsite review of the Mile 4 site and recommend additional data on that basis

For Appraisal Design.--As an alternate to a site at Devil's Table, another site dubbed Mile 4 located about 4 miles upstream of the confluence of Rattlesnake Creek and the Naches River has been offered for consideration. A geologic reconnaissance will be necessary to evaluate this site.

In respect to the existing landslide, a study of the failure mechanisms may be in order to ascertain reservoir rim stability for any site considered. This study would require exploration drilling, rock mechanics testing, and possibly a geotechnical analysis on stability. For any site under consideration in this valley, an inventory of material availability is required.

EAST SELAH REREGULATING RESERVOIR

Introduction

East Selah reregulating reservoir was visited Monday afternoon, November 1. The weather was sunny and bright with temperatures near 60° F. The East Selah reregulating site is located on the flood plain of the Yakima River between the river and Interstate 82, about 4 miles north of Yakima, Washington, in sections 31 and 32, T. 14 N., R. 19 E., Willamette meridian. This feature is special because it is not a storage reservoir.

Description

The concept of a reregulating facility to improve the operational effectiveness of upstream storage releases was first identified following the 1973 irrigation season. This was the first season that significant water shortages were felt by proratable irrigation water right users[1/]. During the 1977 drought, the concept again surfaced and was briefly evaluated in the Bureau of Reclamation report "Drought Relief Measures: Idaho, Oregon, Washington, 1977."

The Yakima River Basin Association of Irrigation Districts and other local interests felt that the reregulating concept warranted further consideration, and the Washington Department of Ecology (WDOE) was requested to evaluate the feasibility of such a facility. The WDOE contracted the firm of CH_2M Hill to undertake a feasibility study. CH_2M Hill completed the study and summarized their findings in the report "Yakima River Reregulating Storage" in May 1978.

1/ *On January 31, 1945, Civil Action No. 21 of the District Court of the United States at Yakima, Washington, established the amount of water each user or district is entitled to receive and classified the rights into proratable and nonproratable. This action became known as the 1945 Consent Decree. In shortage years the nonproratable rights are supplied first and the remaining water divided proportionately among the proratable water rights.*

During the study, CH_2M Hill considered several possible sites for a reregulating reservoir and prepared detailed information on three sites: Wenas, Selah, and East Selah Gravel Pits. Based on engineering, economic, and environmental feasibility, the latter appeared to be the most favorable site. However, it was concluded that further operation studies should be conducted to determine if the "saved water" could actually be stored in project reservoirs to increase yield. Another aspect of the CH_2M Hill study which required further review was the evaluation of irrigation benefits attributed to the use of the saved water.

The following data was extracted from the CH_2M Hill feasibility study:

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 the river gradient across the site (about 20 feet) and the area diked. The storage volumes can be maximized by excavating the diked area to the elevation of the river at the discharge point. 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 insure their stability.

Ground water.--The gravel pit area is mapped in the Geological Survey Water Supply Paper No. 1595 as an area where there is significant ground-water discharge into the Yakima River from the east. The ground water 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 dewatered 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 ground-water levels, but they are influenced by the gravel pit dewatering operations. It appears the normal ground-water depth east of Interstate-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 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 open-work 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 ground-water 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 floodflows, 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 will require 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 floodflows.

Structures.--Eight structures are required to regulate flows through the cells. A floodproofing 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. 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 to prevent passage of fingerlings. The outlets have bar screens to prevent entrance of adult fish.

Cells A and B inlet structures transfer water from the inlet canal to the respective cells. 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 will require a fully opened floodproofing structure gate so that the inlet canal can carry water from the diversion point to cells A and B inlet structures. The canal capacity is 300 ft^3/s 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 foot per second with flows greater than 300 ft^3/s. 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 ft^3/s 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. Open-work 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.

Preliminary operation studies by the Bureau of Reclamation show that East Selah reregulating is expected to reduce operational wastes at Sunnyside by an average of about 50 ft^3/s during the irrigation season. The facility would be expected to have a relatively narrow operating range of 3-5 feet and fluctuate up or down at a rate approaching 1/2 foot per day (about 150 ft^3/s inflow or outflow). It would include two structures to control inflows and outflows. These would be separated by ____ miles in discharge and ____ feet in stream elevation. Possible problems include potentially high rates out of the facility, raising of local ground-water levels (with resulting problems to basements and septic tanks in the area), and interference with the gravel pit operations.

If the East Selah reregulating facility is constructed, anadromous fish enhancement potential is good because flows in the lower river would be stabilized and a significant amount of existing and future storage water conserved. There is little chance of establishing a reservoir fishery due to the large fluctuations that would occur, and the existing warm water fishery would be lost. Waterfowl use the existing ponds almost year round. Some fish and/or wildlife mitigation measures will be needed, particularly for lost waterfowl breeding habitat. A fish barrier may be needed on the outlet to keep anadromous fish from entering the reservoir.

The reservoir map for the East Selah reregulating reservoir was developed using Geological Survey 7-1/2-minute quadrangle maps, Selah and Pomona, Washington. A copy of this reservoir map (33-100-445) is included in the supporting data.

Geology

Data Reviewed

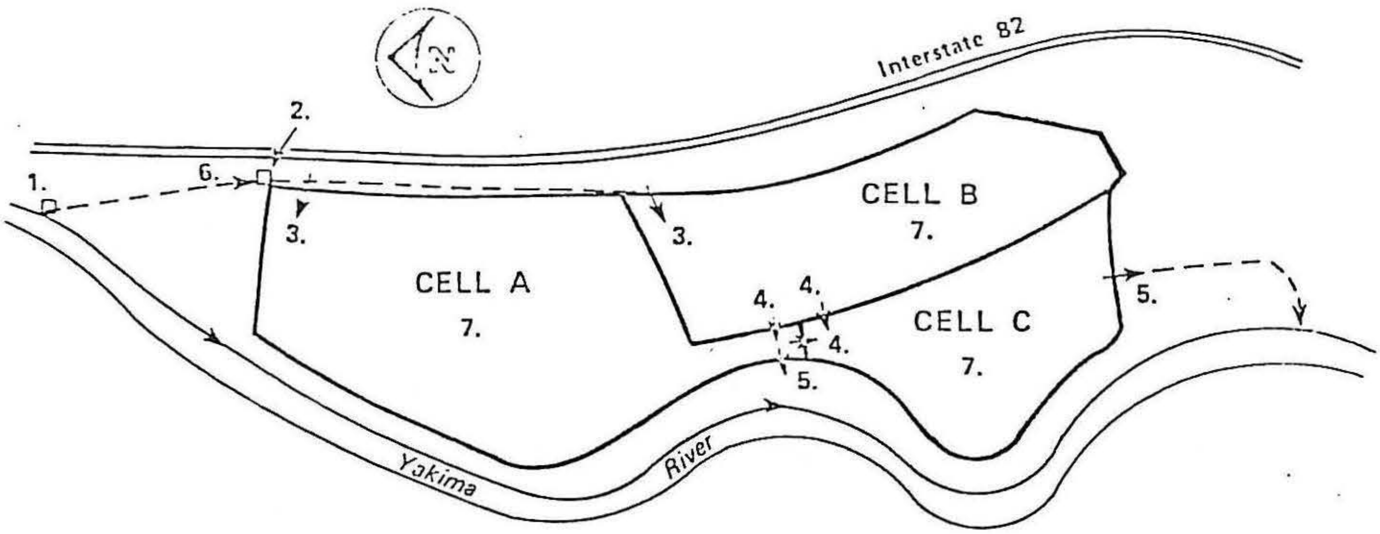
Yakima River Reregulating Storage, feasibility study by CH_2M Hill, May 1978.

Preliminary Findings Report (October 1982), Yakima River Basin Water Enhancement Project.

Field Review of Potential Reservoir Site by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington.

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington. November 1981.

Site Geology.--The flood plain of the Yakima River contains both deposits of alluvium and flood materials. The gravels are mostly basalt that has been eroded to subangular to a subrounded shape. The alluvium is a well to poorly graded gravel with a small percentage of fines. Material size and compaction increase slightly to about 15 feet in depth where the gravel size and amount



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.

of compaction are fairly constant. Below 15 feet, the material is slightly cemented and stands on near-vertical cut slopes. At a depth of 45 feet, there is a 2-foot-thick hardpan layer.

Some problem areas associated with this feature are related to the effect of raised water levels by the reregulating reservoir. The extent of seepage under Interstate 82 which borders the reservoir on the east is unknown and may influence the road embankment stability and raise the local ground water east of the highway. Raised ground water could adversely affect dwellings in this area.

The dikes which border the Yakima River and the proposed reservoir show the effects of earlier erosion and would require adequate erosion protection to remain stable.

Reservoir seepage may be a potential problem. It is conceivable that open work gravels may exist in some areas of the reservoir providing seepage paths between the river and the reservoir.

Design

Data Reviewed.--The data reviewed by the designers consisted of:

CH_2M, Feasibility Study for the Yakima River Reregulating Storage, dated May 1978.

Draft Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (dated November 1981)

Structural Features.--Three sites were examined by CH_2M Hill in assessing the feasibility of a reregulating reservoir for the Yakima River. The site at the East Selah gravel pits was the only one visited by the Damsite Review Team, and so comments will be limited to that site alone. It is understood that this feature is further along in the planning process than the other sites being considered and is not a part of the elimination process. Comments from the Damsite Review Team were requested to evaluate the feasibility level study by CH_2M Hill and to make an assessment of the need for additional data for feasibility and/or final design.

Based on a review of the feasibility study, of primary interest is the level of design required for the structures. It would appear that the dikes have been designed for something approaching the 100-year flood, although there is no indication of overflow spillway capacities or the flows for which the dikes may be overtopped. There is an indication that the 100-year flood of 38,000 ft^3/s in the reach of the Yakima River near the reregulating site would result in 1,300 ft^3/s passing through the gravel pit area. Since the inlet structure has a capacity of 300 ft^3/s, it would appear that there is a considerable potential for overtopping and breaching of the dike sections for flood magnitudes less than 100 years recurrence. Also, the indications of bedrock accelerations from 0.1 to 0.35 for the MPE (Maximum Probable Earthquake) and the MCE (Maximum Credible Earthquake) respectively cause some concern for the stability of the dike structures during strong seismic shaking. The feasibility study indicates that both the dikes and dike foundations will be composed of sands and gravels; materials that in a loose state are susceptible to liquifaction for the level of shaking indicated. An assessment of the level of damage or loss of life resulting from catastrophic failure indicates little cause for concern. However, repair of structural damage and loss of the facility are still of some concern. These will have some impact on the level of hydrologic and seismic events the structures must be designed to withstand.

