Chapter 2

Affected Projects and Programs

2. Affected Projects and Programs

The Columbia River is the fourth largest river in North America. It originates at Columbia Lake in the Columbia Mountains of British Columbia, Canada and flows 1,214 miles to the Pacific Ocean (Figure 1-1). From its source, the river flows northwest for approximately 200 miles, then reverses course and travels south for nearly 300 miles through mountainous terrain in southeastern British Columbia. The Columbia River crosses into the United States near the northeastern corner of Washington State and continues south through highlands before bending westward. After looping again to the east, the river turns westward and flows for over 300 miles between Washington and Oregon to the sea.

The Columbia River Basin drains over 259,000 square miles. It produces an average annual runoff at The Dalles of about 173 million acre-feet (MAF) (enough water to cover 173 million acres to a depth of 1 foot). The drainage area comprises most of Washington, Oregon, and Idaho; the western quarter of Montana; the southeastern corner of British Columbia; and small portions of Wyoming, Utah, and Nevada. There are more

than 150 dams and reservoirs whose operations are coordinated in the basin—31 of them are operated by Federal agencies.

The Snake River is the principal tributary of the Columbia River. The Snake River drains an area of about 109,000 square miles, including portions of Idaho, northwestern Wyoming, northern Utah and Nevada, southeastern Washington, and eastern Oregon) (Figure 1-1). Major tributaries downstream of Hells Canyon Dam include the Salmon, Grand Ronde, Imnaha, Clearwater, Tucannon, and Palouse Rivers. The Snake River flows through a canyon of varying depths from about 5,500 feet in upstream Hells Canyon to less than 450 feet near its confluence with the Columbia River. Much of the lower Snake River Canyon is generally steep, with basalt bluffs rising up to 2,000 feet to rolling uplands.

Most juvenile salmon originating from the Snake River Basin make their way past eight Federal dams and reservoirs on the lower mainstem Snake and Columbia Rivers before reaching the Pacific Ocean (Figure 1-1).

This Feasibility Report/Environmental Impact Statement (FR/EIS) is concerned with actions for improving fish passage at the four Federal dams on the lower Snake River. This section summarizes key project and program information for these four dams, which make up the Lower Snake River Project. It includes a description of the facilities at each dam and a discussion of existing river system fish programs. These four dams are all equipped with passage systems for adult and juvenile fish. The systems are continually being improved as new technologies for passage are developed.

2.1 Project Characteristics

The four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) are multiple-use facilities that provide public benefits in many different ways. The Lower Snake River Project uses are inland navigation, hydropower generation, irrigation, recreation, and fish and wildlife. Project facilities include dams and reservoirs, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish passage structures, fish hatcheries, parks and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat.

All four lower Snake River dams are run-of-river facilities. They are not authorized, designed, or operated for flood control. These run-of-river facilities have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for hourly regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. Other Federal dams on the Columbia River and its tributaries were developed for storage purposes. Storage reservoirs, such as the Dworshak Reservoir on the North Fork of Clearwater River, are used to store water and adjust the river's natural flow patterns to conform more closely with water uses.

The normal operating ranges and usable storage volumes for the affected four lower Snake River facilities are listed in Table 2-1. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Table 2-1. Characteristics of the Four Lower Snake River Facilities

Facility	Type of Facility	Snake River Mile	Reservoir Name	Reservoir Capacity [1/] (acre-feet)	Total Reservoir Capacity (acre-feet)	Reservoir Elevation [1/] (NGVD29)
Lower Granite	run-of-river	107.5	Lower Granite Lake	49,000	483,800	733 to 738
Little Goose	run-of-river	70.3	Lake Bryan	49,000	565,200	633 to 638
Lower Monumental	run-of-river	41.6	Lake Herbert G. West	20,000	432,000	537 to 540
Ice Harbor	run-of-river	9.7	Lake Sacajawea	25,000	406,500	437 to 440

1/ normal operating range
NGVD29 = National Geodetic Vertical Datum
Source: Corps and NMFS, 1994

The following sections describe the features that are generally present at all four lower Snake River facilities.

2.1.1 Adult Fish

The Lower Snake River Project was originally designed and constructed with adult passage facilities at the four dams. These facilities include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems (Table 2-2). The adult fish passage facilities at each dam have certain features in common (Figure 2-1). In general, there is a set of main fishway entrances near the far end of the spillway, between the spillway and powerhouse, and at the near end of the powerhouse. Two entrances are typically used at each location. Additional smaller entrances (floating orifice gates) are provided across the face of the powerhouse.

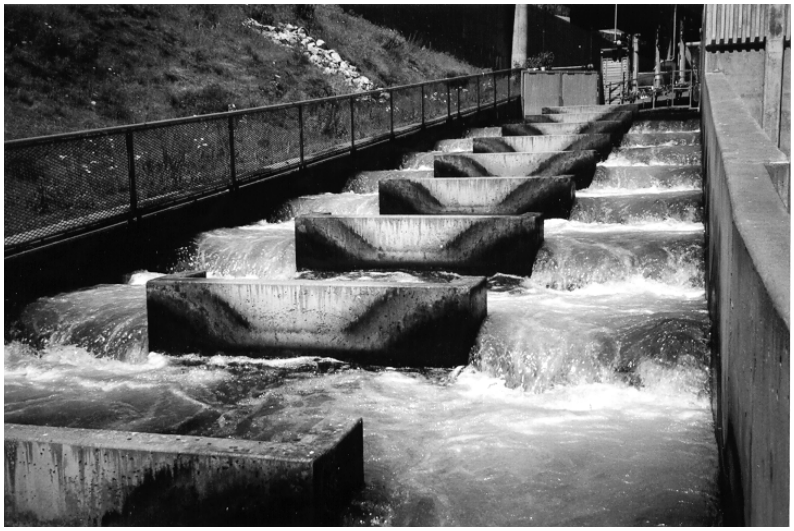


Figure 2-1. Existing Adult Fish Passage Systems

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Granite Dam	**Bypass System** • extended submerged bar screens (ESBSs) with flow vanes • improved modified balanced flow vertical barrier screens • gatewell orifices (10 inch) • bypass channel running the length of the powerhouse • bypass pipe to transportation facilities or river **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • passive induced transponder (PIT) tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouse's collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Little Goose Dam	**Bypass System** • ESBSs with flow vanes • vertical barrier screens • gatewell orifices (12 inch) • bypass channel running the length of the powerhouse • metal flume on face of dam and upper end of fish ladder • dewatering structure • two emergency bypass systems • corrugated metal flume (to transportation facilities or river) **Transportation Facilities** • upwell and juvenile/adult separator structure • raceways for holding fish • distribution system (to raceways, barge, or river) • sampling and marking building • truck and barge loading facilities • PIT tag detection and deflection systems	**North Shore Fish Collection** • two downstream entrances • one side entrance into stilling basin on north end of spillway • tunnels connect these fishway entrances to powerhouses collection system **South Shore Fish Ladder** • two south shore entrances **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • four floating orifices **Auxiliary Water Supply System**

Table 2-2. Components of Juvenile and Adult Fish Passage Facilities at the Lower Snake River Project (continued)

	Juvenile Fish Passage Facilities	Adult Fish Passage Facilities
Lower Monumental Dam	**Bypass System** • standard length submerged traveling screens (STSs) • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • bypass flume (to tailrace below the dam) **Transportation Facilities** • upwell and juvenile/adult size separator structure • sampling facilities • raceways for holding fish • office and sampling building • truck and barge loading facilities • PIT tag detection and deflector systems	**North Shore Fish Ladder** • two north shore entrances • connects to powerhouse collection system **South Shore Fish Ladder** • two downstream entrances • one side entrance into spillway basin **Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • ten floating orifices **Auxiliary Water Supply System**
Ice Harbor Dam	**Bypass System** • standard length STSs • vertical barrier screens • gatewell orifices (12 inch) • collection channel • dewatering structure • sampling and marking building **Transportation Facilities** • transportation flume/pipe to tailrace (below dam)	**North Shore Fish Ladder** • counting station **North Shore Collection System** • two downstream entrances • one side entrance into spillway basin • counting station **North Shore Auxiliary Water Supply System** **South Shore Fish Ladder** • counting station • two south shore entrances **South Shore Powerhouse Collection System** • two downstream entrances • one side entrance into spillway basin • common transportation channel • twelve floating orifices **South Shore Auxiliary Water Supply System**

Source: Corps, 1999a

Adult fish passage facilities are operated in accordance with the U.S. Army Corps of Engineers' (Corps) Fish Passage Plan (Corps, 2000a). Fish ladders typically operate all year with two weeks shutdown for maintenance in the January through March timeframe. Fish counting is done April through October at Ice Harbor, Lower Monumental, and Little Goose, and April through December at Lower Granite.

2.1.2 Juvenile Fish

Juvenile fish bypass facilities were installed at each of the four lower Snake River dams shortly after they were constructed (Figures 2-2a and 2-2b and Table 2-2). The facilities were upgraded as new technology developed.

