Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Evaluate The Effectiveness Of Fish Screens

Bonneville project number, if an ongoing project 8506200

Business name of agency, institution or organization requesting funding
Pacific Northwest National Laboratory

Business acronym (if appropriate) PNNL

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
None			

NPPC Program Measure Number(s) which this project addresses.
Council Measure 7.11 (NPPC 1994) which follows from previous Council Measures [Section 800 (NPPC 1987) and Section 900 (NPPC 1984)]

NMFS Biological Opinion Number(s) which this project addresses.
NA

Other planning document references.
Walt Larrick, U.S. Bureau of Reclamation, 509/575-5848 ex209;
Steve Rainey, National Marine Fisheries Service 503/230-5418;
Bryon Nordlund, National Marine Fisheries Service 503/230-5418;
John Easterbrook, Washington State Department of Fish and Wildlife 509/575-2733
Chuck Keller. U.S. Bureau of Reclamation, 208/756-6850

Subbasin.
Yakima, Upper Columbia Basin, Salmon River

Short description.
Evaluate the biologic and hydrologic effectiveness of juvenile fish passage facilities that were designed to correct structural problems at irrigation diversion dams, canals and ditches that interfered with the passage of anadromous fish.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	X	Watershed
*	Resident fish	*	O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries		Research		Ecosystems
	Climate	X	Monitoring/eval.		Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.
Fish Passage Facilities, Irrigation Screens, Monitoring and Evaluation of Fish Protection Facilities

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
none		

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	On-Site Evaluations Yakima Basin and other Fish Screens	a	Monitor operations, flows, screens and seals to determine if they

			provide safe, efficient fish bypass.
		b	Support cooperating agencies in evaluating new or revised screen designs as they are developed and in addressing site-specific concerns at fish screen facilities as they are identified.
2	Use of Behaviorial Barriers at Fish Screening Facilities to Enhance Fish Protection	a	Use PNNL screen facility to test sound, light, or other behavioral barriers to improve screen efficiency.
		b	Assess potential to use behavoral barriers at irrigation diversions. Perform engineering analysis to determine the most cost effective means of delivering sound stimulus in irrigation canals.
3	Fish Screening Information Access via Electronic Networks	a	PNNL screen evaluation reports will be placed on a website and linked to BPA and other cooperating agency sebsites.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	1/1999	12/1999	66.67%
2	1/1999	12/1999	31.67%
3	1/1999	12/1999	1.67%
			TOTAL 100.01%

Schedule constraints.
The Task 1 schedule is constrained by the irrigation season and spring outmigration. Monitoring must begin before canals are filled with water.
The Task 2 schedule is constrained by the availability of juvenile sized salmonids.

Completion date.
12/2003

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	based on CY1999 estimate	95,969
Fringe benefits	based on CY1999 estimate	55,783
Supplies, materials, non-expendable property	based on CY1999 estimate	61,556
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags:	
Travel	based on FY1998 estimate	12,847
Indirect costs	based on FY1998 estimate	73,844
Subcontracts		
Other		
TOTAL		$299,999

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$300,000	$300,000	$300,000	$300,000
O&M as % of total	0.00%	0.00%	0.00%	0.00%

Section 6. Abstract

This project has been in place since 1985. The project objective is to evaluate the effectiveness of fish protection facilities as they built and revisit screens to ensure that the screens continue to protect fish after years of operation. The Council's Program includes actions to correct structural problems at irrigation diversion dams, canals and ditches that interfere with the passage of anadromous fish. Evaluations are guided by provisions of Council Measure 7.11 (NPPC 1994) which follows from previous Council Measures [Section 800 (NPPC 1987) and Section 900 (NPPC 1984)]. Video cameras and multidirectional flow meters, will be used to monitor screen facilities to determine if the sites are equipped to provide safe fish passage and operated within design limits. Fyke nets will be placed in the canals to determine if the sites are maintained in a "fish-tight" condition. Design improvements for fish screens will be tested using salmonids in controlled behavioral and conditional response tests. During the irrigation season (March-October), we expect to monitor fish behavior and document sedimentation, debris buildup, and flow-patterns at all Phase II screens and any other screens requested by the BPA or other agencies. Information collected will be presented to BPA as technical reports and open literature publications. Additionally, results will be sent to other

agencies involved with screening facilities. Reports will be placed at http://rebar.bpa.gov/Environment/ and http://www.pnl.gov/ecology/. Problems with operations and maintenance will be reported immediately to agencies responsible for daily operation of a screening facility.

Section 7. Project description

a. Technical and/or scientific background.

This project was established to evaluates fish screening facilities that were being constructed and operated in the Yakima River Basin, Washington. The evaluations are guided by provisions of Council Measure 7.11 (NPPC 1994) which follows from previous Council Measures [Section 800 (NPPC 1987) and Section 900 (NPPC 1984)]. The evaluations are conducted to ensure screening facilities "correct structural problems at irrigation diversion dams, canals and ditches that interfere with the passage of anadromous fish" [Council Measure 7.11 (NPPC 1994)]. These are off-site enhancement projects to mitigate the impacts of hydropower elsewhere in the basin. In addition to site specific evaluations, this project provides laboratory facilities to evaluate proposed operational or design changes that might enhance the protection of juvenile salmonids.