Another consideration that causes some concern is the level of seepage anticipated through and beneath the dike structures. It would appear that CH_2M Hill has established a trial and error approach to the dike designs; wait and see where the dike fails initially, then go back and fix the problem. This approach may be suitable as long as the repair is not considered expensive in comparison with the initial construction, and the loss of the facility during repairs is of little consequence. Also, of concern with regard to seepage is the anticipated rise of ground water in the inhabited areas east of Interstate 82 and the stability of the highway itself. Therefore, we recommend studies to determine inundation of septic tanks and other systems on properties east of the highway. Permeability of the embankment and foundation and possible means of preventing damage to these properties should be investigated. A slurry trench was mentioned as a means of partial cutoff along the highway, but no assessment of its impact on the problem was provided in the CH_2M Hill report. Seepage stability studies should be undertaken to determine dike stability and permeability. Lastly, there appears to be some potential for erosion of the dike at bends in the river channel. Some consideration for armoring these areas may be appropriate.

Functional requirements for the structure include inlet structures with fishscreens which will limit the velocities to approximately .5 ft/s to prevent damage to fingerlings. Certain passage facilities between the cells will also be required for storage in certain cells while maintaining mining activities in any selected cell. Discharge facilities to the river will also be provided for releases from a specific cell. These facilities should contain structures to prevent upstream passage of anadromous fish. The entire system must be sized to maintain sufficient storage and water surface levels, and provide capability to mine one of the cells continuously, dewater cells during off irrigation season and protect anadromous fish.

Additional Data Required

A prudent first step in obtaining additional data would include surveying existing wells and septic systems on property east of Interstate 82 and a ground water monitoring program at the reregulating site. The detail and amount of design data required for the actual structures involved at the reregulating facilities is largely dependent on the magnitude of floods and earthquakes to be designed for. Therefore, design requirements should be established. There is no indication that any foundation or borrow investigations have been conducted. These must precede any realistic seepage and stability studies. The amount of concern for structural failure will largely dictate the efforts in additional data requirements. Data collection should also include:

1. At least one drill hole for each water control structure.

2. Foundation exploration along Interstate 82 as needed to obtain information on the road embankment and foundation.

FORKS DAM AND RESERVOIR

INTRODUCTION

Forks dam and reservoir sites were visited Wednesday, November 3. The weather was clear to partly cloudy with temperature 40° F. The DSRT visited this site Wednesday, November 3, 1982. Phil Hess, Rick Brathobee, and Dave Broitt, employees of Boise Cascade Corporation, accompanied the DSRT to this site.

Description

Forks damsite is located on the Teanaway River about 1 mile downstream from the junction of the North and West Forks of the Teanaway River, with both abutments lying on Boise Cascade lands. This site is below the Casland damsite that has been identified in earlier studies. Reservoir sizes being studied range from 46,000 to 390,000 acre-feet.

An earthfill dam is anticipated for this site. With a crest elevation of 2448 the dam would be about 290 feet high, have a crest length of about 5,050 feet, and contain about 27 million cubic yards of enbankment material. The reservoir capacity would be about 390,000 acre-feet and would inundate about 4,200 acres of land (about 100 acres of cultivated or irrigated pasture, 1,500 acres of river bottomland, brush and tree covered, and the remainder in forested or dry grazing land), nearly all of which are in private ownership.

The dam and reservoir would also inundate the following: (1) about 15 to 20 miles of Forest Service, county, and private roads and several miles of trails, (2) at least 2 public campgrounds; (3) Illahee Camp, (4) Bible Rock Camp; (5) about 50 summer homes and cabins; and (6) about 25 permanent homes in which the residents are there year round.

The Forest Service and county roads will be relocated because they serve upstream campgrounds and lookout stations.

Hydrology

Hydrologic data available indicate a low ratio of inflow to capacity; only Bumping Lake enlargement has a lower ratio. Refill after severe droughts, requiring near emptying, may take 2-3 years. The location is good from a water supply/use standpoint, although storage in the upper Yakima basin is not absolutely required to meet the basin's needs.

The reservoir drainage area is about 171 square miles, and the average annual runoff is 260,000 acre-feet. Based on reconnaissance level data, the inflow design flood at the damsite is estimated to have a peak flow of 76,700 ft^3/s and a 5-day volume of 247,000 acre-feet.

Environmental Considerations

Forks Reservoir will be wide and shallow. Water for instream flows will probably be the warmest of any of the seven features being studied in the upper Yakima basin. Primary production will most likely be very high, similar to Tieton, and the fishery will be similar. If preliminary figures hold, to which there is doubt, the lake would suffer from algal blooms and dissolved oxygen problems in the hypolimnion; it would be similar to Lake Lowell, Idaho. Forks Reservoir may develop a sedimentation problem. Presently there is not enough information available to define the problem.

The Teanaway River in this reach is a fair trout stream but relies on hatchery restocking. There were anadromous fish runs here in the past, but diversions on the lower river have virtually eliminated these runs. Some native cutthroats and brook trout live here.

This Douglas-fir forested area, with cottonwoods in the bottoms, provides marginal deer and elk winter range. It receives heavy snowfall and is so high in elevation that it is used only during mild winters. Although the area has value as big game winter range, this value is decreasing as recreational home development increases. It is likely that winter range near the site would have to be developed as mitigation for lost habitat.

The shallow canyon and hilly terrain supports some raptors such as goshawks, Coopers hawks, red-tails, and a few eagles. Ruffed, blue, and spruce grouse are found in fair numbers. There is little waterfowl use in the area.

Adverse impacts that would occur with storage include a blockage to movements of populations of native resident fish and the displacement of raptor and grouse habitat. A positive effect would be the development of a fishery in the reservoir. The reservoir would probably be oligotrophic or mesotrophic (many questions regarding potential productivity need to be researched). A minimum pool of 10-15 percent of total should be provided.

Land quality would probably decline from its present value for timber production and farmsteads. Any archeological resources present, probably of the minor summer activities types, would be negatively affected by fluctuating water levels and wave action.

Advanced 7-1/2-minute Geological Survey quadrangle maps, Mt. Stuart 2SE, 2SW, 3NE, and 3NW were used in developing the preliminary area-capacity curve and Forks Reservoir map.

Geology on the Site

Data Reviewed

Preliminary Findings Report, Yakima River Basin Enhancement Project, October 1982

Field Review of Potential Reservoir Site by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington, USBR, November 1981

Site Geology.--The dam and reservoir sites are on the north limb (flank) of a very gently sloping syncline. The axis of the syncline plunges very gently to the southeast. The site is in the middle and lower part of the Roslyn Formation, variously described as arkose, sandstone, and shale. The formation is poorly exposed in the area (along some roadcuts and in several places along the south bank of the Teanaway River). Where exposed, the formation is a white to yellow, massive, arkosic, medium-grained, fairly soft sandstone that readily breaks down to a sandy soil. The sandstone can easily be broken with a light hammer blow. The formation appears to dip very gently downstream. The permeability of the formation is probably low.

The wide valley floor is covered with fine-and coarse-grained alluvium to an estimate depth of 75 feet. Stream terraces also occur along some of the valley sides. The depth of overburden on the abutments probably varies from 5 to 40 feet deep.

The adequacy of the bedrock to support the dam and appurtenant works is a problem that needs to be resolved. There is a possibility that coal seams are present in the sediments on the right abutment.

The depth to bedrock across the wide valley floor at the axis of the damsite needs to be defined.

Borrow materials for construction of the dam need to be identified. Explorations will be needed to determine types and quantities of impervious, pervious materials, and riprap.

Design

Data Reviewed

The data reviewed by the designers was limited to:

Preliminary Findings Report, October 1982

Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (November 1981)

Structural Features

Embankment Dam.--As indicated by the previous section on damsite geology, the data available on site geology and borrow availability are extremely limited. It would appear that considerable overburden may overlie bedrock in portions of the valley section and up to 40 feet in depth on the abutments. The height of the dam structure above streambed is approximately 290 feet. Therefore, it is very important to know something of the foundation conditions. If the assumptions of depth to bedrock and availability of borrow is proven, the construction of a rolled earthfill embankment with a cutoff trench to bedrock appears to be feasible.

Of great importance to the embankment design will be the depth and composition of overburden materials at the site (both in the valley section and the abutments), and the quantity and composition of borrow materials available. A preliminary assessment of the potential for seismic activity in the area of the damsite may also be of much importance, depending on the findings of the foundation exploration. The competence of bedrock and verification of coal seams within the right abutment may also be determined through the foundation exploration.

Spillway and outlet works.--for an embankment dam for the dam axis located at the proposed downstream location the spillway would be best located on the left abutment. An uncontrolled ogee crest entrance and an open-chute spillway with a stilling basin would be required to accommodate the large predicted maximum probable flood. The depth to bedrock on the left abutment will have to be determined to ascertain that adequate foundation exists for the spillway structure. There are indications from preliminary inspections that considerable depths of alluvium exist high on the abutment. Excavation for the spillway inlet structure will probably require fairly deep excavations into the hillside.

A spillway located on the right abutment would probably require less excavation for the inlet structure. However, the deep draw just downstream of the dam would not allow an alinement of the chute which would provide adequate foundation for the slopes required. If the chute slope followed the topographical slopes and discharged into the draw, there could be a threat to the safety of the dam by headcutting due to high velocity flow.

The outlet works would be best located as a tunnel through the left abutment. Further study would be required to coordinate the outlet works basin with the spillway basin. Tunneling problems could be encountered if shale seams exist along the alinement. Blocky sandstone could also be a problem, but this can be remedied with adequate support and tunneling methods. A drop inlet structure with trashracks and the inlet sill located above reservoir sediment level. Tailwater and degradation studies should be performed so that the hydraulics of the structures can be determined. In addition, fish requirements should be assessed so that designs for fish screens and temperature and water quality control can be provided.