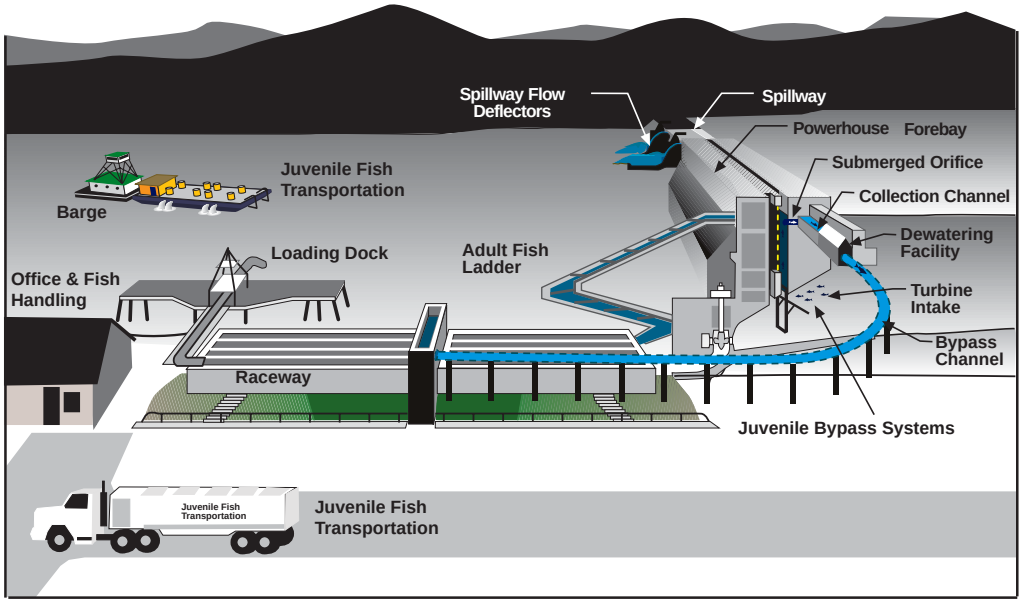


Figure 2-2a. Existing Fish Passage Systems

In 1987, the Columbia River Fish Mitigation Program (CRFMP) was initiated. Under this program, juvenile fish bypass/collection facilities were upgraded at Ice Harbor (1996), Lower Monumental (1993), and Little Goose (1998). Other improvements such as spillway flow deflectors at Ice Harbor and extended submerged bypass screens (ESBS) at Little Goose and Lower Granite, have also been added. Also, studies are underway to investigate ways to improve water quality (i.e., lower temperature) in the ladders.

The fish agencies and tribes recommended postponing the upgrade of the Lower Granite facilities, pending the decision on this FR/EIS. Although the existing facilities at Lower Granite currently provide high survival (99.5 percent) for juvenile passage, numerous studies have shown substantial stress occurs in fish that pass through the bypass system. However, the cost of replacing the facilities to eliminate these known stress problems would be lost if a decision is made to breach the dam. Therefore, if the decision is to continue current operations, replacing this facility would be an element of that action. Specific plans for upgrading the Lower Granite juvenile fish facility are presented in Appendix E, Existing Systems and Major System Improvements Engineering.

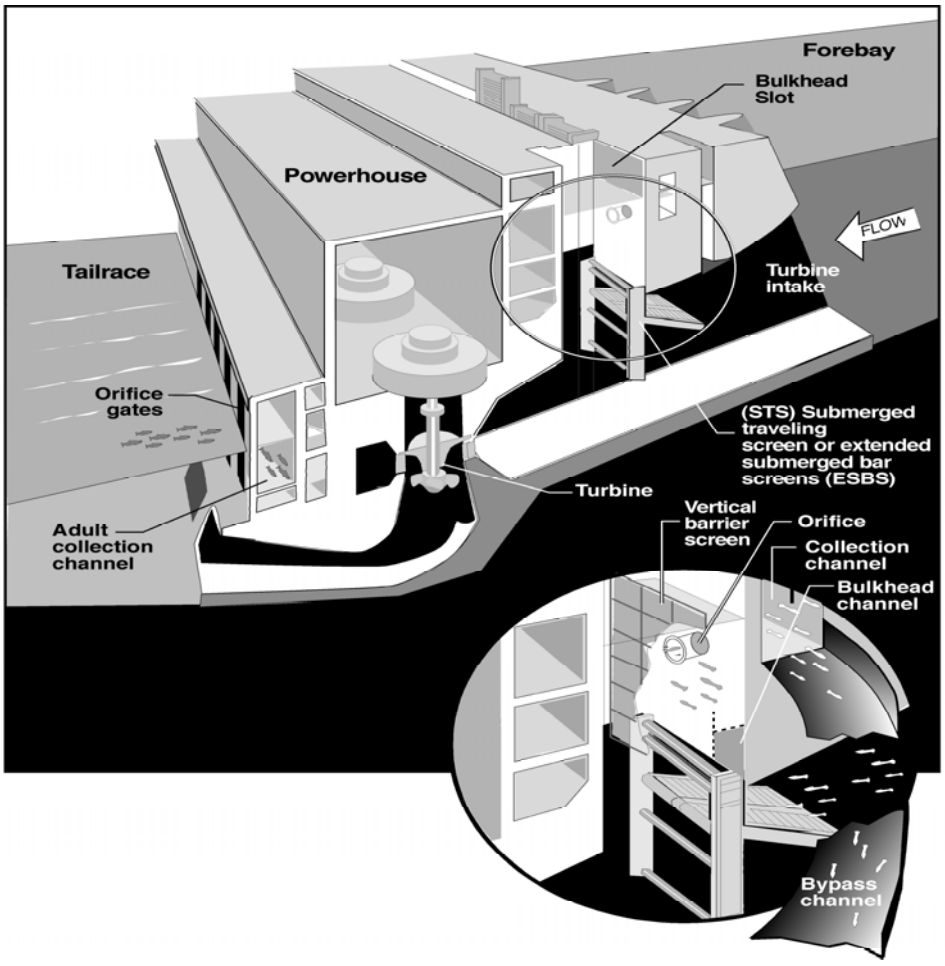


Figure 2-2b. Juvenile Fish Bypass Facilities

Current measures for collection and transportation of juvenile fish outmigration are identified in the 1995 and 1998 opinions, and the Endangered Species Act (ESA) Section 10 Permit (#895) for the Juvenile Fish Transportation Program (JFTP). The National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS] 2000 Biological Opinions were released December 2000. The Corps operates the JFTP in cooperation with NMFS.

Typical existing facilities for juvenile fish (Figure 2-2b) that enter the turbine area (compared to those that would pass over the spillway) include the following:

- **Turbine Intakes—**Each generating unit at the lower Snake River dams has three turbine intakes. These intakes are similar at all four dams except that they are slightly smaller at Ice Harbor.
- **Turbine Intake Screens—**Standard length submerged traveling screens (STSs) are devices that are lowered into the turbine bulkhead slots to guide fish from the turbine intake and subsequent turbines. The screened area is 20 feet high and 20 feet wide. The screen is a continuous belt that travels around the frame like a

conveyor belt. The screen revolves so that debris collected on the front face is carried over to the back side where it is washed off by the flow through the screen. STSs are used at Lower Monumental and Ice Harbor. STSs were replaced with ESBSs at Lower Granite (1996) and Little Goose (1997). The ESBSs are 40 feet long and 20 feet wide and significantly increase the number of fish guided away from turbines.

- **Bulkhead Channel—**Fish guided into the bulkhead slot swim or are carried upward by the flow deflected by the fish screen. Fish not guided by the screen pass through the turbine.
- **Collection Channel—**The fish move through an orifice into the collection channel within the powerhouse. At Lower Granite, a collection channel was constructed in the dam and became operational in 1975. Little Goose and Lower Monumental were constructed with imbedded pipelines for juvenile bypass systems. Subsequent modifications at Little Goose (in 1984 and 1985) and Lower Monumental (1991) resulted in mining of tunnels similar to the collection channel at Lower Granite. At Ice Harbor, a collection channel was constructed in the ice/trash sluiceway along the upper face of the powerhouse in 1995.
- **Bypass Channel—**Fish are directed through a bypass pipe or flume to the fish collection/handling facilities (see Figures 2-2a and 2-2b).
- **Fish Collection/Handling—**Fish arriving at the juvenile fish facilities by pipe or flume are separated from adult fish and debris by a separator. They are then passed to holding ponds or raceways where they are held until being loaded into a truck or barge.
- **Transportation—**Juvenile fish are transported under the guidelines of the Fish Passage Plan and the Corps' JFTP. Juvenile fish are not transported at Ice Harbor, but the majority are bypassed directly to the tailrace below the dam. At Lower Granite, Little Goose, and Lower Monumental, juvenile fish that go through the bypass systems can be routed either directly back into the river below the dam, or to holding and loading facilities for loading into barges or trucks for transport. Trucks are used for transport when the number of fish collected is 20,000 or fewer per day at Lower Granite.

The transport barges and trucks carry the fish past the remaining projects in the Columbia-Snake River System for release below Bonneville Dam in high velocity waters at night to reduce predation. River water circulates through the barges, allowing the fish to imprint the chemicals and smells of the water during the trip downriver. Similarly, trucks are specially equipped to maintain proper conditions during transport (e.g., operation and maintenance of water temperatures). The adults use this "imprinting"

mechanism during upstream migration to guide them to the location where they originated (e.g., spawning area or hatchery).

Collection of juvenile fish generally starts March 25 at Lower Granite and a few days later at Little Goose and Lower Monumental. There are currently eight barges in the Corps' fish passage fleet. Early in the season (typically the second week in April), a barge leaves Lower Granite every other day. As numbers of fish increase, barging is increased to every day. In order to follow the "spread-the-risk" policy initiated in the 1995 and 1998 Biological Opinions, the current goal is to transport about half of the juvenile Snake River salmon and steelhead. The remainder are either bypassed back to the river, pass through the turbines, or may pass over the spillway if spill occurs. In its 2000 Biological Opinion, NMFS requested that summer migrants (those collected after June 20) be transported from all transport facilities.

2.1.3 Reservoir Operation Levels

Drawing down the reservoirs to increase water velocity and decrease travel time of downstream migrating juvenile salmon was first considered in the late 1980s. As identified in its 1995, 1998, and 2000 Biological Opinions, NMFS requested operation of the three lower Snake River facilities (Little Goose, Lower Monumental, and Ice Harbor dams) within 1 foot of reservoirs at minimum operating pool (MOP) from April 3 until adult fall chinook begin to enter the Snake River. This level is considered the bottom 1 foot of the operating range for each reservoir. Lower Granite Dam would be operated within 1 foot of the MOP from April 3 through November 15 of each year. After November 15, all four reservoirs would be operated within their normal 3- to 5-foot operating ranges.