Evaluation of 7 Phase I sites in the Yakima Basin from 1985 through 1990 relied heavily on the use of release-and-recapture tests with hatchery fish to monitor major fisheries concerns such as the potential for injury, migration delay, and screen integrity. Measurements of approach and sweep velocity in front of the screens and flow through the fish bypass system were completed at 8 sites to determine if screening facilities satisfied design criteria established to ensure safe fish passage conditions. The methods and results of Phase I evaluations were presented in BPA annual reports (Abernethy et al. 1989, 1990; Neitzel et al. 1985, 1986, 1988, 1990 a,b,c).

Due to the large number of Phase II screening facilities, the expense of conducting release-and-recapture tests with fish, and other constraints, such as gaining approval to acquire and release fish stocks for research, we developed new methods and strategies to evaluate Phase II fish screens. Using the new methods and technologies, we determined if screening facilities were; 1) properly equipped to provide safe fish passage; 2) operated within their design limits; and 3) properly maintained in a "fish-tight" condition.

Using these 3 benchmarks, we streamlined the evaluation process and documented the performance of Phase II fish screening facilities in Washington (Table 1) and dozens more in Idaho in 1994 (Neitzel and Blanton 1997). We also were able to identify fish species, monitor and fish behavior, document sedimentation and debris buildup, and document aberrant flow patterns in the screen forebay by observing particle drift and eddies. These techniques provide the groundwork for monitoring and documenting screening facility performance in order to "certify" or "audit" fish screen facilities.

The approach to evaluating Phase II screens includes two types of tasks. The first is in-field, on-site evaluation of operating screens. Second, is the testing of specific

operational or design criteria at a Phase II screen operating at the PNNL laboratory in Richland, Washington.

Task I-a, Field Evaluations - During 1998, we will evaluate operation of the fish screening facilities in the Yakima Basin or elsewhere (During 1997 we responded to a request to evaluate flows at the Chandler facility and we have been asked to evaluate flows at the Dryden Screens during 1998.) We will determine if sites are properly equipped to provide safe, efficient fish bypass by reviewing design drawings, operating procedures, and components installed and in use at the facility. We will monitor approach and sweep velocities in front of the screens and in the fish bypass to determine if the facilities meet fish passage criteria. Screen integrity will be monitored by completing "real-time" inspections of sites using underwater video technology.

Task I-b, Technical assistance task - We propose to a technical assistance task to support cooperating agencies in evaluating screen designs as they are developed and to address site-specific concerns at Phase I or Phase II sites as they are identified. Many questions concerning screen design can be addressed by with the modular fish screen already installed at the PNNL laboratory. An example of a design criteria that can be evaluated is the angles vs. parallel screen or orifice size for the fish return. Both have been successfully tested at the PNNL facility (Neitzel et. al 1996, Abernethy et. al 1996).

SITE NUMBER	LOCATION	SCREENS IN OPERATION	PNNL EVALUATION	CRITERIA	SCHEDULED FOR EVALUATION
54	Bachelor/Hatton Screens	YES	1994 (1)	YES	1998
66	Bull Diversion Screens		1997	YES	1998
64	Clark Screens		1997	YES	1998
52	Congdon Screens	YES	1997	YES	1998
68	Ellensburg Mill Screens		1997	YES	1998
58	Fruitvale Screens	YES	1997	YES	1998
43	Gleed Ditch Screens	YES	1994 (2)	YES	1998
53	Kelley/Lowrey Screens	YES	1994 (2)	YES	1998
41	Kiona Screens	NO	1993 (partial)	YES	Removed in 1996
67	Lindsey Screens		1997	YES	1998
46	Lower WIP Screen/Ladder	YES	1997	YES	1998
63	McAusland Screens		1997	YES	1998
42	Naches/Cowiche Screens	YES	1994 (2)	YES	1998
56	Naches/Selah Screens	YES	1997	YES	1998
44	New Cascade	YES	1997	YES	1998

	Screens				
48	Snipes/Allen Screens	YES	1997	YES	1998
49	Taylor Screens	YES	1997	YES	1998
47	Toppenish Pump Screen		NO	YES	1998
59	Union Gap Screens		1997	YES	1998
65	WIP Upper Screens		1997	YES	1998
57	Yakima-Tieton Screens		1997	YES	1998

Many problems identified during and after our Phase I evaluations in the Yakima Basin may still be unresolved. We propose to revisit up to 6 Phase I sites to monitor potential fisheries problems (such as flow balance, conditions in the bypass separation chamber, screen integrity, and operations) using the new tools and technology developed to monitor Phase II screens.