RCC (Roller-Compacted Concrete) or a composite concrete and embankment dam at the proposed site would be 290 feet high, the dam would be 5,050 feet long with a crest elevation of approximately elevation 2448. It would have a capacity of 260,000 acre-feet. An RCC may be economically feasible at this site. The preliminary maximum probable flood has a peak of 76,700 ft^3/s and a 5-day volume of 247,000 acre-feet. This flood would require a relatively large spillway which would be quite costly if located along either abutment. Placing the spillway over the RCC dam would result in a saving in spillway cost, but may not balance the increased material and construction costs relative to those of an embankment dam. The location of the outlet works through the dam may also result in a cost saving. Another consideration which affects the economic feasibility of building an RCC dam is the depth of alluvium in the channel area. At present there has been no investigation to determine this depth. Site team geologists, however, have speculated that this depth may range from 75 to 100 feet. If this is the case, an RCC dam may be less feasible because of the necessity to attain firm formation for the foundation of the dam. Additional data will be required to adequately assess this problem. Construction materials for an RCC dam may be easier to acquire in the reservoir and stream area because of wider ranges of acceptability in property and gradation requirements than for an embankment dam. Identification of construction material quality, quantity, and type will be required to substantiate this assumption. It must be noted that the Bureau of Reclamation has not absolutely quantified unit construction costs to be applied at an RCC Dam. Further study will be required to arrive at applicable parameters to be used for comparative estimates.

The abutments and foundation at this damsite consist of weak sandstone and some shale seams. There will probably be strain related problems resulting from variable rock quality and shale seams. Proper abutment and foundation treatment will be required to handle these problems.

Because of the runoff availability and size of the reservoir a longer than normal time may be required for reservoir filling. There is a concern related to reservoir rim stability and critical areas should be adequately treated and/or monitored during reservoir filling.

Another structural option would be to build a composite dam at this site. This would consist of a concrete center section, which would serve as a spillway, and abuting embankment sections on either side. This could limit the cost of quantities at the foundation while providing a more compatible structural condition at the abutments and allowing a cost saving by locating the spillway over the dam. The same requirements concerning materials and further investigations as noted in RCC considerations would apply.

Additional Data Required

For Elimination Process

Surface reconnaissance to identify borrow availability

Two drill holes in valley section to determine composition of overburden and depth to firm formation

Estimate of depth to firm formation on abutments

Possibly a preliminary assessment of the potential for seismic activity in the area of the damsite

Review of assumed existing data:

1. Drill logs of local wells

2. Corps of Engineers geologic work in the area

Flood hydrology including diversion floods

Topography 1-inch equals 100 feet, 4,000 feet downstream, 2,000 feet upstream. Also, surface geology at the same scale

Tailwater

Outlet works - discharge and head requirements

Reservoir operation requirements and allocations

Access requirements

For Appraisal Design (in addition to the preliminary assessment)

One hole 450 deep in each abutment

Four holes 200 feet deep in channel*

One hole on left side--upstream of stilling basin 30 feet into rock

Auger holes and test pits for borrow

Analysis or evaluation of coal in reservoir

Riprap source

Power availability

*Note that permeability testing and possibly some standard penetration testing may be required in these additional drill holes.

HORSETAIL DAM AND RESERVOIR

Introduction

Horsetail was visited Thursday afternoon, November 4. The weather was cloudy and cool probably in the high 30's. The DSRT visited this site Thursday afternoon, November 4, 1982.

Description

Horsetail damsite (also known as Little Naches damsite) is located on the Little Naches River about 1-1/2 miles upstream of the confluence of the Bumping River and about 1/2 mile upstream from Horsetail Falls, in the Snoqualmie National Forest. Reservoir sizes from 13,000 to 88,000 acre-feet are being studied.

An embankment dam is anticipated at this site. With a crest elevation of 2864 the dam would be about 234 feet high, have crest length of about 1,000 feet, and contain about 2.6 million cubic yards of embankment material. A dam rising this high above stream level would create a reservoir with a capacity of 88,000 acre-feet. The reservoir would extend over 4 miles upstream and would inundate about 1,100 acres of land (about 400 acres of bottomlands, brush and tree covered, and the remainder in forested and dry grazing land). The reservoir would also inundate several miles of Forest Service roads and trails and three Forest Service camps. These roads will have to be relocated because they serve upstream campgrounds and lookout stations.

Hydrology

Hydrologic data available indicates an excellent ratio of inflow to capacity (80,000 total acre-feet size) even in the driest years, indicating an excellent refill capability. The reservoir would be expected to fill in all years or all but 1 or 2 years. If the size of the reservoir were doubled, this site would still have a good refill capability--near that of Kachess Reservoir in the existing system; slightly less than Tieton enlargement, Devils Table, and Cle Elum enlargement; but better than Forks or Bumping Lake Lake enlargement. The location within the basin is very good to excellent because it can satisfy the critical need of the upper Naches basin.

The reservoir drainage area is about 145 square miles, and the average annual runoff is 177,000 acre-feet. Based on reconnaissance level data, the inflow design flood at the damsite is estimated to have a peak flow of 68,000 ft^3/s and a 5-day volume of 218,000 acre-feet.

Environmental Considerations

Primary production in Horsetail Reservoir will be very similar to Wymer Reservoir. A reservoir larger than the 88,000-acre-foot size will have a reduced level of fish production per unit of surface area, which will begin to approach fisheries such as the present Lake Cle Elum. Water from the smaller Horsetail will be warmer than most other alternatives but will be cooler as the reservoir capacity is increased.

Anadromous fish enhancement potential is only moderate because of location (could not provide flows in the Bumping River) and the lack of carryover storage. The reservoir would inundate several miles of anadromous fish spawning habitat, primarily used by steelhead. Wildlife use is lower than potential due to heavy recreation use in the area but is still significant and would probably require developed winter range for mitigation. The resident fishery is also a low value, put-and-take fishery, but the use is quite high. Potential for a reservoir fishery is moderate. The reservoir would be oligotrophic and should have a minimum pool of 15 percent of total storage.

The preliminary area-capacity curve and reservoir map were developed using Geological Survey 7-1/2-minute quadrangle maps, Old Scab Mountain and Cliffdell, Washington, and advanced 7-1/2-minute quadrangle maps, Snoqualmie 4SE and 4SW.

Geology on the Site

Data Reviewed

Preliminary Findings Report, Yakima River Basin Water Enhancement Project, Washington, October 1982

Field Review of Potential Reservoir Site by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington, November 1981

Site Geology.--The damsite is on the southwest limb of a gently sloping syncline, as the basalt flows dip very gently northeast.

The damsite is in a steep-sided, narrow, box-like canyon cut into hackly jointed but hard and competent basalt that outcrops on the abutments in some places in near-vertical cliffs.

The fairly flat canyon bottom is about 300 feet wide and floored with alluvium up to an estimated 10 feet deep. About 1 mile upstream from the dam, the reservoir widens out to one-half mile and contains alluvial sediments of various gradations.

Potential problems relating to geology may occur in connection with road relocations necessary for the construction of this site. No obvious problems, are present in respect to the dam foundation, reservoir rim stability, or seepage.

Design

Data Reviewed.--The data reviewed by the designers was limited to:

Preliminary Findings Report (October 1982)

Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (November 1981)

Structural Features

Embankment Dam.--As indicated by the previous section on damsite geology, the data available on site geology and borrow availability are extremely limited. Two heights of dam at this site are currently being examined. The first would have a height above streambed of approximately 234 feet and a crest length of approximately 1,000 feet. The dam would be entirely within the confines of the steeped-walled canyon with little surficial material overlying the basalt. A higher dam at the same site would rise approximately 80 feet higher than the first but would require a wing dike section to be constructed on the left abutment area. This would approximately triple the crest length. The type of structure to be constructed at this site would not appear to be limited by the foundation conditions or site topography. Therefore, the availability of borrow in the area may be a determining factor, and it is essential that some investigations be done prior to appraisal design. Since surficial materials will most likely be completely removed in foundation stripping, the potential for seismic activity is a less important parameter at this site than at sites with liquefiable foundation materials. A concrete-faced rockfill or zoned rockfill with impervious core are possible embankment dams for this site, depending on borrow availability.

Concrete Arch Dam.--The canyon walls at this location slope steeply from the valley floor to approximately elevation 2800. From this point, on the left abutment, the slope flattens to approximately 3:1. On the right abutment, the slope decreases to about a 2-1/2:1 from elevation 2800 to elevation 3000. Above elevation 3000 the slope is gradual. The dam heights are anticipated at this site (both suitable for a concrete structure). The lower dam would be approximately 234 feet high and about 1,000 feet wide with a reservoir capacity of 88,000 acre-feet. Its foundation and abutments would be contained within the limits of the U-shaped portion of the canyon. This, along with the hard basalt foundation, contribute to the feasibility of the lower dam alternative. The high dam alternative would be approximately 80 feet higher with an increase in reservoir capacity of about 80,000 acre-feet. Abutment rock strength in the upper reaches appears to be adequate and the increased hydraulic loading could be adequately resisted by the foundation and lower reaches of the abutments. However, adequate remedial work would be required at the flatter abutment slopes. Thrust blocks at both abutments can be constructed to handle lower head stress transfer. The larger reservoir could be a very feasible and important consideration in the overall project plan. Its impact on the upstream areas, in addition to those addressed for the low dam, should be addressed for further studies.

For the high dam alternative, an embankment dike would be required in the low area near the left abutment.

The design flood is estimated to have a peak of 68,000 ft^3/s and a 5-day volume of 218,000 acre-feet. Locating the spillway over the dam to handle the large discharges anticipated from this flood create positive economical considerations concerning a concrete dam alternative. In addition, the strength of the rock and shallow alluvium and colluvium depth create ideal conditions for this type of structure. Further study will be required to determine the stability of the groins and downstream foundation to handle the large flood discharges.

There appears to be fairly large quantities of sand, gravel, and cobbles in the area. However, there has not been material survey conducted to ascertain adequate quality and quantity of these materials for concrete aggregate.

The outlet works can be located through the dam. Its inlet should be located above the anticipated reservoir sediment level.

<u>(RCC) Roller-Compacted Concrete Dam</u>.--The positive aspects previously mentioned in assessing the feasibility of a concrete arch dam, such as, competent abutment and foundation rock and economical aspects of locating the spillway and outlet works at the dam, apply to an RCC dam. However, an RCC dam is a gravity dam involving larger quantities and different types of materials which could impact adversely on its economic feasibility. Nonetheless, and economical study should be considered when determining final alternatives at this site.