2.1.4 Turbine Operation

Historical studies demonstrated that operating turbines within one percent of peak efficiency would maximize survival of juvenile salmon passing through the turbines (Bell, 1990). Since the mid-1980s, the Corps has made every effort to operate turbines at the four dams within the 1 percent peak efficiency rate. In its listing of the Snake River salmon in 1991 and 1992, and under the 1995 and 2000 Biological Opinions, NMFS requested that the Corps operate turbines within 1 percent of peak efficiency during juvenile and adult migration seasons, which extends from March 15 to November 30 on the lower Snake River.

Studies following this operational change have shown turbine mortality to be less than 7 percent (Normandeau Associates, et. al, 1996; Normandeau Associates, Inc. and Skalski, 1997) at each dam. Studies prior to this operational change typically showed about 15

percent mortality to juvenile salmon from passage through turbines at each dam (Bell, 1990).

2.1.5 Spill for Juvenile Passage

As previously mentioned, the Lower Snake River Project facilities are run-of-river with only a 3- to 5-foot operating range, which provides little storage of water. Therefore, when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs, water is involuntarily spilled. In contrast, voluntary spills would be those that are not required to pass excess flows downstream (e.g., the powerhouse could pass the flows and there is sufficient power demand). Voluntarily passing water over dam spillways rather than through the powerhouse is an operations approach used to divert juvenile fish from the turbines as they approach a dam. The majority of spill occurs at night to enhance downstream passage of juveniles that migrate past dams primarily during this period.

The Corps began spilling water for juvenile salmon at several lower Snake dams in 1977, as a way of improving juvenile fish passage survival. A more comprehensive spill program was initiated in 1989, when a long-term spill agreement was signed by BPA, the fisheries agencies, tribes, and others (BPA et. al., 1995). The Corps considers the spill requests each year when determining operations of its dams.

In response to the 1995 and 1998 Biological Opinions, spill at the dams has been increased substantially during juvenile fish migrations. However, spill has associated risks, because spilling water can entrain air when the water plunges into the spillway basins, causing raised levels of dissolved gas in the water (dissolved gas supersaturation) that can be harmful to fish. In addition, when spill occurs, fish that could be collected and transported around a series of dams are bypassed downstream to the next reservoir and whatever dams are left to pass. Therefore, the spread-the-risk policy in the 1995 and 1998 Biological Opinions was adopted to allow multiple ways of passing juvenile fish downstream (i.e., fish are either passed over the spillway into the tailrace, bypassed around the dam and transported by truck or barge, or are bypassed around the dam and released below the tailrace). Under the existing operations, spill is limited to the adjusted total dissolved gas "cap" (see Section 4.5, Aquatic Resources) as administered by the states of Oregon and Washington. The largest concentrations allowed are 115 percent in the forebays and 120 percent in the tailwaters. The NMFS 2000 Biological Opinion has requested the following spill criteria:

- Ice Harbor Dam—a 24-hour spill (with night-time spill limited to the total dissolved gas (TDG) at the cap and daytime spill limited to 45 thousand cubic feet per second (kcfs) for adult passage
- Lower Monumental Dam—a 24-hour spill at the gas cap

- Little Goose and Lower Granite Dams—a 12-hour spill (6 pm to 6 am) up to the gas cap.

2.1.6 Completion of Gas Abatement Measures

Dissolved gas supersaturation emerged as a major threat to the survival of the Snake River and Columbia River salmon runs in the late 1960s. This occurred from releases of large volumes of water over spillways. In response, the Corps initiated a major effort to modify Corps' dams to reduce the problem. The measures taken were: 1) completion and use of upstream storage to minimize spill, 2) installation of turbines in skeleton bays (unused turbine bays) at the lower Snake River and Columbia River dams to also minimize spill, and 3) installation of spillway flow deflectors in the spillbays at the lower Snake River and Columbia River dams.

Spillway flow deflectors (Figure 2-3) produce a more horizontal spill flow that limits the plunge depth of water over the dam spillway. This reduces the amount of TDG, but high spill can diminish the effectiveness of the flow deflectors. Spillway flow deflectors are installed in all eight spillbays at Lower Granite and all 10 bays at Ice Harbor.

Deflectors were installed in six of eight bays at Little Goose and Lower Monumental. Studies at these two dams by fishery agencies indicated that deflectors should not be added in the end bays because of concerns relating to the tailrace hydraulic conditions in the immediate vicinity of adult fish ladder entrances. These localized conditions could delay adult fish from finding the ladder entrances. However, NMFS' 2000 Biological Opinion has requested further investigations on spillway deflector optimization, including the addition of end-bay deflectors.

Spillway flow deflectors originally were not installed at Ice Harbor because of concerns over adult fish passage, and because it was only a few miles to low supersaturated waters in the Columbia River coming from the free-flowing yet controlled Hanford Reach. In 1996 and 1997, spillway flow deflectors were added to 8 of the 10 spillway bays at Ice Harbor as a result of increased spills to accommodate the requests made by NMFS in the 1995 Biological Opinion, which included keeping a portion of the downstream migrating fish in the river (versus transport) as part of the spread-the-risk policy. This action raised the spill cap from about 25 kcfs to about 75 kcfs at 120 percent gas concentrations, which benefited fish passage efficiency (FPE) (see Section 5.4, Aquatic Resources). In 1997 and 1998, flow deflectors were installed in the two remaining Ice Harbor spillway bays along with an added training wall which raised the spill cap (i.e., the maximum amount of spill that results in the highest allowed total gas concentration) from about 75 kcfs to about 105 kcfs at 120 percent gas concentrations.

Studies are continuing on structural measures to reduce TDG production as well as on TDG effects on juvenile fish mortality. In addition to studies on the potential installation of spillway flow deflectors in bays where they have not yet been installed, other studies involved evaluations of raising stilling basins and installing alternate methods of passing water. Under existing conditions, additional deflectors and other structural modifications would be added at Lower Granite, Little Goose, and Lower Monumental.

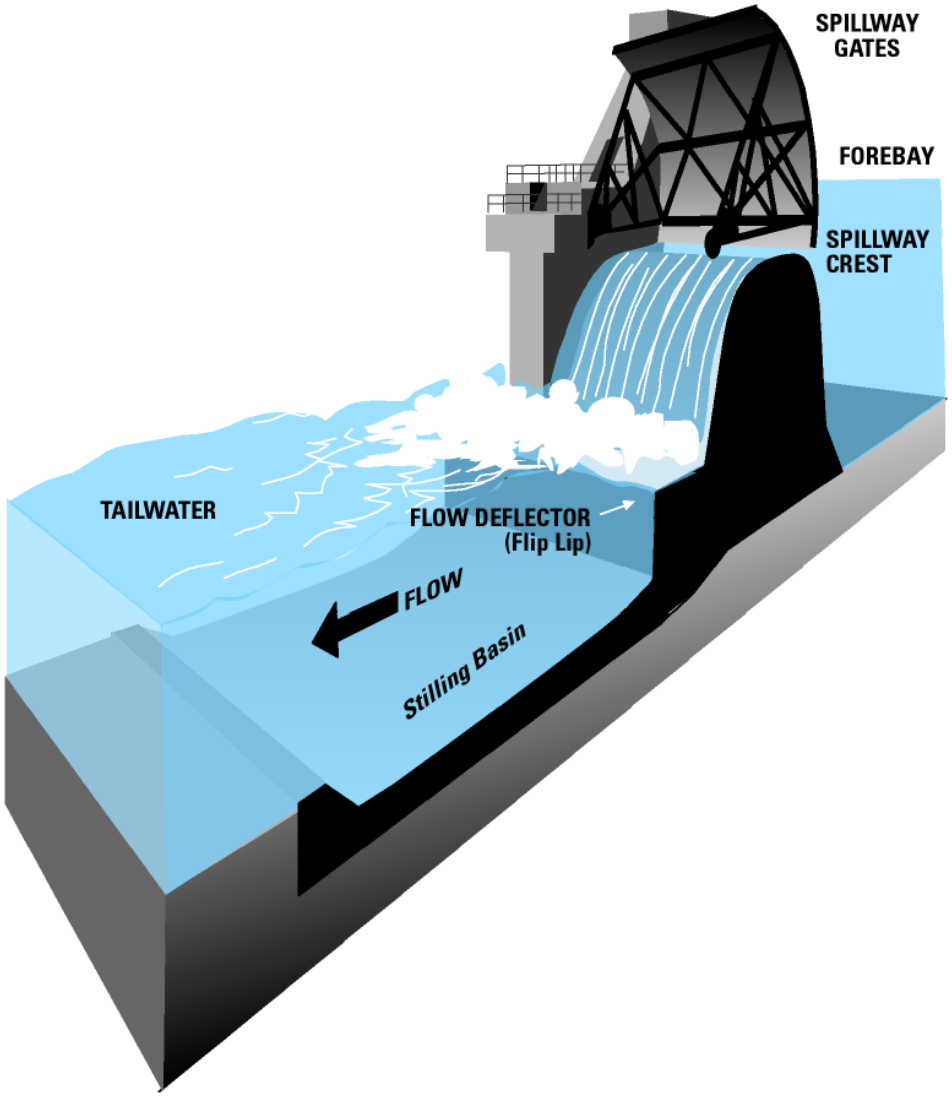


Figure 2-3. Spillway Flow Deflector (flip lip), Lower Granite Dam Spillway

Monitoring of dissolved gas concentrations has greatly advanced in the past 30 years. With the existing operations, a network of monitoring stations has been established above and below each dam, and at other major sites throughout the Federal Columbia River Power System (FCRPS). This network provides the Corps, the Fish Passage Center (a technical office of the Columbia Basin Fish and Wildlife Authority [CBFWA]), and NMFS with immediate access to dissolved gas information throughout the system. Under existing conditions, this monitoring of dissolved gas concentrations would continue. The NMFS 2000 Biological Opinion calls for some improvements in this monitoring plan.