TECHNICAL REFERENCES:

Abernethy, C.S., D.A. Neitzel, and W.V. Mavros. 1996. Movement and Injury Rates for Three Life Stages of Spring Chinook Salmon Oncorhychus tshawytscha: A Comparison of Submerged Orifices and an Overflow Weir for Fish Bypass in a Modular Rotary Drum Fish Screen. Prepared by the Pacific Northwest National Laboratory, Richland, Washington for the Bonneville Power Administration, Portland, Oregon.

Abernethy, C. S., D. A. Neitzel, and E. W. Lusty. 1990. Velocity Measurements at Three Fish Screening Facilities in the Yakima River Basin. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Abernethy, C. S., D. A. Neitzel, and E. W. Lusty. 1989. Velocity Measurements at Six Fish Screening Facilities in the Yakima River Basin. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Mueller, R.P., D.A. Neitzel, W.V. Mavros, T.J. Carlson. (Ms submitted). Evaluation of Low and High Frequency Sound for Enhancing the Capacity of Fish Screening Facilities to Protect Outmigrating Salmonids. Prepared by the Pacific Northwest National Laboratory, Richland, Washington for the Bonneville Power Administration, Portland, Oregon

Mueller, R.P., C.S. Abernethy, and D.A. Neitzel. 1994. A Fisheries Evaluation of the Dryden Fish Screen Facility. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D.A. and S.L. Blanton. 1997. Washington Phase II Fish Diversion Screen Evaluations in the Yakima River Basin, 1997. Prepared by the Pacific Northwest National Laboratory, Richland, Washington, for the Division of Fish and Wildlife, Bonneville Power Administration, Portland, Oregon.

Neitzel, D.A., S.L. Blanton, C.S. Abernethy, and D.S. Daly. 1996. Movement of Fall Chinook Salmon Fry *Oncorhynchus tshawytscha*: A Comparison of Approach Angles for Fish Bypass in a Modular Rotary Drum Fish Screen. Prepared by the Pacific Northwest National Laboratory, Richland, Washington for the Bonneville Power Administration, Portland, Oregon.

Neitzel, D. A., C. S. Abernethy, and E. W. Lusty. 1990a. A Fisheries Evaluation of the Wapato, Sunnyside, and Toppenish Creek Canal Fish Screening Facilities, Spring 1988. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D. A., C. S. Abernethy, and E. W. Lusty. 1990b. A Fisheries Evaluation of the Westside Ditch and Wapato Canal Fish Screening Facilities, Spring 1989. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D. A., C. S. Abernethy, and G. A. Martenson. 1990c. A Fisheries Evaluation of the Westside Ditch and Town Canal Fish Screening Facilities, Spring 1990. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D. A., C. S. Abernethy, E. W. Lusty, and S. J. Wampler. 1988. A Fisheries Evaluation of the Richland and Wapato Canal Fish Screening Facility, Spring 1987. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D. A., C. S. Abernethy, and E. W. Lusty. 1986. A Fisheries Evaluation of the Richland and Toppenish/Satus Canal Fish Screening Facility, Spring 1986. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Neitzel, D. A., C. S. Abernethy, E. W. Lusty, and L. A. Prohammer. 1985. A Fisheries Evaluation of the Sunnyside Canal Fish Screening Facility, Spring 1985. Prepared for the Bonneville Power Administration by the Pacific Northwest Laboratory, Richland, Washington.

Northwest Power Planning Council (NPPC). 1984. *Columbia River Basin Fish and Wildlife Program*. Northwest Power Planning Council, Portland, Oregon.

Northwest Power Planning Council (NPPC). 1987. *Columbia River Basin Fish and Wildlife Program*. Northwest Power Planning Council, Portland, Oregon.

Northwest Power Planning Council (NPPC). 1994. *Columbia River Basin Fish and Wildlife Program*. Northwest Power Planning Council, Portland, Oregon.

b. Proposal objectives.

There were three specific measurable objectives for Project 8506200:

1. Provide fisheries and hydrological evaluations of new screens as they are installed. The criteria used to measure this goal are the screen criteria developed by the National Marine Fisheries Service.
2. Provide a laboratory facility for testing proposed changes to facility components (e.g., application of behavorial guidance systems, new bottom seals, forebay configurations, screen mesh size).
3. Provide on site monitoring of operating screens. Monitoring criteria are: operating as designed, seals installed and maintained to prevent fish from passing through screens, and approach and sweep flows to NMFS criteria.

The testable hypothesis for Project 8506200 is fish screening facilities can be designed, constructed, operated and maintained to protect fish that are diverted into irrigation canals.

Underlying Assumptions

The underlying assumptions for testing this hypothesis are:

1. Fish are not killed or injured as they are diverted from the irrigation canal back to the river.
2. Fish can not pass downstream of the facility into the irrigation canal
3. Migrating fish are not delayed in or by the fish screening facility.
4. Fish are not subjected to increased predation by the presence or operation of the screening facility.
5. Fish are protected during all possible screen operating scenarios, including periods between scheduled maintenance.