<u>Spillway and Outlet Works for an Embankment Dam</u>.--The design flood previously mentioned will probably require a large spillway. Both dam height alternatives will present similar conditions, except that a smaller spillway may be required for the high alternative because of larger reservoir capacities in the higher reaches. If, however, the spillway was located on the right abutment, more excavation into the hillside would be required for the high alternative. There appears to be adequate width on either abutment to accommodate a free overflow crest, concrete-lined chute and stilling basin. However, a spillway on the right abutment may require a longer chute and more excavation into the hillside. For the high dam option, it may be feasible to locate the spillway in the dike if adequate depth of foundation is available for the spillway inlet. Gated spillways could be economically feasible for both dam heights and should be studied.

The outlet works should be located, as a tunnel, through either abutment. It appears that the tunnel could be shorter through the left abutment. The inlet should be above sediment level. The outlet works could be utilized for diversion, evacuation, and downstream service requirements.

Additional Data Required

<u>For Elimination Process:</u> None

<u>For Appraisal Design</u>

Topography (1" = 200') 5-foot contour interval

Geologic mapping on the topography

Foundation exploration for a saddle dike on the left abutment will be required if this site prevails after screening has been completed

Exploration will consist of two drill holes about 50 feet deep

Reservoir operation

Bypass requirements

Updated PMF (Probable Maximum Flood)

Tailwater

Diversion floods

Outlet works operation, head and discharge

Power availability

Access

Topography (1"=2000')

Geologic mapping of reservoir area and road relocation

Materials reconnaissance for location and quantities of earthfill, rockfill, and concrete aggregate materials

Note that comparison studies of different embankment heights, as well as cost comparisons between different dam heights, may prove useful prior to appraisal design for this site.

TIETON (RIMROCK) DAM AND RESERVOIR ENLARGEMENT

Introduction

Tieton Dam (Rimrock Lake) was visited Friday morning, November 5. The weather was cloudy and raining with temperatures in the 30's. The DSRT visited this site Friday morning, November 5, 1982.

Previous Studies

Tieton Dam is located on the Tieton River, a tributary of the Naches River, about 40 miles west of Yakima. The Naches River flows southeast to join the Yakima River near the city of Yakima.

This site has been identified in several previous studies. A memorandum from the Chief, Planning Technical Services, dated June 20, 1980, regarding the enlargement of Cle Elum and Tieton Dams and the Formulation Working Document, Cle Elum and Tieton Powerplants, Yakima Project, Washington, June 1981, are the most recent studies identifying the structure.

Description

Tieton Dam is a semihydraulic earthfill structure with a concrete core wall; structural height is 319 feet and hydraulic height is 198 feet. The dam rises a maximum of 205 feet above the bed of the Tieton River to a crest elevation of 2935 feet and has a crest length of 920 feet and crest width of about 40 feet. The core wall extends about 2 feet above the crest to form a parapet. The dam embankment contains approximately 2,049,000 cubic yards of material.

The spillway is a concrete-lined open channel in the left abutment and consists of a concrete gate structure with six drum gates, a trapezoidal concrete-lined chute, a concrete stilling basin, and an outlet channel leading to the Tieton River. The six drum gates are 65-foot by 8-foot devices that operate independently and can control the reservoir level between elevations 2918 and 2926 feet. The total effective crest length of the drum gates is 390 feet, and the maximum flow capacity of the spillway is 39,200 ft^3/s.

The outlet works consist of a tunnel through the left abutment, an auxiliary inlet shaft that joins the main tunnel, trashrack protected structures at the inlets, and two 60-inch and one 24-inch needle valves. The tunnel is 2,186 feet long, consisting of four sections that vary in cross-sectional area of about 250 square feet. The upstream inlet is protected by a concrete intake tower about 1,683 feet upstream of the dam core wall. The auxiliary intake tunnel is approximately 8.5 feet in diameter, protected by a trashrack structure at the inlet, and connects with the main tunnel about 400 feet upstream of the dam core wall.

A gate chamber is located at the dam core wall where flows are split into two 72-inch-diameter pipes each controlled by a 5-foot by 6-foot emergency high pressure slide gate. The two 72-inch pipes terminate about 500 feet downstream of the core wall in two 60-inch needle valves at the valve house. A 30-inch-diameter Y is connected across the two 72-inch outlet pipes and terminates in a 24-inch needle valve. Flows from the needle valves discharge into a stilling basin protected with riprap. Maximum discharge from the two 60-inch valves at full pool level is about 2,590 ft^3/s. Use of the smaller needle valve in conjunction with both large valves would not appreciably increase the maximum discharge capability.

Any increase in the active storage capacity of the reservoir would require complete replacement of the spillway structure. The outlet works could accommodate a modest water surface rise of the magnitude of 5 to 10 feet, without major modifications, and for the outlet works there are no operational or other constraints to raising the dam.

However, any attempt to incorporate power features into the existing outlet works would require major modifications of the structure, including new gates, pipes, and control structure. In addition, any modification that reduces the discharge capability of the existing outlet would result in compromising the reservoir emergency evacuation capabilities.

Rimrock Lake, the Tieton Dam impoundment, has a surface area of about 2,525 acres at full pool. Total active storage is 198,000 acre-feet. The dead storage is negligible since the intake for the dam outlet is located in the former bed of the Tieton River.

Hydrology

As spills from Tieton Dam occur in the majority of the years of record, the feasibility of increasing the storage of Rimrock Lake to use these spills was examined.

The average runoff from the basin for the period of record was 370,000 acre-feet. To obtain an active storage of 370,000 acre-feet would require raising Tieton Dam 56 feet to a crest elevation of 2991. Any further increase in height would result in what would probably be unacceptable encroachment on Clear Creek Dam. With an active storage equal to the average annual runoff, in an average year all the runoff from the basin could be regulated to meet demand throughout the year. In dry years the reservoir may not fill, and in wet years, flood control releases or possibly spills may still occur.

An examination of flow data and historical storage and releases from Tieton Dam showed that under present conditions all of the water supplies would be used to meet existing irrigation needs during the 1929-31 period and nearly all during the 1940-45 period. Yield of additional storage would come from carryover into these periods.

Assuming that all new water supplies developed from the increased storage would be used to supply new land irrigation, the yield would be 172,000 acre-feet (370,000 minus 198,000) divided by 6 years (1940-45 period) or about 30,000 acre-feet (disregarding losses). The 30,000-acre-foot demand could be met during the rest of the study period (1926-76).

Environmental Considerations

Rimrock Lake provides a major kokanee fishery in central Washington. However, the lake has no dead storage, and during years of extremely low runoff the lake is essentially emptied, seriously degrading the fishery. Fish apparently begin to emigrate from the reservior when the drawdown reaches about 40,000 acre-feet, and emigrating fish (kokanee) die because they cannot survive in a stream environment. In 1979, Rimrock Lake was drawn down to 200 acre-feet, and an estimated 6 million kokanee that would have provided the sport fishery for 1981-83 passed downstream. About 450,000 kokanee fry were planted in 1980 to provide a sport fishery for 1982-84. The present runoff forecast indicates another drought and that Rimrock Lake may be emptied in 1981, which would be the third time in 8 years. The Washington Department of Game estimates that a minimum pool of 30,000 acre-feet in Rimrock Lake is needed to preserve and maintain the fishery. However, the potential for changing operations to maintain a minimum pool of 30,000 acre-feet appears small under existing development. All storage is presently allocated to irrigation, and this storage becomes more valuable to irrigators during water short years when Rimrock Lake would be drawn down to very low levels.

Enlargement of Rimrock Lake will offer little change from existing conditions. Fish production will increase, but the fish will be somewhat dispersed. The slight decrease in total phosphorus concentration will not improve visibility enough to improve angling success.

Anadromous fish enhancement potential is minor because of the small amount of new storage possible and poor location on the Naches system. Impacts on wildlife would be moderate, and mitigation for lost goose brooding habitat and wildlife habitat may be required.

Geology of the Site

Data Reviewed

Safety Evaluation of Existing Dams, Geology Report, Tieton Dam, August 1982

Feasibility Geologic Report, Tieton Dam Powerplant, January 1982. SEED, Evaluation Report for Tieton Dam, April 1981

Site Geology

Tieton Dam is located on the eastern slope of the Cascade Mountain Range that experienced intense volcanism during the Tertiary Period. In Pleistocene times, the area was subjected to intense glaciation. After the glaciers retreated, the Tieton River cut through much of the glacier deposits.

The steep, narrow canyon at the damsite has been eroded downward through much of the glacial deposits and into the andesite-microdiorite rock complex which occurs on the left abutment and part of the right abutment. Much of the right abutment of the dam is on the glacial materials. In the excavation of the dam in the stream channel, an older sedimentary rock (shale) was exposed in the foundation. This sedimentary rock is probably an older formation that was intruded by the andesite-microdiorite complex.

Problems include:

1. The main problem to raising the dam is the integrity of the structure. There has already been some concern with the deflection of the core wall and settlement of the embankment - concerns that would be increased with an increased height of dam.

2. Further explorations may be needed to determine the liquefaction potential of the embankment fill.

3. Further study needs to be made of the active slide behind the spillway stilling basin.

4. Borrow materials for embankment requirements have not been identified.

5. The geologic problems related to a relocated highway along the reservoir have not been addressed.

Design

Data Reviewed.--The data reviewed by the designers consisted of:

Cursory review of correspondence and data files for Embankment Dams Section, E&R Center

SEED Data Book

Evaluation Report for Tieton Dam, April 1981

Preliminary Findings Report, October 1982

Structural Features

Embankment Dam.--Tieton Dam is an existing earthfill structure, placed by the semihydraulic fill method. The embankment has a height of 205 feet above streambed and a crest length of 920 feet. The water barrier is provided by a central reinforced concrete core wall and thin upstream clay puddle core. The concrete core wall has a maximum height of about 320 feet. The dam has an average upstream slope of 3:1 and downstream slope of 2:1.

The embankment was placed by dumping material at the outer slopes and hydraulically washing the fines to the center against the concrete core wall. On the upstream side of the core wall a pool was maintained to settle out the fine material, forming the clay puddle core. Downstream of the core wall, care was taken to drain off the fine clay particles, producing a semi-impervious material.

The dam has been reviewed with regard to the feasibility of increasing the structural height by a maximum of 56 feet. The conclusions of the SEED Team (Evaluation Report, 1981) are considered as valid indicators of the current condition of the existing structure and are repeated below:

Based on available information, Tieton Dam and appurtenances are currently judged satisfactory for safe operation. Close monitoring of embankment deflections and seepage conditions and periodic evaluation of monitoring data are necessary to ensure that safe conditions prevail and to determine the need for future investigations regarding structural integrity.