2.1.7 Flow Augmentation

Dams upstream of Lower Granite can regulate water for flood control, irrigation, and other uses, interrupting the seasonal river flow patterns in downstream areas. Flow augmentation (i.e., increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs) can aid migration of juvenile salmon. The original Fish and Wildlife Program of the Northwest Power Planning Council (NPPC) (NPPC, 1982) included an amount of upstream storage to be controlled by the fishery agencies and tribes. This water (termed the "Water Budget") was used to simulate the natural spring freshet for the juvenile salmon outmigration. The increased flow is presumed to help flush fish downriver and reduce their exposure to predators and other potential hazards in reservoirs.

The Fish Passage Center was established to recommend management strategies concerning the Water Budget, which includes water releases from Dworshak plus additional water from the Hells Canyon complex and the upper Snake River. The amount and timing of release for the Water Budget were determined each year, based on the amount of water potentially available in storage.

The 1995 Biological Opinion changed the operating regime for flow augmentation volumes to target flows at Lower Granite. A Technical Management Team (TMT) was established to advise the operating agencies on dam and reservoir operations to optimize passage conditions for juvenile and adult anadromous salmonids. The TMT (see Section 1.4.4) consists of representatives from NMFS, USFWS, BOR, Corps, BPA, states, and tribes. It meets weekly during the juvenile fish migration seasons to discuss flows and spills, and to plan operations for fish.

All TMT recommendations are made to the Corps and BOR, which have authority to operate the FCRPS projects, and to the Corps and BPA, which have the authority to make agreements with Canada regarding storage in Canada (for mainstem Columbia River projects).

The 1995 Biological Opinion called on the BOR to provide 427 thousand acre-feet (KAF) of water for flow augmentation by acquiring water supplies from willing sellers in the middle and upper Snake River Basin. With the exception of 2001, when approximately 80,000 acre-feet were provided due to severe drought and power conditions, the BOR has provided these flows each year by leasing or acquiring water supplies and by releasing water from uncontracted storage space in BOR-owned reservoirs. The Idaho statute that authorized release of the additional 427 KAF expired on January 1, 2000. This was extended until January 1, 2001. BOR is pursuing authorization to extend it. The statute covers only the release of water from storage (not natural flows) and specifies that the amount of flow augmentation that BOR can provide from all sources is limited to 427 KAF in any year.

NMFS' 2000 Biological Opinion addresses flow augmentation. The action agencies (Corps, BPA, and BOR) are currently developing implementation plans in response to this opinion. Although flow augmentation levels could change as a result of the planning efforts, the 427 KAF was assumed to be incorporated into each alternative evaluated in this FR/EIS.

In addition to the 427 KAF, Idaho Power Company also provides spring/summer storage releases from Brownlee Reservoir of about 237 KAF. Also during the summer period, the Corps releases about 1.2 million acre-feet (MAF) from Dworshak Reservoir. From these three entities (BOR, Idaho Power, and Corps), approximately 1.9 MAF of Snake River Basin storage is made available for augmentation.

The BOR conducted a study of the effects of providing 1.0 MAF; however, additional flow augmentation was eliminated from further analysis in this study due to issues/concerns raised in BOR's *Snake River Flow Augmentation Impact Analysis Appendix*, dated February 1999. Some of those issues/concerns are:

- Insufficient storage space in the Snake River basin under BOR and Corps exclusive control to provide large amount of water for flow augmentation without significant impacts to natural resources, recreations, and economic sectors.
- Inability of BOR to meet its historic obligations and commitments to project beneficiaries if additional flow augmentation was required.
- Inability of BOR to fully meet all congressionally authorized project purposes if required to provide 1,427,000 acre-feet for flow augmentation.
- Affected states general opposition to flow augmentation.
- Congressional action could be needed to clarify BOR's responsibilities or additional authorization and appropriate may be needed.

NMFS' 2000 Biological Opinion indicates that the existing seasonal flow objectives established by the 1995 Biological Opinion "represent a fair balance between flow and water quality/conditions." However, the issue of providing water from BOR's upper Snake Basin and Idaho Power's Hells Canyon projects to assist in achieving Snake River flow objectives are being addressed in a separate Section 7 consultation (NMFS, 2000).

2.1.8 Lower Snake River Fish and Wildlife Compensation Plan

The *Lower Snake River Fish and Wildlife Compensation Plan* (Comp Plan) was authorized by the Water Resources Development Act of 1976 to mitigate for fish and wildlife losses caused by construction and operation of the four lower Snake River dams. The Comp Plan consists of fish hatcheries, satellite fish facilities, a fish laboratory, wildlife habitat areas and development areas, and lands with fishing and hunting access. The facilities and lands of the Comp Plan are primarily located in the upper, middle, and lower subbasins of the Snake River Drainage, in Washington, Oregon, and Idaho. The remaining facilities and lands are located in the upper Columbia, Yakima, and Mid-Columbia

subbasins. Some facilities are located on existing Federal lands, but the majority are on deeded lands and easements.

The hatcheries developed under this plan were designed to produce about 28 million juvenile spring, summer, and fall chinook salmon, and steelhead as well as any other stock in need of supplementation. Nine hatcheries were modified or constructed along with a number of collection facilities for gathering adults, and acclimation ponds for acclimating juveniles to water sources where they would return as adults (Figure 2-4). These facilities are operated by state fisheries agencies or USFWS. Recently, additional acclimation facilities have been constructed by the Corps and are operated by the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation.

The Comp Plan includes a large number of Habitat Management Units (HMUs) that were developed as mitigation for the loss of habitat associated with the four dams and reservoirs (Figure 2-5). These were developed for a wide variety of habitat and species. HMUs range in size from less than 1 acre to over 3,000 acres. Initially, they were developed on existing project lands and subsequently, additional lands were purchased and leased for mitigation both along the lower Snake River or up to 100 miles or more from the river. Table 2-3 summarizes the number and area of HMUs for each dam.

Further detailed discussion of the HMUs is provided in Section 4.6, Wildlife, and in Appendix L, Lower Snake River Mitigation History and Status.

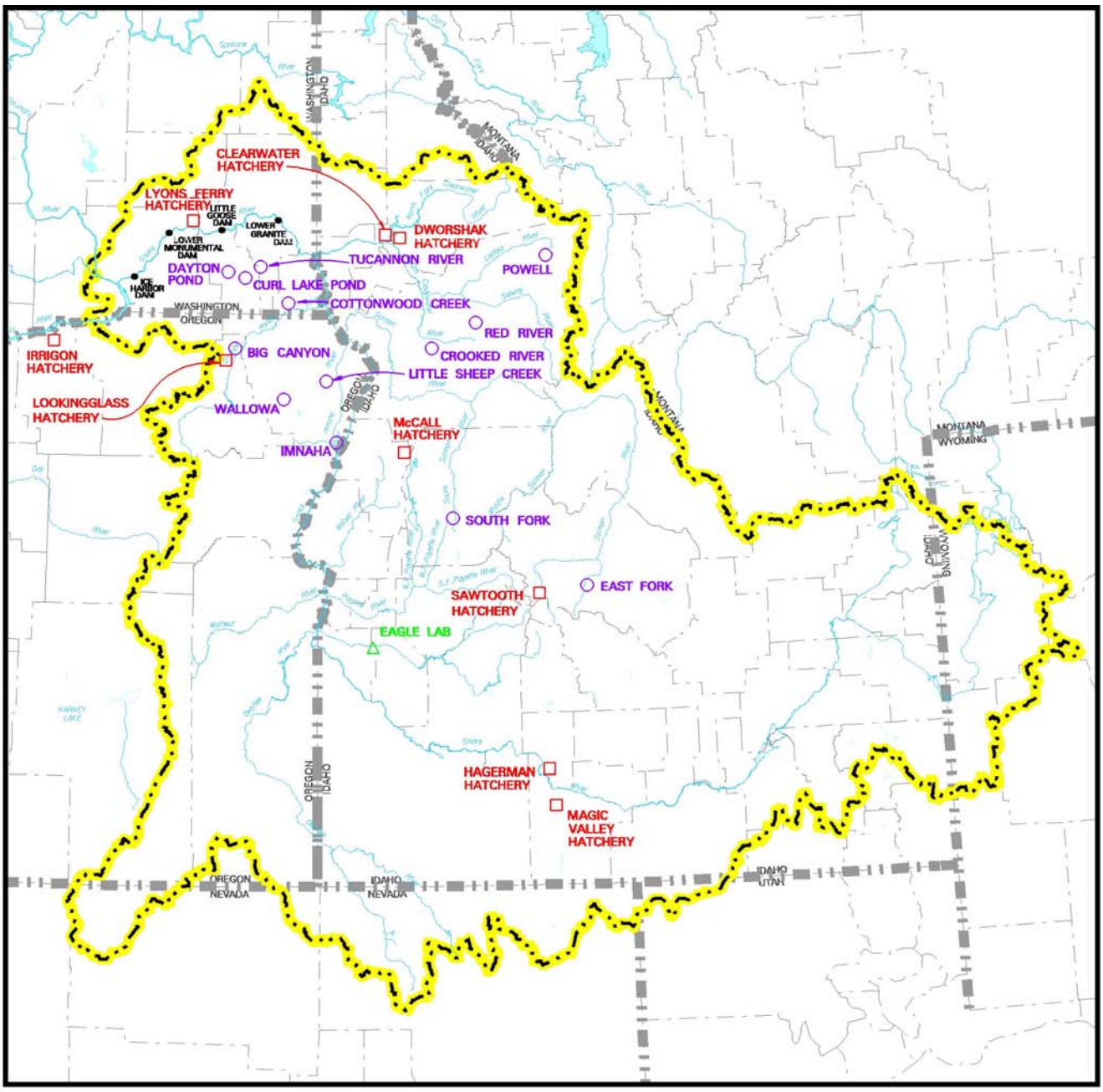
Table 2-3. Number of HMUs per Facility

Dam	No. of HMUs	Total Acres
Ice Harbor	14	2,032
Lower Monumental	13	4,381
Little Goose	18	3,019
Lower Granite	17	5,002
Total	**62**	**14,434**

2.1.9 Surface Bypass Collector Prototype Operation

The existing juvenile bypass facilities are constantly being evaluated and improved by scientists and engineers. For example, since 1996, a prototype surface-oriented bypass and collection system has been under evaluation by the Corps at Lower Granite. The system is designed to collect downstream migrating juveniles in the forebay and safely bypass them either over the dam or transport them downstream in trucks or barges (see Section 2.1.2, Juvenile Fish). The basis for the surface bypass collector (SBC) design was the successful surface-oriented bypass system currently in use at Wells Dam on the mid-Columbia River. At Wells Dam, the spillways are located on top of the submerged powerhouse turbines, causing a surface bypass effect. Fish are attracted to the water currents created by the turbines, but instead, pass over the spillway rather than diving to the turbine openings. At dams operated by the Corps, the spillways are next to, rather than over, the powerhouse.