Information collected during field and laboratory studies in 1999 will be presented to BPA as technical reports. The report will include site descriptions, the methods used to make evaluations, the results and discussion of evaluations, and recommendations on how to improve monitoring methods, operating procedures, screen operations, and facility maintenance to address problems. In addition, results of technical assistance efforts will be sent to BPA as letter reports, with copies going to the other agencies involved with the screening facility. Reports will be placed at http://rebar.bpa.gov/Environment/ and http://www.pnl.gov/ecology/. Problems associated with operations and maintenance will also be reported verbally to the agencies responsible for daily operation of a screening facility.

c. Rationale and significance to Regional Programs.

Rationale: Unscreened and inadequately screened irrigation diversions, or poorly maintained screens facilities result in the loss of many juvenile salmon and steelhead that have survived the rigors of natural rearing only to be killed at the beginning of their journey to the ocean. Screening irrigation diversions has a high probability of

reducing salmon and steelhead mortality and will require the use of all available resources for funding, design, construction and installation.

Project 8506200 has provided the region with the evaluations of installed screening facilities to ensure that the facilities are accomplishing the objectives for which they were designed and built. Monitoring a screening facilities' compliance with design and maintenance criteria is key to measure 7.11B of meeting its objective of protecting juvenile salmon and steelhead during their migration to the ocean.

Furthering the Goals of the FWP: During the last 50 years, state and federal entities initiated water diversion screening programs and passage improvements throughout the Columbia River Basin. Installation of new screens and improvement of old screens was initiated in the Yakima Basin during 1985. Project 8506200 relates to screen improvement projects throughout the basin. These include: 7.10A.3 (Fisheries Managers maintenance of a prioritized list of tributary screening and passage facilities), 7.10A.4 (National Marine Fisheries Service, Working Oversight Committee, Appropriate Technical Work Groups and Bonneville identification of resources needed to accomplish screening and passage and monitoring and evaluation plans), 7.10A.5 (Bureau of Land Management, Idaho and Oregon/Washington Offices; U.S. Forest Service Regions 1,4,6; and Bureau of Reclamation, Pacific Northwest Region requirements that existing and new water use authorizations have functional fish screens and other passage facilities), 7.10A.6 (Corps of Engineers inspection of underwater diversions), 7.10A.7 (Idaho, Oregon, Washington requirements that installation, operation, and maintenance of fish screens are in compliance with state laws), 7.10.D (Bonneville's evaluation of Dryden Dam screens), and 7.11 (Improvement of irrigation diversions in the Yakima River basin).

Relevent Projects: Project staff regularly work with Washington State Department of Fish and Wildlife, the Idaho Department of Fish and Game, the U.S. Bureau of Reclamation, and the National Marine Fisheries Service. Project work also requires coordination with the irrigation districts of the Yakima Basin and the Yakama Indian Nation.

Pertinent Staff	Affiliation
John Easterbrooks, Biologist, Screens Shop, Yakima, Washington	Washington Department of Fish and Wildlife
Ken Bates, Staff Engineer, Olympia, Washington	Washington Department of Fish and Wildlife
Gary Power, Regional Supervisor, Salmon Region, Salmon, Idaho	Idaho Department of Fish and Game
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Lynn Stratton, Construction Supervisor, Anadromous Fish Screening Program, Salmon, Idaho	Idaho Department of Fish and Game
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Chuck Keller, Biologist, Salmon, Idaho branch office	U.S. Bureau of Reclamation
Walt Larrick, Biologist, Yakima Office	U.S. Bureau of Reclamation
Steve Raney, Hydraulic Engineer, Portland, Oregon	National Marine Fisheries Service
Bob Pearce, Hydraulic Engineer, Portland, Oregon	National Marine Fisheries Service
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Project 8506200 is related to screen improvement projects throughout the basin. These include: 7.10A.3 (Fisheries Managers maintenance of a prioritized list of tributary screening and passage facilities), 7.10A.4 (National Marine Fisheries Service, Working Oversight Committee, Appropriate Technical Work Groups and Bonneville identification of resources needed to accomplish screening and passage and monitoring and evaluation plans), 7.10A.5 (Bureau of Land Management, Idaho and Oregon/Washington Offices; U.S. Forest Service Regions 1,4,6; and Bureau of Reclamation, Pacific Northwest Region requirements that existing and new water use

authorizations have functional fish screens and other passage facilities), 7.10A.6 (Corps of Engineers inspection of underwater diversions), 7.10A.7 (Idaho, Oregon, Washington requirements that installation, operation, and maintenance of fish screens are in compliance with state laws), 7.10.D (Bonneville's evaluation of Dryden Dam screens), and 7.11 (Improvement of irrigation diversions in the Yakima River basin).