Current conditions at the structure considered capable of affecting the future safety of the dam are primarily related to embankment and corewall deformations and seepage conditions in the foundation and embankment.

A seismic evaluation for Tieton Dam has never been performed. A seismic evaluation to establish an MCE (maximum credible earthquake) and to analyze embankment stability, deformations, liquefaction potential, and other effects of seismic loading is required for a more complete safety evaluation.

Landslides within the reservoir area and at the damsite do not appear to present safety hazards for the structure.

Of particular interest in evaluating the feasibility of raising the existing dam would be information about the embankment phreatic water surface under varying reservoir water surface elevations, and information on embankment and foundation materials from the standpoint of both static stability and liquifaction potential. A response to the question of dam raising (memorandum to Chief, Division of Planning Technical Services, from Chief Design Engineer, March 13, 1982) indicates that: Of particular concern are indications of significant core wall deflections over time which has undoubtedly caused extensive cracking. Therefore, the embankment's water barrier capabilities depend on the current condition of the puddled clay core. Significant embankment settlement (up to 5 feet) has been recorded over the core. The integrity of this core, at least in the upper portions, is questionable. A preliminary seismic evaluation would be of great benefit.

In lieu of the above data, a preliminary assessment of the feasibility in raising the existing dam would be that an increase in dam height of approximately 3 to 5 feet would be the maximum allowable without considerable disruption to appurtenant structures. The increase in embankment height of 5 feet may be assumed to be accomplished by the addition of embankment material to the dam crest with a backslope to the uppermost berm on the downstream face. Significant excavation of the crest may be required to ensure an impervious core. The maximum of a 56-foot rise in embankment height may be assumed to be accomplished by complete removal and replacement of the existing structures although little data are currently available with regard to borrow locations or availability. These preceding assumptions may be useful to the elimination process.

Spillway and Outlet Works

The existing spillway consists of six drum gates, a concrete-lined chute, and a stilling basin. Raising the reservoir 10 feet would require replacement of the gates and rehabilitation of the chute and stilling basin.

Additional raising of the reservoir, depending upon head and discharge requirements, could create a situation where structural capacity could not be adequately increased in the limited space available at the left abutment.

The outlet works could accommodate a rise of water surface of 5 to 10 feet without modification. However, evacuation capability could be adversely impacted for a 10-foot or higher rise in water surface. The adequacy of the outlet works for evacuation is addressed in the subject SEED report.

Required modification of the spillway and outlet works would be quite costly and should be studied in detail in conjunction with any anticipated rise in reservoir water surface.

Additional Data Required

For Elimination Process.--None--use the designer's assumptions.

For Appraisal Design.--The recommendations of the SEED Team and status (as reported in a SEED Examination report memorandum dated July 1, 1982) are useful as a guide for initial data required to further evaluate the safety of the existing structure and are listed below. Additional data requirements will be outlined pending receipt of these data and results of the elimination process. The status of previous SOD recommendations as of July 1982 are:

78-SOD2-A - Install instrumentation capable of determining embankment seepage conditions and phreatic surface.

Status: In April 1982, four porous-tube piezometers were installed to determine embankment seepage conditions and phreatic surface near the maximum section of the dam. Instrumentation included one porous-tube piezometer which was installed in DH-101 on the crest of the dam at station 6+20 about 10 feet downstream from the core wall and three porous-tube piezometers which were installed in DH-102 on the crest of the dam at station 6+30 about 10 feet downstream from the core wall.

78-SOD2-B - Revise the current IDF and perform flood routing studies using the recommended IDF.

Status: The IDF is being revised by the Hydrology Branch.

78-SOD2-C - Perform a seismic evaluation for Tieton Dam.

Status: Outstanding.

78-SOD2-D - Review adequacy of the current schedule for obtaining embankment and core wall deflections. Consider obtaining deflections during periods of high reservoir water surfaces rather than, or in addition to, measurements after annual reservoir drawdown.

Status: Outstanding.

78-SOD2-E - Perform timely analyses of deflection, settlement, and seepage data. Based on these analyses, consider additional investigations to more adequately determine the water barrier capabilities of the core and core wall.

Status: Outstanding.

78-SOD2-F - Establish and monitor permanent surface settlement points on the embankment adjacent to the upstream side of the core wall.

Status: Outstanding.

78-SOD2-G - Consider installation of permanent instrumentation capable of determining deflections at the bottom of the inspection wells.

Status: Outstanding.

WYMER DAM AND RESERVOIR AND AFTERBAY DAM

Introduction

Wymer Afterbay Dam and Wymer Dam and Reservoir sites were visited Tuesday morning and early afternoon, Tuesday, November 2. The weather was sunny and bright with temperatures about 50 to 55° F. The DSRT visited this site Tuesday, November 2, 1982, and met with the landowner, Jack Eaton, to discuss problems associated with this site.

Description

An embankment dam is anticipated for this site. With a crest elevation of 1873 the dam would be about 515 feet high, have a crest length of 4620 feet, and contain about 30.7 million cubic yards of embankment material. The reservoir capacity would be about 320,000 acre-feet and would inundate about 2,300 acres of dry grazing lands.

In order to fill this reservoir, excess Yakima River water would be diverted during the off irrigation season at the Kittitas Reclamation District's (KRD) diversion point below Keechelus Lake and transported in the district's North Branch Canal to the termination point west of the Badger Pocket Area. From that point, water would be conveyed by gravity through a 3-1/2-mile-long tunnel into the North Fork of Squaw Creek where it would flow into the reservoir.

The KRD canal would be improved and the lower end of the North Branch Canal enlarged, Swauk pumping plant constructed on the Yakima River at Thorp, and a tunnel constructed at the lower end of the North Branch Canal through Manastash Ridge to the Wymer site. About 3 miles of Interstate 82 would be relocated.

Hydrology

The water supply to this site comes from three sources potentially: (1) Squaw Creek--minor, (2) pumping from the Yakima River--either near Thorp into the KRD canal or near the mouth of Squaw Creek, and (3) diversions from the Yakima into the KRD canal. The potential of these sources is dependent on the instream flow levels. In this regard the water supply for Wymer is not well defined at this time. However, best estimates thus far indicate a fairly good ratio of inflow to capacity for an offstream site. The ratio is about the same as the Bumping Lake enlargement (inflow averaging about half the capacity). As such, this would be a site for long-term carryover storage. In most all years the reservoir would only be partly drawn down, although when drawn down all the way during a drought it may take 3-5 years to refill.

The drainage area of Squaw Creek is about 98 square miles, and the average annual runoff is 248,000 acre-feet. Based on reconnaissance level data, the inflow design flood at the damsite is estimated to have a peak flow of 50,500 ft^3/s and a 5-day volume of 161,000 acre-feet.

Environmental Considerations

The construction of a reservoir on Squaw Creek would have an effect on water quality. Average depth of the water in the 320,000-acre-foot reservoir would be about 150 feet when full. An annual yield of 100,000+ acre-feet is projected for use mainly as fish flows. Under these conditions, the water in the reservoir would be replaced every 3 years.

The use of the North Branch Canal to divert water to the offstream storage site would occur during the nonirrigation season (October through April). Water at Easton Diversion Dam on the Yakima River is of excellent quality. The Bureau of Reclamation has monitored water quality monthly at Cle Elum on the Yakima for several years. Cle Elum is the first measuring station below Easton Diversion Dam. The following is a summary of selected parameters on 36 water samples collected over a 4-year period (1974-77).

EC $\times 10^6$			Ortho P mg/L			Total P mg/L			NO_3-N mg/L			Suspended Solids mg/L		
High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean	High	Low	Mean
94	40	59	.030	.000	.005	.080	.000	.023	.50	.00	.04	34	1	6

Based on data collected by the Bureau of Reclamation on the effects of storage on water quality in the Yakima basin, little change would be expected.

The reservoir would stratify during the summer months with warm surface water and cold water in the deep zones. The thermocline would probably develop at a deeper depth than other reservoirs in the basin because there would be no inflow to the reservoirs during the summer months. Positive impacts would occur because of improved flows in the 1-1/2-mile section of Squaw Creek below the dam, possible lowered summer discharge temperatures if water is drawn from the hypolimnion, and from formation of a reservoir fishery and recreational site.

The primary wildlife values at this site are for raptors, especially prairie falcons. Other raptor species here include Swainson's hawks, osprey, red-tail hawks, and golden eagles. The Bureau of Land Management is currently considering establishment of a raptor preserve in the Burbank Valley over the next ridge toward Yakima.

Chukar, gray partridge, pheasant, California quail, and sage grouse are found in the area. The largest known sage grouse strutting area is found here. The riparian cover present provides insects and winter thermal cover. The area has a few resident deer, and some deer winter in the valley. A small remnant pronghorn antelope herd is found here.

At present, there is no significant fishery in Squaw Creek. Prior to the heavy grazing regime, it was reported that the creek supported spawning runs of trout.

Negative impacts from constructing an offstream storage reservoir here would be a significant decline in upland game birds, loss of strutting ground, elimination of the resident deer, probable disturbance of the remnant antelope herd, reduction in Yakima River flows to 150 ft^3/s from the KRD's diversion point below Keechelus Lake to the mouth of Squaw Creek, and complete displacement of all other wildlife within the reservoir area. The feeder canal system from the Yakima River could be hazardous to big game. The reduction in Yakima River flows would be detrimental to both resident and anadromous fish, river boaters, and probably waterfowl.

The reservoir would probably develop into a good, highly used smallmouth bass and planted trout fishery. It would also be a popular location for water sports such as swimming, water-skiing, and boating. Realization of benefits would require certain restraints on magnitudes of discharge rates and fluctuations and reservoir level fluctuations.

The beauty of the existing canyon would be inundated. Archeological sites of unknown significance remaining after salvage would be damaged by fluctuating water levels and wave action.

The preliminary area-capacity curve and reservoir map were developed using Geological Survey 7-1/2-minute quadrangle maps, Wymer and Badger Gap.

Geology of the Site

Data Reviewed

Preliminary Findings Report, Yakima River Basin Water Enhancement Project. (October 1982)

Field Review of Potential Reservoir Site by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington, November 1981

Site Geology.--Relatively flat-lying lava flows of lightly to moderately fractured basalt forms the canyon walls of Squaw Creek. The canyon sides rise on a slope of about 20°, scattered deposits of slope-wash up to 5 feet thick occur on each abutment. The narrow canyon bottom is underlain by alluvial deposits estimated to be less than 10 feet deep.