Seven designs for SBCs are being evaluated (see Appendix E, Existing Systems and Major System Improvements Engineering). Each design emphasizes attraction of juvenile fish prior to diving and encountering the existing turbine screening bypass system (Corps, 1996b). These designs were evaluated from an engineering perspective only; there were no biological evaluations performed. The prototype study at Lower Granite has only evaluated one of the designs.



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SATELLITE

South Fork	A
East Fork	B
Wallowa	C
Big Canyon	D
Imnaha	E
Little Sheep Creek	F
Dayton Pond	G
Curl Lake Pond	H
Tucannon River	I
Cottonwood Creek	J
Red River	K
Crooked River	L
Powell	M

HATCHERY

Hatchery Name	Associated Satellite
McCall Hatchery	A
Magic Valley	B
Hagerman Hatchery	B
Lookingglass Hatchery	E
Irrigon Hatchery	C,D,F
Lyons Ferry Hatchery	G,H,I,J
Dworshak Hatchery Expansion	A
Sawtooth Hatchery	*(None)*
Clearwater Hatchery	K,L,M

FISH DISEASE LABORATORY

DISTRICT BOUNDARY

KM 70 35 0 MILES 35 70

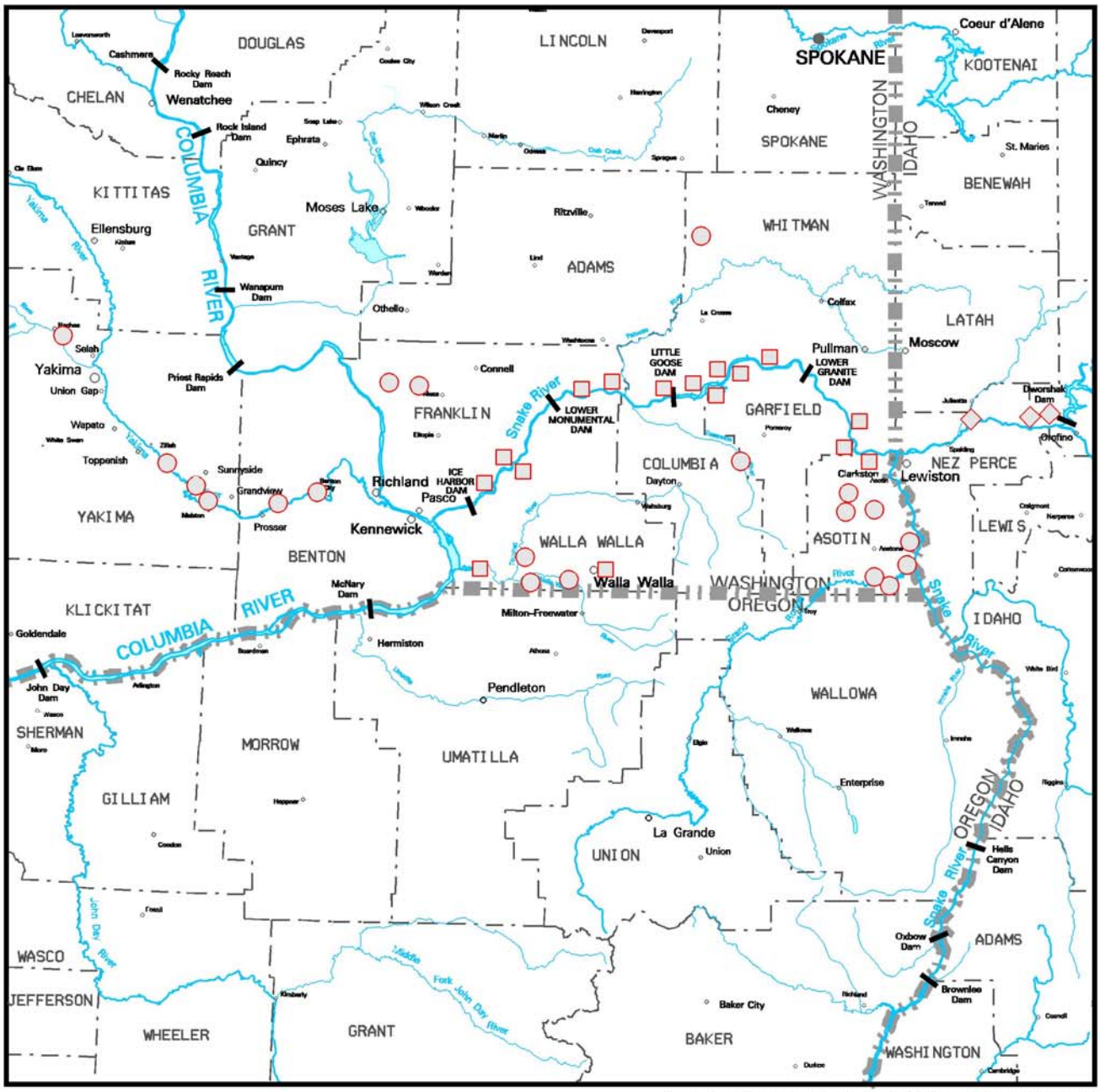
GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

490,000 ACRES

1 : 53,222,400

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–4.
REGIONAL HATCHERIES



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HABITAT MANAGEMENT UNIT

US Army Corps of Engineers Owned

WA Dept. of Fish and Wildlife Owned

To Be Developed

KM 25 0 7.5 15 30 MILES

125,000 ACRES

1 : 1,900,800

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–5.

REGIONAL HABITAT MANAGEMENT UNITS

The Lower Granite SBC underwent a series of tests from 1996 through 2000. Generally the entrance configurations and project operations were not similar between test years. In 1998, modifications were made to the Lower Granite prototype to effectively make the collector deeper and to include a behavioral guidance structure (BGS) to guide fish to the SBC entrance. Preliminary results from the 1998 SBC/BGS prototype tests were used to develop estimates of what performance might be expected from a permanent SBC system at a dam. These results were applied to the seven SBC designs currently being evaluated (see Appendix E, Existing Systems and Major System Improvements Engineering). The evaluation suggests that between 46 and 78 percent of juveniles could be bypassed, depending on the particular design type. The remainder would be passed through the turbine (4 to 11 percent) or intercepted by the screened bypass (18 to 43 percent). SBC technology gained from this testing may be used in potential future applications on the Lower Snake River Project and at other surface bypass systems in the region. For example, Granite County PUD is currently testing a version of a surface bypass facility at Rocky Beach Dam.

2.1.10 Power Marketing

The integrated system of 30 Federal hydroelectric facilities in the Columbia River Basin, on average, accounts for approximately 60 percent of total regional energy and 70 percent of total electrical generating capacity. The four dams in the Lower Snake River Project have a total nameplate capacity of 3,033 megawatts (MW) (Table 2-4) or about 5 percent of the total regional energy or 7 percent of the total electrical generating capacity. When there is a surplus of hydropower, it is an important export product for the region. BPA markets and distributes the power generated by the Corps and BOR at the Federal dams in the Columbia River Basin, including power generated by the four dams on the lower Snake River. The power is sold to public and private utilities in the region, utilities outside the region, and some of the region's largest industries. Power lines originate at generators at the dams and extend outward to form key links in the regional power transmission grid. BPA owns and operates the transmission system. The Northwest grid is interconnected with Canada to the north, California to the south, and Utah and other states to the east. Power produced at dams in the Pacific Northwest is provided to customers both locally and thousands of miles away.

2.1.11 Navigation

The 465-mile Columbia-Snake Inland Waterway represents a key link to the Columbia-Snake River Basin interior region. It facilitates barge transport from the Pacific Ocean to Lewiston, Idaho, the most inland port. This transportation system consists of navigation channels and locks, port facilities, and shipping operations (see Table 2-4). The system is used for commodity shipments from inland areas of the Pacific Northwest and as far away as North Dakota. The

lower Snake River is part of the shallow draft portion of the waterway. The Corps maintains a navigation channel 250 feet wide and 14 feet deep from the mouth of the Snake River to the confluence of the Snake and Clearwater Rivers. The navigation channel accommodates tugs, numerous types of barges, log rafts, and recreational boats and connects the interior of the basin with deep water ports on the lower Columbia River. The average annual tonnage passing through Ice Harbor lock between 1987 and 1996 was 3,883,000 tons. Commodity movement on the lower Snake River is dominated by grain, with wheat and barley comprising about 75 percent of the average annual tonnage passing through Ice Harbor lock between 1992 and 1996. Wood chips and logs, and wood products accounted for 20 percent. Petroleum products accounted for another 3 percent, with the remaining 2 percent comprised of a variety of products including other farm products, chemicals, and sand and gravel.