Novel Ideas: The evaluation of fish screening facilities has evolved since PNNL began working with BPA during 1985. Together we have identified many of the problems that reduce the potential effectiveness of the screening facilities and have been able to work with the WDFW and NMFS to change designs, operations, and maintenance of the screens. Today, the potential to further improve and maintain the fish screening facilities has changed. Screen technology has progressed to the point that screens can be placed in very small diversions (less than 1 cfs total flow). This has resulted in the desire to protect fish during the very earliest period of their life history.

Some of the information that PNNL has collected indicates that protecting zero-age fish will require further improvements in screening technology. Physical barriers probably can not be designed to reliably achieve and maintain the very small tolerances required to protect fish that are less than 30 mm in length. Thus, barriers affecting fish behavior may have to be used in conjunction with screens or other physical barriers to dissuade most fish from entering diversion canals. Investigations conducted in the United States and Norway indicate that sound can be used to direct Atlantic and Pacific salmon greater than 120 mm in length (Knudsen et al. 1992, 1994, 1996; Taft et al.1995). During 1996, PNNL staff conducted tests with 40 to 60 mm chinook salmon and found that even fish of this size reacted to infrasound (Neitzel et al. In press). These data indicate that infrasound potentially could be used to improve the protection of very small fish that can not be adequately protected by physical barriers alone.

The use of the PNNL screen facility is also important to provide a setting for the testing of improvements/modifications to the fish screens. Mark and recapture techniques that have proved so useful in the past screen evaluations are difficult to employ. The potential for introducing non-indigenous stocks into streams near test site is not acceptable. This is especially true where there are Threatened or Endangered species in the watershed. Additionally, the protection of very small fish (less than 30 mm) requires a very controlled environment because it is difficult to recapture and account for test fish and marking small fish it also difficult.

PNNL has two screening facilities at its Richland laboratory; a 4 ft wide forebay with a 4-ft wide, 2-ft diameter drum screen. The drum can be tested using 1/8-in. or 3/16-in. mesh perforated plate. The PNNL laboratory also has a screen facility with a 6 ft wide forebay. The bay can be set up to provide flows that are perpendicular to the flow or approach the screens at a twenty degree angle.

d. Project history

Project 8506200 began in 1985 with a fisheries evaluation the Sunnyside Canal Fish Screening Facility. Since 1985, project staff have completed fisheries evaluations at: Richland Canal Fish Screening Facility, Toppenish/Satus Canal Fish Screening Facility, Wapato Canal Fish Screening Facility, Toppenish Creek Canal Fish Screening Facility, Westside Ditch Fish Screening Facility, and Town Canal Fish Screening Facility. Water velocity evaluations were also completed at the Columbia Canal Fish Screening Facility, Roza Canal Fish Screening Facility, Easton Canal Fish Screening Facility, and Chandler Canal Fish Screening Facility. Project staff evaluated the potential for migration delay and increased loss to predation at Wapato and Sunnyside Canal Fish Screening Facilities during 1991 operations. They evaluated the Dryden Fish Screening Facility during 1994. In addition, components of modular fish screens were evaluated in the laboratory at Richland during 1994 and 1995. During 1997, all the active Phase II screens were evaluated during the spring, summer and fall. An evaluation of infrasound as a behavioral improvement to fish screening facilties began in 1996. Early results indicate that the 0-age salmonids can be guided away from fish screens. Additioanlly, angled screen criteria were tested. Results indicate that significant savings can be affected by using non-angled 6-ft screens at many sites.

e. Methods.

Methods, Task 1-a. The approach to evaluating Phase II screens include two types of tasks. The first is in-field, on-site evaluation of operating screens. Second, is the testing of specific operational or design criteria at the Phase II screen operating at the PNNL laboratory in Richland, Washington.

Task I-A, Field Evaluations - During 1999, we will examine up to 20 fish screening facilities in the Yakima Basin (or elsewhere) and evaluate their operation using the 3-step approach. We will determine if sites are properly equipped to provide safe, efficient fish bypass by reviewing design drawings, operating procedures, and components installed and in use at the facility. We will monitor approach and sweep velocities in front of the screens and in the fish bypass to determine if the facilities meet fish passage criteria. Screen integrity will be monitored by completing “real-time” inspections of sites using underwater video technology. The methods and results of Phase I evaluations are presented in BPA annual reports (Abernethy et al. 1989, 1990; Neitzel et al. 1985, 1986, 1988, 1990 a,b,c).

Task I-B, Technical assistance task - We propose to establish a technical assistance task to support the cooperating agencies to evaluate screen designs as they are developed and to address site-specific concerns at Phase I or Phase II sites as they are identified. Many questions concerning screen design can be addressed by using the modular fish screen already installed at the PNNL laboratory. An example of a design criteria that can be evaluated is the angles vs. parallel screen or orifice size for the fish

return. Both have been successfully tested at the PNNL facility (Neitzel et. al 1996, Abernethy et. al 1996).

Methods; Task 2. To continue the investigation of the use of sound at fish screening facilities we propose the following three steps.