There is no known faulting within several miles of the dam and reservoir site.

Design

Data Reviewed.--The data reviewed by the designers were limited to:

Preliminary Findings Report (October 1982)

Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (November 1981)

Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (November 1981)

Preliminary Assessment Report, Squaw Creek Off Channel Storage Project - Steve Mitchell - State of Washington (April 1972)

Structural Features

Embankment Dam.--As is evident from the previous section on damsite geology, the data available on site geology and borrow availability are extremely limited. The height of the embankment structure required at this site is slightly in excess of 500 feet with a crest length of over 4,600 feet. Because of the indications of massive basalt overlain by shallow alluvial deposits (10 feet at most) over the entire site, there is little concern at this time for the competency of the foundation. However, the axis should be shifted upstream about 1,000 feet from that previously assumed. The assumed left abutment appears too narrow to support the embankment and provide a sufficiently long seepage path through the abutment. Borrow material for an earthfill embankment appears scarce. Therefore, consideration should be given for a concrete-faced rockfill structure at this site. Since basalt outcroppings are found within the reservoir area in many locations, the borrow source for rockfill is likely to come from the reservoir rim. Processing of the rockfill for the gradations necessary within the embankment will be required, and may yield concrete aggregate for the concrete face and hydraulic structures. Although little data are available on seismic potential in the area, there would be little concern for the performance of a rockfill dam under relatively large seismic loading at this site.

An afterbay dam will probably be required downstream of Wymer Dam if pumping is required from the Yakima River. The afterbay dam is envisioned to have a structural height of about 100 feet. Site foundation conditions appear to be much the same as at the Wymer site. Since borrow availability would still be in question, some type of rockfill structure may be best suited for this site also.

For the purposes of the elimination process, a concrete-faced rockfill dam with 1.5:1 upstream and downstream slopes may be assumed for Wymer Dam. A similar structure may be assumed for the afterbay. The entire foundation may be assumed to be stripped to bedrock at each site. Data gathering for the elimination process is not critical for an adequate determination of construction costs.

Spillway and outlet works for rockfill dam.--Since the flood potential is low on this basin and the storage per foot of reservoir is fairly large, it is reasonable to store the entire flood and provide an emergency spillway for safety of the dam. The emergency spillway could be located through the reservoir rim approximately one-half of a mile upstream of the right abutment. An excavated channel with a grade sill located at elevation 1830 or 1870, depending on the reservoir capacity, would direct excess storage down a draw to Scorpion Coulee Creek and to the Yakima River. The outlet works would be best located as a tunnel through the right abutment. A conduit through the embankment would not be feasible because of high embankment loads on the structures. The outlet works would be utilized to satisfy downstream requirements, evacuate the reservoir in case of emergency, and possibly to evacuate a flood surcharge pool. A drop inlet structure with its sill located at the maximum silt level could be tied into the outlet tunnel located at river level. Locating the tunnel at river level would allow its use for diversion upon closure of the dam.

As was previously mentioned, an afterbay reservoir will be located downstream of the main dam. Therefore, the outlet works tunnel must exit into the afterbay or be extended through the abutment and exited downstream of the afterbay dam. Further studies are required to determine the most feasible outlet work arrangement. Initially, it appears that a tunnel into the afterbay would have problems in stilling discharges and placing the discharge end above sediment in the afterbay. This scheme would be cheaper than the other scheme and would utilize a common exit conduit from the afterbay.

If the tunnel were extended downstream of the afterbay, a stilling basin could be located in the area and utilized both for diversion, evacuation, and required downstream discharges. Sediment buildup would not be a problem in this situation. It is aniticipated that a power-pumping plant capable of pumping approximately 500 ft^3/s be located downstream of the dam along the bank of the Yakima River. This would require a 1-mile-long penstock to the dam. It is planned that discharges for irrigation requirements can be utilized to generate power to offset the cost of pumping water for refilling the reservoir. This penstock can be utilized to provide downstream requirements and could be designed to evacuate the reservoir if the river outlet works were inoperable.

RCC (Roller-Compacted Concrete) or concrete butress.--The strength of the basalt abutments and foundation would be ideal for an RCC or concrete buttress dam. However, there is not adequate natural materials available for either of these types of dams. Concrete aggregate sand and RCC material would have to be crushed and processed from basalt in the area. This along with no potential saving by locating the spillway over the dam would make these dam types relatively expensive.

Additional Data Required

For Elimination Process.--None

For Appraisal Design

Topography (1" = 200') 5-foot contour interval

Geologic mapping on new topography covering damsite, power-pumping plant site, and discharge alinement

Geologic mapping along the alinement of inlet canal and tunnel

Structural height requirements for afterbay

Reconnaissance for borrow availability (earthfill and rockfill materials and concrete aggregate - including quantity, quality, and excavation difficulty)

Hydrology data - maximum probable flood, diversion floods, tailwater studies, sediment studies

Power and pumping plant operating criteria - pumping requirements and power discharges and head requirements

Outlet works discharge versus head requirements

Reservoir operation requirements minimum releases during construction

Information on relocation of highway

Access to the site and structures

Power availability

SATUS DAM AND RESERVOIR

Introduction

Satus damsite was visited Saturday morning, November 6. The weather was clear and warm with temperatures in the 40's. The DSRT visited this site Saturday morning, November 6, 1982.

Previous Studies

The Bureau of Indian Affairs prepared the Irrigation Feasibility Report for the Mabton Project, Yakima Indian Reservation, Washington, dated May 1969, revised August 1972. The report proposed to construct a dam on Satus Creek about 9 miles south and 4 miles west of Toppenish, Washington. The reservoir formed by this dam would have a storage capacity of about 85,000 acre-feet. The first investigation of this dam and reservoir site was made in 1914 by L. M. Holt, Supervising Engineer for the Irrigation Branch, BIA. Using the new criteria to estimate the inflow design flood would necessitate enlargement of the spillway and outlet works, as designed for this feasibility report.

Description

Satus damsite is located on Satus Creek about 9 miles south and 4 miles west of Toppenish, Washington, in section 19, T. 9 N., R. 20 E., W.M. This multiple-purpose storage will be utilized to serve the needs of irrigation, fish and wildlife, and outdoor recreation. Reservoir management would be utilized to maintain water quality control and reduce damage caused by flooding. Reservoir sizes being studied range from 63,000 to 106,000 acre-feet.

An earthfill dam is anticipated for this site. With a crest elevation of 1072 feet, the height of the dam above streambed will be about 182 feet and would have a crest length of about 1,200 feet and would contain about 30 million cubic yards of embankment material. The capacity of the reservoir created by this dam would be about 106,000 acre-feet and would inundate about 1,700 acres of Indian and non-Indian lands.

If this site is developed, about 10 miles of Washington State Highway 97 will be relocated to replace the section of highway that crosses the reservoir area. About 6 miles of 230-kV transmission line, owned by Bonneville Power Administration, would be constructed to replace the high-voltage line that crosses the reservoir area. A cemetery and gaging station would also require relocation. The lands within the reservoir are practically free of timber and heavy brush growth. There is no merchantable timber within the reservoir area, the only trees and heavy brush being located along the bed of the creek. The remaining lands are covered with only light sagebrush. It will be necessary to clear trees and brush along the creek and sagebrush within the reservoir basin.

It is proposed to purchase all lands covered by the reservoir and the area inundated in the damsite and appurtenant facilities. This will include such lands outside the reservoir area to the near legal subdivisions or allotment lines. This area includes both Indian and non-Indian lands.

The most accurate topographic mapping in the area is the Geological Survey 7-1/2-minute quadrangle maps. Toppenish SW., Hembre Mountain, Poisel Butte and Poisel Butte NW., Washington, were used in developing the preliminary area-capacity curve and the reservoir map.

Hydrology

Hydrologic data are available and indicate that the drainage area is about 440 square miles, and the average annual runoff is 105,200 acre-feet. Based on reconnaissance level data, the inflow design flood is estimated to have peak inflow of 148,000 ft^3/s and a 5-day volume of 475,000 acre-feet.

Geology of the Site

Data Reviewed

Preliminary Findings Report, (October 1982) Yakima River Basin Water Enhancement Project

Field Review of Potential Reservoir Sites, by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington

Irrigation Feasibility Report, Mabton Project, Yakima Indian Reservation, Washington, dated May 1969.

Site Geology.--The bedrock is a series of lava flows of the Yakima Basalt Subgroup. Several gently dipping east-west trending synclines and anticlines are present in the area. At the damsite, Satus Creek follows along the center of a syncline. A fault has been located in the north flank of the syncline in the area of the left abutment. The damsite is in a steep-sided, flat-bottomed canyon with basalt cliffs varying in height from 50 feet to more than 100 feet in height. The basalt exposures outcropping in many places along the abutments appear hard and fresh, but moderately fractured. The basalt is highly fractured locally. The valley section is a 700-foot-wide flat floor with about 30 feet of alluvium overlying the basalt.

Adequate amounts of zone 1 material may not be available. The basalts in the abutments exhibit highly fractured zones. Abutment seepage will need to be examined.

Implications of a fault occurring in the left abutment requires and examination of the fault and determinations of its significance as related to abutment stability and abutment seepage.

Examination of the relocations required may reveal geologic-related problems not now known.

Design

Data Reviewed.--The data reviewed by the designers consisted chiefly of:

Mabton Project - Irrigation Feasibility Report and Appendix (Bureau of Indian Affairs dated May 1969)

Preliminary Findings Report (October 1982)

Draft Geologic Appraisal Study of Potential Damsites, Yakima River Basin Enhancement Project, Washington (November 1981)

Structural Features

Embankment Dam.-- A feasibility design and estimate for Satus Dam has been performed by the Bureau of Indian Affairs. The dam designed is an earthfill structure approximately 170 feet high with a crest length of approximately 1085 feet and crest width of 30 feet. Exterior slopes are 3:1 upstream and 2:1 transitioning to 4:1 on the downstream face. The interior zoning consists of wide core of impervious material with shells composed of pervious to impervious fill and a rockfill toe. The dam foundation was investigated through three drill holes in the valley bottom revealing layers of fine-grained materials as well as layers of gravel, cobbles, and boulders to depths of up to 25 feet. A massive basalt formation underlies the overburden in the valley and appears to form both abutments overlain by only a few feet of surficial deposits. No cutoff through the overburden materials has been provided in the design; only a few feet of stripping at the embankment/foundation contact. Some sort of a concrete cutoff structure is provided at the embankment/ foundation contact 50 feet upstream of centerline. According to the cost estimate, some provision for grouting of the foundation has been made, although no discussion was found.