2.1.12 Recreation

There are 33 developed recreation sites adjacent to the lower Snake River reservoirs. These include 29 boat ramps with 59 launch lanes, 9 campgrounds with approximately 435 individual campsites, and 49 day-use facilities (e.g., shelters, swimming beaches, and scenic views). There are also 22 access or primitive recreation areas where camping is allowed. Most of these recreation sites are located in rural areas removed from population centers. Exceptions include the sites at Ice Harbor, which are close enough to be used by residents of the Tri-Cities, and sites at Lower Granite near the Lewiston-Clarkston area. Several of the larger developed sites were constructed by the Corps and are operated by counties, states, or port districts under lease. The details of recreation aspects of the Lower Snake River Project are discussed in Section 4.12, Recreation and Tourism.

2.2 Facility Operations and Structures

The following sections discuss specific operations and structures at each of the hydropower facilities in turn, proceeding downstream from Lower Granite. Summary information for each facility is provided in Table 2-4. Detailed descriptions of fish facilities (Section 3.1, Alternative 1—Existing Conditions), park and recreation facilities (Section 4.12, Recreation), and wildlife habitat (Section 4.6.2, Wildlife) are provided in their respective sections. The four main features (powerhouse, spillway, navigation lock, and non-overflow embankment) common to all four dams are shown on Figure 2-6.

2.2.1 Lower Granite

Lower Granite is located on the Snake River at river mile (RM) 107 near Almota, Washington (Figure 2-6). The project is named after Granite Point, a rock formation 6 miles upstream from the dam. This rock outcropping is the only granite formation in an area of generally dark basalt. Lower Granite Lake extends 39.3 miles upstream on the Snake River and a further 4.6 miles on the Clearwater River. Lewiston, Idaho is located 33 miles upstream of the dam. Lower Granite was placed into service in 1975. Lower Granite has five major components (Figure 2-7). From the south (right bank) to north (left bank), they are the fish passage facilities, powerhouse, spillway, navigation lock, and non-overflow embankment. The dam, located at the head of Lake Bryan, is 3,200 feet long, with an effective height of 100 feet.

The normal operating range of Lower Granite Lake (the reservoir) extends from 733 to 738 feet above National Geodetic Vertical Datum (NGVD29). The powerhouse is 656

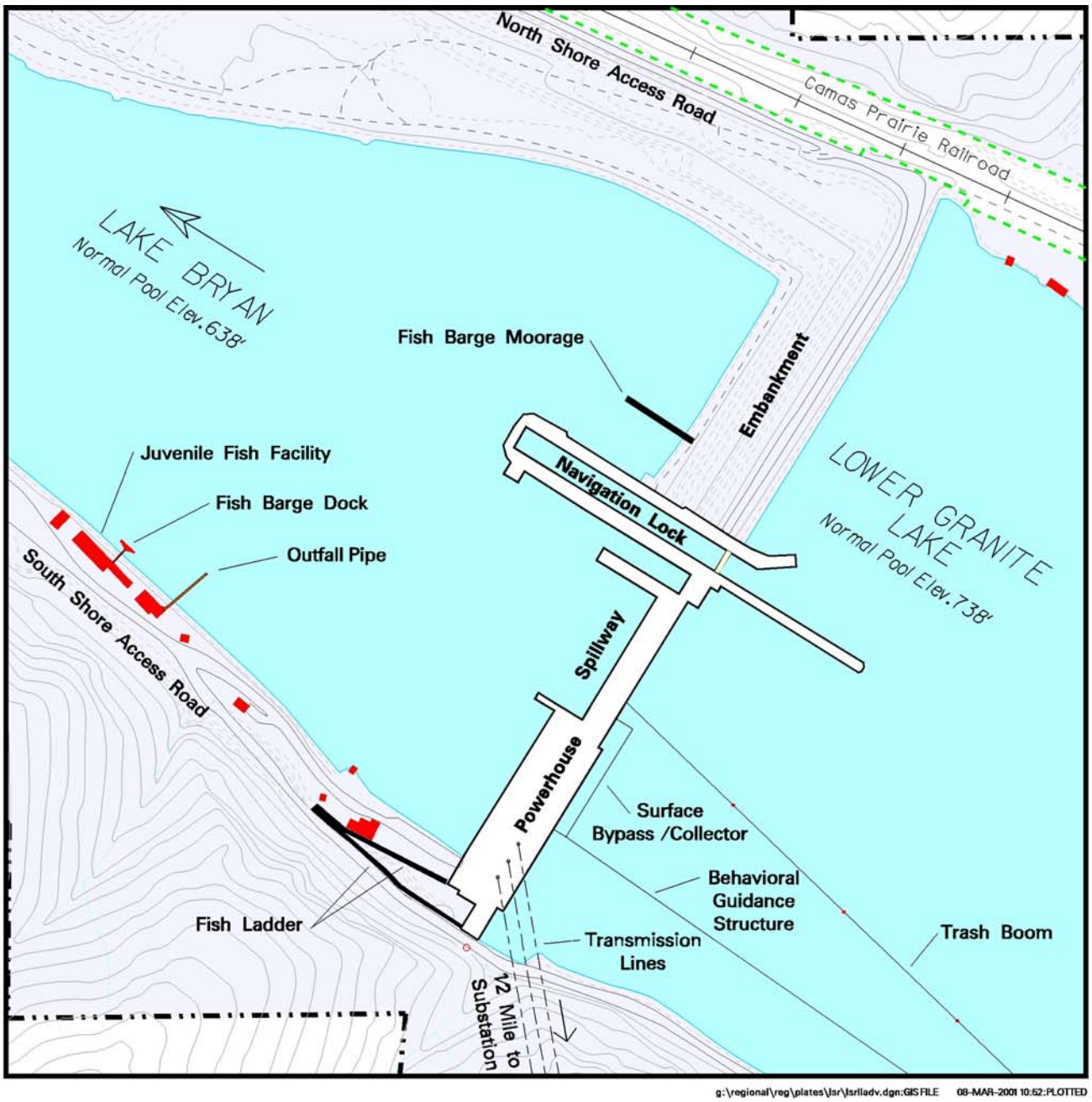
Table 2-4. Facility Operations and Structures

	Lower Granite	Little Goose	Lower Monumental	Ice Harbor
Reservoir				
Normal Pool Operating Range (feet above NGVD29)	733 - 738	633 - 638	537 - 540	437 - 440
Total Length (miles)	43.9	37.2	28.7	31.9
Length of Shoreline (miles)	92	93	86	83
Average Width (miles)	0.3	0.4	0.4	0.4
Surface Area (acres) [1/]	8,448	10,825	4,960	9,002
General (Dam)				
Dam Length (feet)	3,200	2,655	3,791	2,822
Hydraulic Head (feet)	100	98	100	100
Powerhouse				
Powerhouse Length (feet)	656	656	656	671
Nameplate Capacity (MW)	810	810	810	603
Total Number of Units Installed	6	6	6	6
Spillway				
Spillway Length (feet)	512	512	498	590
Number of Spillway Bays	8	8	8	10
Stilling Basin Length (feet)	188	118	180	168
Navigation Lock and Channels				
Lock Chamber Length (feet)	675	668	650	675
Lock Chamber Width (feet)	86	86	86	86
Maximum Operating Lock Lift (feet)	105	101	103	105

NGVD29 = National Geodetic Vertical Datum
1/ At normal operating pool elevation (highest level of range)
Source: Corps, 1999c

feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 188 feet downstream from the spillway along the river bottom. The navigation lock at Lower Granite is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 756 feet long. This embankment is an earthfill structure with an impervious core. The core is protected both upstream and downstream by sand and gravel

Figure 2-6. Looking Upstream at Lower Granite Facility



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–7.
SCHEMATIC OF LOWER GRANITE FACILITY

filter zones flanked by gravel shells. The upstream slope of the embankment is armored with riprap from elevation 756 feet down to 719 feet; below 719 feet, smaller rock fill provides bank protection.

Juvenile fish passage facilities at Lower Granite consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities include one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system. Components of the juvenile and adult fish passage facilities are presented in Table 2-2.

There are 9,220.4 acres of project lands surrounding Lower Granite Lake. These lands include fee lands that are Federally owned and managed by the Corps, as well as easement lands on which the Corps has designated rights (i.e., flowage or access). Approximately 515 acres are leased either to state or local public agencies. Port districts own lands adjacent to the project for industrial development. The majority of these project lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are 13 developed recreation areas adjacent to Lower Granite Lake. These include 12 boat ramps with 28 launch lanes, 2 moorage/marina facilities, 12 day-use facilities, and 3 campgrounds with a total of approximately 168 individual campsites.

Land surrounding the reservoir is also managed by the Corps for wildlife habitat enhancement. HMUs were established along the lower Snake River to compensate for wildlife habitat lost as a result of inundation by the Lower Snake River Project. There are 17 HMUs, totaling 5,002 acres, along Lower Granite Lake. Water pumped from the reservoir is used to irrigate one of these HMUs.

Water is withdrawn from Lower Granite Lake by six municipal and industrial pump stations. The water is used for municipal water system backup, golf course irrigation, industrial process water for paper production and concrete aggregate washing, and park irrigation. Two additional stations owned by Asotin Public Utility District (PUD) #1 have not been operated over the past few years and no plans exist to operate them in the immediate future.

There are three port facilities on Lower Granite Lake (Lewiston, Clarkston, and Wilma). They are used for grain, wood products, and other commodities. The port at Wilma is capable of handling petroleum products.