Step 1: Using facilities in the PNNL laboratory, (some modifications will be required) we will verify that behavioral stimuli (e.g., strobe lights, sound, flow gradients) can be used to modify the behavior of Pacific salmon of the species, age group, and physiological state of interest. We began this work during 1996 with zero age chinook salmon and rainbow trout. We determined that zero age chinook salmon and rainbow trout do respond to infrasound. There are some issues that need to be confirmed during 1998 related to: 1) distinguishing between a "startle" response and, based on other mechanisms, stimuli that are longer lasting and 2) the ability of some of the younger age groups (fish less than 35 mm in length) to avoid sound fields under conditions that tax their swimming ability or other physiological or morphological characteristics.

The work completed during 1996 and 1998 (Step 1) are logically followed by a scale up to field studies and an engineering feasibility studies. These steps (Steps 2 and 3) are described here and will be attempted during 1998 for infrasound. During 1999, we will examine other behavorial stimuli (e.g., strobe lights)

Step 2: We will prepare to scale up to field level demonstration(s) using the information obtained from the laboratory study. We will work with the institutions represented on the Fish Screening Oversight Committee and conduct field demonstrations in settings important to them and under conditions where they could also participate, perhaps by performing some of the fish handling work. This will all be coordinated with the BPA technical representative.

Step 3: This step will grow out of the information generated during 1996 and 1998 by the laboratory studies (Step 1). During Step 3, we will assess the potential to use sound at irrigation diversions (assuming positive results). In this step we will do the engineering analysis to determine the most cost effective means of delivering the sound stimulus across the range of potential applications. It is quite likely, as in the case of the video monitoring system, we would need to innovate to achieve the performance required to met biological operational, and cost requirements.

Critical Assumptions

Uncertainties underlie the assumptions for testing the hypothesis that fish screening facilities can be designed, constructed, operated and maintained to protect fish that are diverted into irrigation canals. The critical uncertainties relate to the extent that:

1. Fish are killed or injured as they are diverted from the irrigation canal back to the river.
2. Fish pass downstream of the facility into the irrigation canal.
3. Migrating fish delayed in or by the fish screening facility.

4. Fish are subjected to increased predation by the presence or operation of the screening facility.
5. Fish protected during all possible screen operating scenarios, including periods between scheduled maintenance.

Factors That May Limit Success: The risks associated with project 8506200 are inherit in the underlying assumptions:

1. Fish are not killed or injured as they are diverted from the irrigation canal back to the river.
2. Fish can not pass downstream of the facility into the irrigation canal
3. Migrating fish are not delayed in or by the fish screening facility.
4. Fish are not subjected to increased predation by the presence or operation of the screening facility.
5. Fish are protected during all possible screen operating scenarios, including periods between scheduled maintenance.

If any of these assumptions about the screens that are being designed, constructed, operated, and maintained in the Columbia River basin are false, salmon and steelhead will not be protected. Project 8506200 objectives are to determine that fish are being protected at irrigation diversions.

f. Facilities and equipment.

PNNL Facilities. Laboratory studies will be conducted at the PNNL laboratory in Richland, Washington. The wet lab at PNNL has been in operation since 1971. A rainbow trout brood stock has been continuously maintained at the lab to provide fish for experimental use. Besides rainbow trout, we are currently holding fall chinook salmon and have access to spring chinook salmon. We have facilities for holding and testing all life stage (egg through adults). We have successfully held and cultured other aquatic species including, cutthroat trout, brook trout, coho salmon, steelhead, whitefish, and various warm water fish and invertebrates at the laboratory.

The wet lab (1600 ft^2) has photoperiod control and is supplied with multiple water sources. Two adjoining labs are also supplied with water. Three other labs are used for special studies, analytical work, and chemical storage. The wet lab and one other lab have hepa-filtered hoods for handling chemicals. All labs are supplied with compressed air and ground fault interrupted electrical outlets.

All critical water pressures and temperatures are continuously recorded and monitored by an automated annunciator system. Abnormal events trigger an alarm that notifies facility operators of problems. In the event of a complete failure of either the well water or river water system, an automated crossover valve opens to supply the working water supply to the entire system.

Water Supplies

River Water. The wet lab is supplied with raw Columbia River water (1000 gpm capacity). Our supply system is part of a larger system that supplies water to a large industrial complex. In addition to redundant pump supplies for the main system, we have our own generator-powered emergency backup pump that can supply water to the lab in the event of primary pump failure. River water can be strained (100 micron self-cleaning filter) to remove large particulate matter. Water temperature varies from 1 to 21° C seasonally.

Well Water. Well water (600 gpm capacity) is pumped from an unconfined aquifer. The water is 17° C throughout the year. Water quality conditions are constant throughout the year. Oxygen level is near saturation without aeration.

Conditioning Equipment

Strainer. A self-cleaning 100µ strainer removes large particulate matter from the river water supply. Strained river water can then be chilled, heated, aerated, or delivered to the wet lab at ambient temperature. In the even of strainer failure, an automated valve opens to bypass the strainer.