Although there does not appear to be any question about the feasibility of constructing a dam structure at the Satus damsite, some comments about the BIA design may be in order. It would appear that a positive cutoff to bedrock, through the permeable layers of overburden will be required. Positive cutoff may be achieved rather easily at this site with a cutoff trench approximately 80 to 90 feet wide and 1-1/2:1 side slopes. Grouting may then be performed through the base of the trench. Some provision for foundation preparation and slush grouting may also be added to the cost estimate. Some exploration of the abutments, along with water testing for permeability may establish the level of grouting to be anticipated. The zoning of the embankment is acceptable except that no provision for internal drainage has been made. Chimney and blanket drains for a structure this size are not uncommon. The availability (or lack thereof) of the drainage materials may have some impact on the cost estimate. In fact, the availability and soil properties of the borrow material in general is very sketchy. Additional investigation possibly through surface reconnaissance and test pits is warranted to better define the borrow areas.

<u>RCC (Roller-Compacted Concrete) Dam</u>.--An alternative to the presently envisioned embankment dam is an RCC dam. The dam at this site would be about 185 feet high with a crest length of 1,200 feet at elevation 1072 feet. The abutments and foundation consist of hard and fresh moderately fractured basalt. Seepage through the abutments and foundation could be a problem, however, this could be remedied by proper grouting and drainage. A fault has been located in the area of the left abutment and its effect on stability and seepage will have to be determined.

Depth of alluvium in the channel is approximately 30 feet. Extending the dam section to this depth to attain firm formation would be feasible from an economic standpoint.

Based on reconnaissance level data, the design flood is estimated to have a peak of 148,000 ft^3/s, and a 5-day volume of 475,000 acre-feet. This magnitude flood would require a wide spillway which could be economically located on the dam. The outlet works could also be located at the dam. An assessment should be made of impacts downstream due to the high anticipated spillway discharges.

It is probable that materials for the dam would have to be crushed and processed. It will be necessary for this type of dam to determine and investigate a source for required materials.

Additional subsurface investigations will have to be performed to assess abutment adequacy, especially in the area of the left abutment fault zone.

<u>Spillway and outlet works for an embankment dam</u>.--A spillway to handle the aniticipated design flood, with a peak of 148,000 ft^3/s and a 5-day volume of 475,000 acre-feet, would probably be fairly large and expensive. It appears that a spillway with an uncontrolled ogee crest, concrete-lined open chute, and a type II stilling basin could be located on either abutment

to handle the anticipated flood. Excavation quantities would probably be higher if the spillway were located on the left abutment. In addition, consideration should be given to the location of the fault located near the left abutment. Further investigations would be required to determine adequate foundation conditions on either abutment.

Because of fill heights associated with a conduit under the dam, it would be preferable to locate the outlet works as a tunnel through one of the abutments. Further study would be required to determine which location would be best. In any event, the intake structure should be located above reservoir sediment level and a stilling basin would be required. The outlet works would be utilized for diversion, evacuation of the reservoir, and downstream service requirements.

Additional Data for Appraisal Design

1. Surface reconnaissance and test pits for borrow investigation - visual classification of materials.

2. Identification of pervious drain materials.

3. Assessment of seismic potential at the damsite.

4. Drill holes on each abutment with water testing for permeabilities, and determination of the nature of the fault on the left abutment. (Note based on January 9, 1984, meeting at ERC.) It was agreed that this data is desirable but not required for developing cost estimates.

SIMCOE DAM AND RESERVOIR

Introduction

Simcoe damsite was visited Saturday afternoon, November 6. The weather was clear to partly cloudy with temperatures in the high 40's. The DSRT visited this site Saturday afternoon, November 6, 1982.

Previous Studies

The Bureau of Indian Affairs prepared the Irrigation Feasibility Report for the Toppenish-Simcoe Project, Yakima Indian Reservation, Washington, dated October 1967 with revisions dated March 1973. The report proposed to construct a dam on Simcoe Creek about 4 miles west of White Swan, Washington. The reservoir formed by the dam would have a storage capacity of about 64,600 acre-feet. This reservoir site was studied as early as 1909-10 by the Reclamation Service. Using the new criteria to estimate the inflow design flood would necessitate enlargement of the spillway and outlet works.

Description

Simcoe damsite is located on Simcoe Creek about 4 miles west of White Swan in section 34, T. 11 N., R. 16 E., W.M. This multiple-purpose storage will be utilized to serve needs of irrigation, fish and wildlife, and outdoor recreation. Reservoir management will be utilized to maintain water quality control and to alleviate minor flow control problems. Reservoir sizes being studied range from 65,000 to 95,000 acre-feet.

An earthfill dam is anticipated for this site. With a crest elevation of 1313 feet, the height of the dam above streambed will be about 163 feet and would have a crest length of about 3,900 feet and would contain about 34 million cubic yards of embankment material. In addition to the main dam, a dike over 1 mile long will be necessary. The dike will also be an earthfill structure with a maximum height of about 61 feet at crest elevation 1313 feet and would contain about 1 million cubic feet of embankment material.

The capacity of the reservoir, created by this dam and dike, would be about 95,000 acre-feet and would inundate about 2,200 acres of non-Indian, Indian, and Tribal lands.

If this site is developed, about 2 miles of county road will be relocated to replace the county road which passes through the reservoir area. Two cemeteries would have to be relocated, Yesmowit and an old cemetery near the south abutment of the dam. The proposed location of the new cemetery, to replace the present cemeteries, is in the northeast corner of section 34, T. 11 N., R. 16 E., W.M. Within the reservoir area there is permanent type pasture and alfalfa. It will be necessary to clear trees and brush from the area along the creeks and sagebrush from the area within the reservoir basin.

It is proposed to purchase all lands covered by the reservoir and the area included in the damsite and appurtenant facilities. This will include such lands outside the reservoir area to the nearest legal subdivisions or allotment lines. This area includes both Indian and non-Indian lands.

Topographic mapping of the dam and reservoir site was accomplished by the Bureau of Indian Affairs, Irrigation Division, Portland Area Office, dated June 16, 1964.

Hydrology

Hydrologic data are available and indicate that the drainage area is about 82 square miles and the average annual runoff is 60,000 acre-feet. Based on reconnaissance level data, the inflow design flood is estimated to have a peak inflow of 44,500 ft^3/s and a 5-day volume of 140,000 acre-feet. In the BIA's Irrigation Feasibility Report, a diversion dam would be constructed on Toppenish Creek to divert a portion of the flows in Toppenish and Agency Creek which would have been conveyed to Simcoe Reservoir by a feeder canal between Toppenish Creek and the reservoir.

Geology of the Site

Data Reviewed

Irrigation Feasibility Report, Toppenish-Simcoe Project, Washington, Bureau of Indian Affairs, October 1967 (revisions March 1973)

Stratigraphy and Structure of the Yakima Indian Reservation, USGS Open File Report No. 80-200, 1981

Site Geology.--The site is on the foothills near the western end of Yakima Valley. Exposed in these low hills are nearly flat-lying basaltic lava flows of the Yakima Basalt Formation of Tertiary Age.

The damsite is in the narrows where Simcoe Creek has cut a channel through a northeast-trending ridge of basalt. Scattered outcrops of moderately fractured basalt occur on both abutments. The explorations at the damsite consist of about 22 diamond drill holes varying from about 40 to 170 feet deep. The generalized logs of the holes show mostly "hard basalt" with a few sections of "decomposed basalt." The drilling shows that the far left abutment is underlain with silt to a depth of 80 feet. The drilling also shows that the 400-foot-wide valley is underlain with alluvium to a depth of about 10 feet.

No explorations have been made at the dike site. No outcrops occur along the axis of the dike site; alluvial materials up to 25 feet thick may be present over the basalt bedrock.

Much exploration has been done for borrow materials. Augers and test pits were used to explore various borrow areas both upstream and downstream from the damsite.

The geologic problem at the site concerns the loessial-type soils in the foundation.

Design

Data Reviewed.--The data reviewed by the designers consisted chiefly of:

Bureau of Indian Affairs Irrigation Feasibility Report for the Toppenish-Simcoe Project, and Appendix (dated October 1967)

Preliminary Findings Report, October 1982

Draft Geologic Appraisal Study of Potential Damsite, Yakima River Basin Water Enhancement Project, Washington, (November 1981)

Structural Features

Embankment Dam.--A feasibility design and estimate for Simcoe Dam have been performed by the Bureau of Indian Affairs. The dam is an earthfill structure with a height of 163 feet above streambed, a crest length of approximately 3,900 feet. Exterior slopes are 3:1 upstream and 2:1 on the downstream face. Maximum section embankment zoning consists of a wide impervious (zone 1) core with shells upstream and downstream composed of pervious to impervious fill (zone 2). A rockfill section is provided at the downstream toe and a layer of riprap protects the upstream face. This zoning transitions to a section with no distinction between zone 1 and 2 on the left abutment. Foundation exploration reveals up to 15 feet of overburden material overlying a basalt formation in both the valley section and both abutments with the exception of the extreme right abutment where loess deposits overlie the basalt to a significant depth. All overburden will be stripped to bedrock with the exception of the loess deposit which receives only about a 5-foot stripping. A concrete cutoff wall has been provided 10 feet into rock and 10 feet into the embankment, presumably as a defense against seepage along the embankment/foundation contact. Foundation grouting is then performed at the concrete cutoff excavation.

In addition to the main dam, it will be necessary to construct a dike approximately 1 mile in length. The dike has a maximum height of approximately 52 feet. Exterior slopes and internal zoning are similar to the left abutment section of the main embankment. No foundation exploration was performed.

While some laboratory data were available in the data reviewed, no drill hole logs were found. The Bureau of Indian Affairs indicates that a fairly well-graded material from clay to coarse gravel is readily available in the immediate area. Also, coarser material for the semipervious and pervious zones, riprap and rockfill is readily obtainable.