2.2.2 Little Goose

Little Goose Dam (Figure 2-8) is located on the Snake River at RM 70.3 near Riparia, Washington. The facility is named after an upstream island that was inundated following completion of the dam. Little Goose Reservoir, known as Lake Bryan, extends 37.2 miles

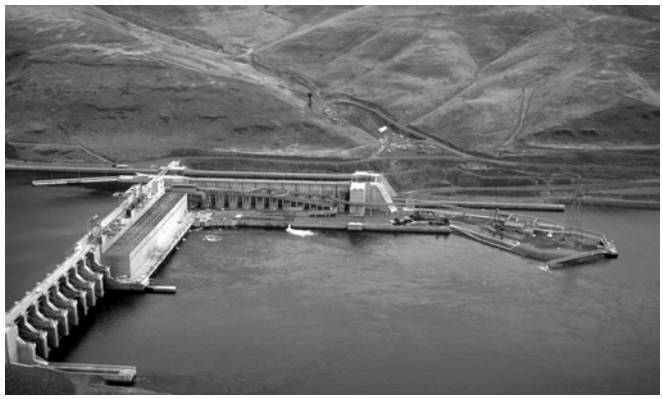
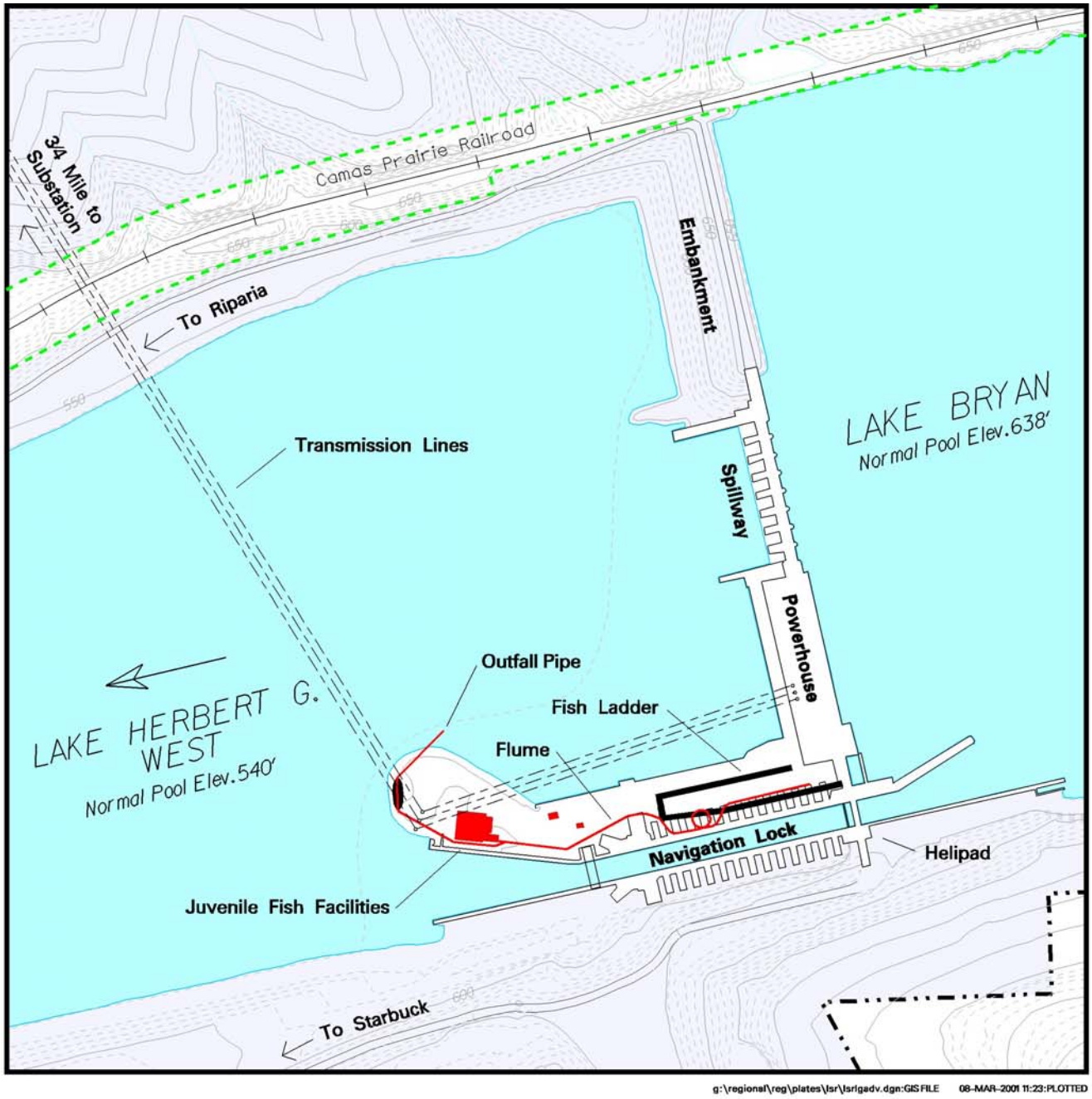


Figure 2-8. Looking South at Little Goose Facility



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–9.
SCHEMATIC OF LITTLE GOOSE FACILITY

upstream to Lower Granite. Little Goose was placed into service in 1970. Little Goose has several major components (Figure 2-9). From the south (top bank) to north (lower bank), they are the navigation lock, fish passage facilities, powerhouse, spillway, and non-overflow embankment. The dam, located at the head of Lake Herbert G. West, is 2,655 feet long with an effective height of 98 feet. The normal operating range of Lake Bryan (the reservoir) extends from 633 feet to 638 feet NGVD29. The powerhouse is 656 feet long and 243 feet wide, and houses six, 135-MW generators. Next to the powerhouse is a 512-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 118 feet downstream from the spillway along the river bottom.

The navigation lock at Little Goose is a single-lift type, 668 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 101 feet. Next to the navigation lock is the north dam embankment, which is a gravel fill structure with rock facing and an impervious core. Juvenile fish passage facilities at Little Goose consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system.

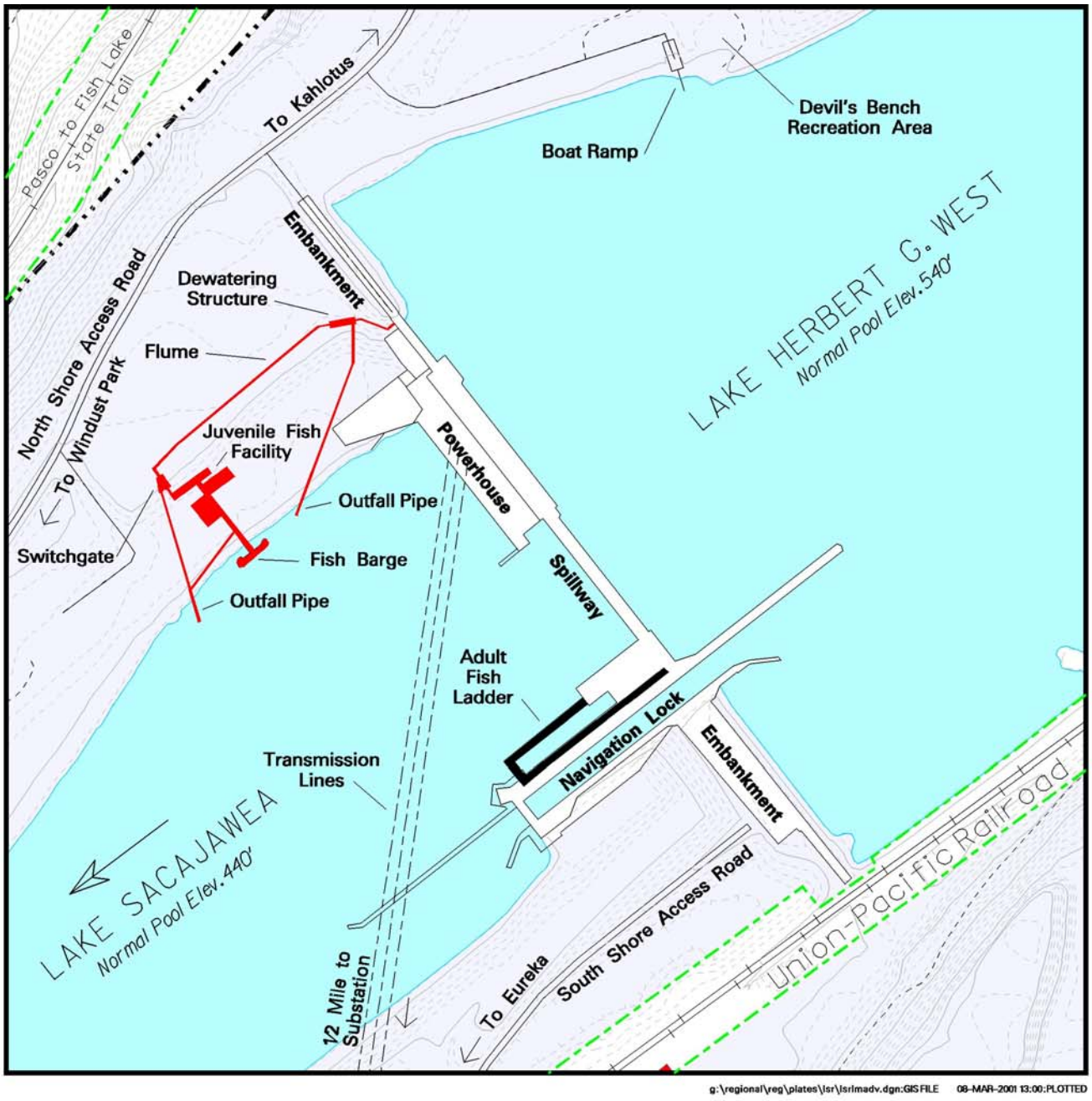
There are 4,859.6 acres of project lands surrounding Lake Bryan. These project lands include both fee and easement lands. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Currently, two areas of approximately 150 acres are leased either to the state or local ports for recreation.