Aerator. One water source, either well water or river water, can be aerated. Since river water is usually saturated, we use our aerator with well water. The aerator is capable of handling at least 500 gpm.

Chillers. The chilled water system is a recycling loop with two chillers. Makeup water is added on demand based on water usage. The chillers are capable of chilling about 50 gpm of water about 5° C. A third chiller used for emergency backup can supply about 15 gpm of water chilled about 5° C. The system is capable of providing temperature control to ± 1°C.

Heat Exchangers. The heated water system has two steam heat exchangers in a recycling loop with makeup water added on demand based on water usage. The system is capable of heating about 100 gpm of water to 40° C. A 40 KW electric boiler serves as emergency backup. The system is capable of providing temperature control to ± 1°C.

Indoor Facilities

Wet Lab. The existing fish culture facilities in the wet lab are summarized in the following table:

Facility	Description	#	Total Capacity
Egg incubators	Vertical flow-through	8	125,000
Fry troughs	10 ft long x 1 ft wide x 6 in deep	8	80,000
Fingerling tanks	4 ft in diameter	5	75,000

Egg Incubators. Eggs are hatched in vertical flow incubator trays (Heath incubators). Four incubators are set up, and two other systems are available. About 125,000 salmon eggs can be incubated at a time.

Fry Troughs. Eight fry troughs (10 ft long by 1 ft wide by 8 in deep) , each capable of holding about 10,000 fry, are housed in the lab. Troughs can be divided to hold several fish groups.

Fingerling Tanks. Fingerlings are reared in fiberglass circular tanks, each capable of holding about 15,000 small fingerlings. More tanks can be added in the lab as needed. When the rearing capacity of these tanks is reached, the fish are moved outdoors.

Special Test Equipment at the PNNL Laboratory

Laser Doppler Velocimeter. Measurements of turbulent fluid properties with fish present require the use of a noninvasive velocity measurement instrument. A laser Doppler velocimeter (LDV) system can be used to measure mean velocities and turbulence quantities such as shear without having to be placed inside the experimental facility. A LDV system that samples 2 velocity components is needed to measure the turbulent shear. PNNL has a fiber-optic based LDV system and has considerable experience using this system to make turbulence measurements in a variety of experimental settings.

Outdoor Facilities

The outdoor tank yard consists of several concrete ponds and a drain system where portable troughs and circular tanks are installed as needed. The outside tank yard covers about 4,000 ft^2. The following table describes our current holding facilities:

Facility	Description	#	Smolt Capacity
Fingerling tanks	4 ft in diameter	4	6,000
Juvenile tanks	6 ft in diameter	4	16,000
Juvenile raceways	Concrete, 10 ft x 4 ft x 3 ft deep	6	30,000
Yearling raceway	Concrete, 40 ft x 4 ft x 3 ft deep	1	50,000
Brood ponds	Concrete, 20 ft dia x 2 ft deep	2	50,000

Effluent Facilities

River Discharge. Wet lab effluent is discharged directly to the Columbia River. The discharge is controlled under a NPDES permit. Under the permit, we are required to monitor suspended and settleable solids, pH, and total discharge volume.

Process Sewer. The process sewer is used to dispose of effluent from bioassays and other tainted water, and as a method of quarantining fish stocks from the Columbia River. The quantity of water we may discharge to the process is limited.

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Scotia.

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Section 8. Relationships to other projects

Project 8506200 is related to screen improvement projects throughout the basin. These include: 7.10A.3 (Fisheries Managers maintenance of a prioritized list of tributary screening and passage facilities), 7.10A.4 (National Marine Fisheries Service, Working Oversight Committee, Appropriate Technical Work Groups and Bonneville identification of resources needed to accomplish screening and passage and monitoring and evaluation plans), 7.10A.5 (Bureau of Land Management, Idaho and Oregon/Washington Offices; U.S. Forest Service Regions 1,4,6; and Bureau of Reclamation, Pacific Northwest Region requirements that existing and new water use authorizations have functional fish screens and other passage facilities), 7.10A.6 (Corps of Engineers inspection of underwater diversions), 7.10A.7 (Idaho, Oregon, Washington requirements that installation, operation, and maintenance of fish screens are in compliance with state laws), 7.10.D (Bonneville's evaluation of Dryden Dam screens), and 7.11 (Improvement of irrigation diversions in the Yakima River basin).