Several comments to the Bureau of Indian Affairs Feasibility Design are provided here for future reference. Embankments of the size contemplated for Simcoe Damsite will benefit from internal drainage features such as chimney and blanket drains. This applies also to the dike section. The availability and processing required for the drainage material should be investigated. The cutoff trench into basalt backfilled with concrete and the concrete cutoff wall extending into the embankment are not necessary features. Positive cutoff to basalt has already been provided by stripping to relatively fresh rock. Some foundation treatment at the embankment contact in the form of slush grouting (in addition to curtain grouting) should be considered. A highly important aspect of the existing design is the apparent lack of consideration for treatment of the loess foundation on the left abutment. Loess materials are notorious for collapse upon wetting (as in the case of reservoir first filling). A settlement of the loess deposits underlying one portion of the dam and no settlement of the dam underlain by basalt could produce internal cracking of the embankment loading to dam failure. Therefore, caution should be exercised to effectively design for the loess deposits. The first option that should be investigated is the possibility of shifting the dam axis out of the loess deposits. If this is not possible, prewetting of the foundation materials during construction or removal and replacement of these materials may be required. Berms at the dam toes may be required also. These conservative measures should be considered during the appraisal process. Also, cutoff or key trenches into the foundation should have at least 1-1/2:1 side slopes.

Because little is known about the dike foundation, exploration should be conducted in the foundation along its axis. Composition and permeability of the foundation materials is an important aspect to design. For design features similar to those incorporated into the main dam should be considered for the dike section.

Spillway and outlet works for embankment dam.--The spillway would be located on the right abutment and would consist of an uncontrolled ogee crest, a concrete-lined chute, and a stilling basin. It is possible that a service spillway could be located at the right abutment in conjunction with location of an auxiliary of emergency structure at the dike along the left side of the reservoir. There could, however, be problems with foundation in this area due to the depth of overburden.

Because of the dam height, it may be preferable to locate the outlet works as a tunnel through the right abutment. It would be utilized for diversion, evacuation, irrigation, and fish enhancement and water quality concerns. Updated fish enhancement and water quality requirements should be provided.

It appears that there are adequate materials available for concrete sand and aggregate. However, some processing of this material will be required.

Additional Data for Appraisal Design

1. At least three drill holes along the dike axis.

2. Identification of pervious drain materials.

3. Obtain a preliminary assessment of seismic potential in the area of the damsite.

4. Investigation into possibly shifting the left abutment out of the loess deposits.

5. Update of design flood.

6. Outlet works design data such as fish enhancement and water quality requirements, service head and discharge requirements, tailwater and sediment data.

7. Diversion floods.

TAMPICO DAM AND RESERVOIR

Introduction

Tampico was visited late Friday afternoon, November 5. The weather was partly cloudy and warm with temperatures in the 40's. The DSRT visited this site late Friday afternoon, November 5, 1982.

Previous Studies

A reconnaissance study was made by the Bureau of Reclamation during 1959 and 1960 but was not made public due to litigation between the Yakima Indians and the Ahtanum Irrigation District over the right to divert the waters of Ahtanum Creek. A feasibility study completed in February 1972 of the Ahtanum Unit, Supplemental Storage Division, Yakima Project, Washington, recognized the division of water between the north and south sides of Ahtanum Creek established by the 1964 court decision. Since that time, new criteria have been extablished to estimate the inflow design flood. As a result, the spillway and outlet works will need to be resized and/or redesigned.

Description

Tampico damsite is located on Ahtanum Creek in Yakima County, Washington, about 18 miles west of Yakima. The axis is near the east section line of section 15, T. 12 N., R. 16 E., W.M. The site is readily accessible by an existing paved county road which extends from Yakima up the Ahtanum Valley and through the reservoir area. The Union Pacific Railraod and Burlington Northern Railroad both provide freight service to Yakima. U.S. Highway 97 passes through Yakima. Proposed Interstate Highway 82, from Pendleton, Oregon, to Ellensburg, Washington, when completed, will pass through Yakima.

Tampico Dam would be a rolled earth and rockfill structure with a maximum height of 185 feet above streambed. The dam crest would have a length of about 5,100 feet at elevation 2003. A two-way road on the crest would provide public access to recreation areas on the south side of the reservoir. The upstream face would have a slope of 2-1/2:1 down to elevation 1910, a 20-foot wide berm at that elevation, and a 3:1 slope below that elevation. The downstream side would have a slope of 2-1/2:1 down to elevation 1900 and 3:1 below that point. The upstream slope would be protected by a 3-foot layer of riprap above elevation 1910. About 6,800,000 cubic yards of embankment would be required for the dam. A cutoff trench with a maximum bottom width of 100 feet would be excavated to bedrock. The foundation would be pressure grouted.

The reservoir would be cleared of brush and trees. Light to moderately heavy clearing of about 260 acres of trees and brush would be required. The rest of the reservoir area is cultivated or grazing land and would require only minor clearing. There is no marketable timber in the reservoir area.

Tampico Dam would provide storage on Ahtanum Creek. Reservoir sizes being considered in this study range from 37,000 to 65,000 acre-feet of total capacity. The total capacity of the reservoir in the feasibility study was 55,000 acre-feet, including 7,600 acre-feet of joint-use capacity, 37,400 acre-feet active conservation capacity, and 10,000 acre-feet of inactive and dead capacity. A preliminary area-capacity curve and reservoir map were developed using the Geological Survey 7-1/2-minute quadrangle map, Tampico, Washington.

Construction of the dam and reservoir would necessitate relocation of about 4.2 miles of county road, about 3 miles of Benton REA 34.5 kV Tieton-White Swan transmission line, 3.4 miles of Pacific Power and Light Company 11-kV power distribution line, 3.4 miles of Pacific Northwest Bell Telephone Company line,, and the USGS stream gaging station at the Narrows.

Hydrology

Hydrologic data are available and indicate that the drainage area is 121 square miles and the average annual runoff is 65,000 acre-feet. Based on reconnaissance level data, the inflow design flood is estimated to have a peak inflow of 59,600 ft^3/s and a 5-day volume of 189,000 acre-feet.

Geology of the Site

Data Reviewed

Geologic Feasibility Report, Tampico Damsite, Yakima Project, Washington, October 1967

Preliminary Findings Report (October 1982) Yakima River Basin Water Enhancement Project

Field Review of Potential Reservoir Site, by the Damsite and Structure Review Team, Yakima River Basin Water Enhancement Project, Washington

Geologic Appraisal Study, Potential Damsites, Yakima River Basin Water Enhancement Project, Washington

Site Geology.--Ahtanum Valley is a flat-bottomed, steep-walled valley eroded into the south side of an east-west trending syncline. The principal rock type underlying the area is a thick section of various basalt flows of the Tertiary Yakima Basalt Subgroup. Included in the basalt are some inter-flow materials of fine sediments and agglomerate of the Ellensburg Formation.

At the damsite, basalt cliffs rise to as high as 75 feet on the right valley side and as high as 45 feet on the left side. Most of the rock is moderately jointed, dense, and strong. The upper part of the abutments is overlain by cemented gravels and fine sediments that are mostly covered with slopewash up to 10 feet deep. Alluvium in the valley floor is up to 30-feet thick and overlies an agglomerate.

The Geologic Feasibility Report discusses several aspects of this site in respect to geology. Comments from examining the site and the reservoir in respect to settlement, seepage, and stability indicate that this site would satisfactorily accommodate a dam without serious problems.

Design

Data Reviewed.--The data reviewed by the designers consisted of:

Feasibility Study, Anthanum Unit, Supplemental Storage Division, Yakima Project, Washington, completed in February 1972, by the Bureau of Reclamation

Preliminary Findings Report (October 1982)

Draft Geologic Appraisal Study of Potential Damsites, Yakima River Basin Water Enhancement Project, Washington (November 1981)

Structural Features

Embankment Dam.--A feasibility study completed by the Bureau in 1972 was reviewed for adequacy. Tampico Dam would be a rolled earth and rockfill structure with a maximum height of 185 feet above streambed. The dam crest would have a length of approximately 5,100 feet at elevation 2003. A two-way road on the crest would provide public access to recreation areas on the south side of the reservoir. The upstream face would have a slope of 2-1/2:1 down to elevation 1910, a 20-foot-wide berm at that elevation, and a 3:1 slope below that elevation. The downstream face would have a slope of 2-1/2:1 down to elevation 1900 and 3:1 below that point. The upstream slope would be protected by a 3-foot layer of riprap above elevation 1910. About 6,800,000 cubic yards of embankment would be required for embankment zoning (largely consisting of impervious core material, and sand gravel shells upstream and downstream). A cutoff trench with a maximum bottom width of 100 feet would be excavated to bedrock. The foundation would be pressure grouted. The report indicates that sufficient borrow materials have been located for the embankment requirements. However, the location and quantity of borrow materials was cased on a visual examination only, and should be backed up by some explorations.

There is no mention of the seismic potential in the area of the damsite, or the effect of seismic activity on the alluvial foundation deposits.

Since the feasibility design was performed, criteria for estimating the inflow design flood have been established. This may have an impact on the embankment design if additional flood storage space is necessary.

Pending the results of flood studies and a preliminary assessment of seismic potential in the area of the damsite, the embankment design from the 1972 study appears to be satisfactory.

RCC (Roller-Compacted Concrete) Dam.--An alternative to the presently envisioned embankment dam would be an RCC dam. The dam would be 185 feet high and the crest length would be about 5,100 feet long at elevation 2003. The abutments and foundation at this site consists of Yakima basalt. This rock type would provide adequate foundation conditions and the 30-foot depth of alluvium contributes to the economic feasibility of this type of dam.

Adequate quality and quantity of materials for this type of dam would have to be ascertained. It is possible that crushing and processing of the basalt would be required to obtain adequate material.

An updated design flood will be required. This will likely be larger than that used for the feasibility design. As a result, the spillway capacity will probably have to be increased. Placing the spillway over the dam to accommodate this increase would contribute to the economic feasibility of an RCC dam.

The outlet works could be located through the dam. Additional information will be required concerning fish enhancement and water qualtiy requirements.

Spillway and outlet works for an embankment dam.--An updated design flood will be required based on a new data and formulation criteria. This will probably require a redesign of the spillway. The existing glory hole spillway may have to be replaced by a chute-type spillway if it cannot be sufficiently enlarged to handle a required increased discharge.

The function of the outlet works should be reevaluated. The need for the high intake tower, fish screens, and access bridge should be reassessed.

Additional Data Required

1. Updated design flood.

2. Operational data related to fish enhancement and water quality requirements

3. Obtain a preliminary assessment of seismic potential in the area of the damsite.

4. Borrow exploration.