There are seven developed recreation areas adjacent to Lake Bryan. These include 6 boat ramps with 13 launch lanes, 1 marina, 3 day-use facilities, and 2 campgrounds with a total of approximately 88 individual campsites. There are 18 HMUs, totaling 3,019 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There are three port facilities on Lake Bryan (Almota, Central Ferry, and Garfield), all used for grain. The port at Central Ferry also services other commodities.

2.2.3 Lower Monumental

Lower Monumental is located on the Snake River at RM 41.6 near Magallon, Washington (Figure 2-10). The dam is named after a large rock with vertical basalt columns. This rock, named Ship Rock by Lewis and Clark, was later renamed Monumental Rock. The reservoir at Lower Monumental, named Lake Herbert G. West in 1978, extends 28.7 miles upstream to Little

Figure 2-10. Looking South at Lower Monumental Facility



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–11.
SCHEMATIC OF LOWER MONUMENTAL FACILITY

Goose. Lower Monumental was placed into service in 1969. Lower Monumental has several major components (Figure 2-11). From the south (top bank) north (lower bank), they are the south non-overflow embankment, navigation lock, fish passage facilities (also located between the powerhouse and the north non-overflow embankment), spillway, powerhouse, and the north non-overflow embankment. The dam, located at the head of Lake Sacajawea, is 3,791 feet long, with an effective height of 100 feet. The normal operating range of Lake West (the reservoir) is from 537 to 540 feet NGVD29. The powerhouse is 656 feet long and houses six 135-MW generators. Next to the powerhouse is a 498-foot-long concrete spillway equipped with steel tainter gates. The spillway has eight spill bays, each 50 feet wide. The tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 180 feet downstream from the spillway on the river bottom. The navigation lock at Lower Monumental is a single-lift type, 666 feet long by 86 feet wide, with a 14-foot minimum operating depth and a maximum lift of 103 feet. Next to the navigation lock is the north dam embankment, which is 968 feet long. Juvenile fish passage facilities at Lower Monumental consist of a bypass system and transportation facilities (see Table 2-2 and Sections 2.1.1, Adult Fish, and 2.1.2, Juvenile Fish). Adult fish passage facilities are comprised of north and south shore fish ladders, a powerhouse collection system, and an auxiliary water supply system.

There are 9,143.6 acres of project lands surrounding Lake West. These project lands include both fee and easement lands. Port districts own land both on and adjacent to the project lands for industrial development. The majority of the Corps-managed lands, 7,024.0 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Approximately 1,177 acres are leased to the State of Washington for Lyons Ferry State Park.

There are six developed recreation areas adjacent to the Lake West. These include 4 boat ramps with 8 launch lanes, 1 marina, 9 day-use facilities, and 1 campground with approximately 50 individual campsites. There are 13 HMUs, totaling 4,381 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. Well water is used to irrigate one HMU. There is one port on the reservoir (Lyons Ferry). It is used for grain.

2.2.4 Ice Harbor

Ice Harbor is located on the Snake River at RM 9.7 near Levee, Washington (Figure 2-12). Major cities in the local vicinity include Kennewick and Pasco, which are located upstream of the confluence of the lower Snake and Columbia Rivers, and Richland, which is located at the confluence of the Yakima and Columbia rivers. Ice Harbor is named after a mooring spot a few miles upstream of the Snake-Columbia confluence.

Figure 2-12. Looking Northeast at Ice Harbor Facility

The reservoir at Ice Harbor, known as Lake Sacajawea, extends 31.9 miles upstream to Lower Monumental. Ice Harbor was placed into service in 1961. Ice Harbor has several major components (Figure 2-13). From the south (right bank) to north (left bank), they are the fish passage facilities (also located between the spillway and the navigation lock) powerhouse, spillway, navigation lock, and non-overflow embankment. The dam is 2,822 feet long, with an effective height of 100 feet. The normal operating range of Lake Sacajawea extends from 437 to 440 feet NGVD29. The powerhouse is 671 feet long and houses three 90-MW and three 110-MW generators. Next to the powerhouse is a 590-foot-long concrete spillway equipped with steel tainter gates. The spillway has 10 spillbays, each 50 feet wide. The tainter gates are each 50 feet wide by 52.9 feet high. A concrete-lined stilling basin extends 168 feet downstream from the spillway along the river bottom.

The navigation lock at Ice Harbor is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 624 feet long.

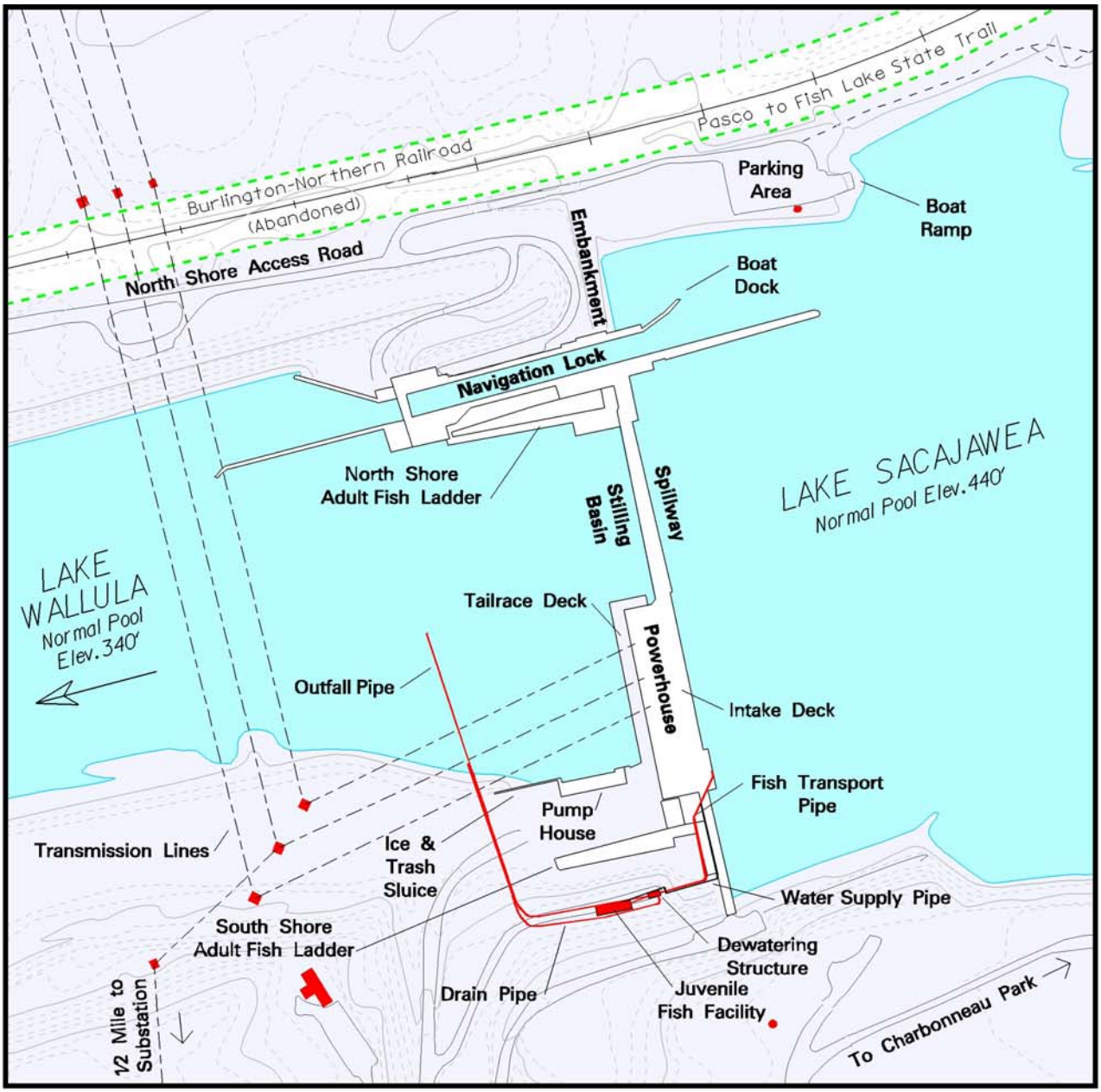
Juvenile fish passage facilities at Ice Harbor consist of a bypass system and juvenile transportation facilities. Adult fish passage facilities are made up of separate north and south shore facilities (see Table 2-2 and Sections 2.1.1, Adult Fish and 2.1.2, Juvenile Fish). The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities are comprised of a fish ladder, a powerhouse collection system, and an auxiliary water supply system.

There are 4,037.7 acres of project lands surrounding Lake Sacajawea. These lands include both fee and easement lands. The majority of the Corps-managed lands, 3,517.3 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are seven developed recreation areas adjacent to the Lake Sacajawea. These include 6 boat ramps with 10 launch lanes, 1 marina, 2 moorage facilities, and 3 campgrounds with a total of approximately 145 individual campsites. There are 14 HMUs, totaling 2,032 acres, along the reservoir. Water pumped from the pool is used to irrigate 3 of these HMUs.

There are two ports on Lake Sacajawea (Windust and Sheffler). Both are used for grain.

Approximately 37,000 acres of non-Federal land are presently irrigated with water pumped from Lake Sacajawea. Between the 14 irrigation pumping stations at the reservoir, there are about 75 pumps. The irrigated lands grow a variety of crops, including cottonwood/poplar trees, potatoes, and corn.



Conservation Pool
USACE Lands
USACE Project Boundary
Railroad Boundary
Access Road
Service Road
10–Foot Contour Lines

METERS 75 25 0
FEET 125 250 500

GEOGRAPHIC INFORMATION SYSTEMS
Corps of Engineers
Walla Walla District

1 ACRE
0.5
0.25

1 : 6,000

LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

Figure 2–13.
SCHEMATIC OF ICE HARBOR FACILITY