Section 9. Key personnel

Key Staff: Duane Neitzel, Project Manager 0.26 FTE

Scott Abernethy, Senior Fisheries Specialist 0.30 FTE
Sue Blanton, Fisheries Specialist 0.22 FTE
Bob Mueller, Fisheries Specialist 0.10 FTE

RESUMES

DUANE A. NEITZEL: Staff Scientist EDUCATION: B.A., Zoology, University of Washington, 1968M.S., Biology, Washington State University, 1982EXPERIENCE: Mr. Neitzel is a staff scientist with the Aquatic Ecology Group of Battelle, Pacific Northwest Laboratories. He joined Battelle in 1972. His research efforts have focused on the assessment of impacts to aquatic ecosystems from the development and production of energy, and the management of hazardous wastes. Mr. Neitzel has reported his work in over 100 journal articles, symposium proceedings, and technical reports. Additionally, he has managed or facilitated environmental research workshops related to hazardous-waste site management, fisheries research, arid ecosystems, and marine pollution research. Some of his major assignments are summarized below:

Mr. Neitzel manages an evaluation of fish screening facilities that are being constructed in the Yakima River basin, Washington and Lemhi River basin, Idaho. The facilities are being built in irrigation canals and are designed to divert fish in the irrigation canals back to the Yakima River. The evaluation is being conducted for the Bonneville Power Administration as part of their salmonid enhancement efforts in the Columbia River basin. Mr. Neitzel participated in a 5-year study of entrainment and impingement at two water intakes on the Columbia River. Studies included estimates of impacts to phytoplankton, zooplankton, and fish. These studies were used to support the Washington Public Power Supply System's National Pollutant Discharge Elimination System permit application. The fish studies concluded with an assessment of engineering and operational changes that eliminated significant entrainment and impingement mortalities for fish populations. In 1981, Mr. Neitzel prepared a report for the U.S. Fish and Wildlife Service that outlines procedures for providing biological input to the design, location, and modification of water intake structures. This project concluded with a guidance manual for implementation of the procedures. Mr. Neitzel has presented the results of this regionally, nationally, and internationally, including the American Fisheries Society, an international meeting of fisheries engineers in Japan, and to the U.S. Congressional Office of Technical Assessment.

PUBLICATIONS

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C. SCOTT ABERNETHY: Senior Technical Specialist I
EDUCATION: B.S., Fisheries Management, University of Washington, 1969EXPERIENCE: Mr. C. Scott Abernethy is a senior technical specialist at the Pacific Northwest National Laboratory (PNNL). His primary area of expertise is fisheries biology with emphasis on salmon and trout culture. In 26 years at PNNL, Mr. Abernethy has participated in field projects, many of which are related to the impacts of water use in the Columbia Basin on salmon and other native fish populations. Mr. Abernethy has also been a major contributor in studies to evaluate the effectiveness of fish screening facilities in irrigation diversions in the Yakima Basin, Washington and the Lemhi Basin, Idaho.Mr. Abernethy's broad research experiences have exposed him to many technological tools used in the fisheries field. He is experienced in fish transport, use of anesthetics, and fish marking techniques, including the use of PIT tags. He has used underwater video technology to survey and map bottom substrate and to locate salmon redds in the tailraces of dams on the Snake River. He also has used underwater video to observe fish behavior and monitor the integrity of fish screens in irrigation canals. Mr. Abernethy is also proficient in entering and processing data for computer analysis.PUBLICATIONSAbernethy, C.S., D.A. Neitzel, and W.V. Mavros. 1996. Movement and Injury Rates for Three Life Stages of Spring Chinook Salmon O*ncorhynchus tshawytscha*: A Comparison of Submerged Orifices and an Overflow Weir for Fish Bypass in a Modular Rotary Drum Fish Screen. . Prepared for the Bonneville Power Administration by Pacific Northwest National Laboratory, Richland, Washington.

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SUSAN L. BLANTON: Technical Specialist I
EDUCATION: B.S., Zoology, Miami University, 1992
EXPERIENCE: Ms. Blanton is currently a Technical Specialist I in the Ecology Group within the Water and Land Resources Division. She joined the Pacific Northwest National Laboratory in 1994. Her research has focused on diverse salmonid issues in the Columbia and Snake River Basins. She has evaluated fish screening facilities in the Yakima River Basin, supported hydroacoustic fish passage research efforts at Snake and Columbia River hydroelectric projects, studied the effects of gas bubbles in salmonids, contributed to preparation of environmental impact statements, and conducted teacher workshops on numerous aspects of aquatic ecology. Selected experiences are given below.

Fish Screen Facility Studies - Ms. Blanton has evaluated fish screening facilities in the Yakima River Basin, Washington. The facilities are built in irrigation canals and are designed to divert fish in the irrigation canals back to the Yakima River. Evaluations are done to ensure that the screens are properly maintained and that operating criteria set by the National Marine Fisheries Service for the protection of juvenile salmonids are met. These studies are conducted for the Bonneville Power Administration as part of their salmonid enhancement efforts in the Columbia River Basin.

PUBLICATIONS

Neitzel, et al., 1996. Movement of Fall Chinook Salmon Fry *Onchorhynchus tshawytscha:* A Comparison of Approach Angles for Fish Bypass in a Modular Rotary Drum Fish Screen. Pacific Northwest National Laboratory, Richland, Washington.

Bonneville Power Administration (BPA). 1996. Movement of Fall Chinook Salmon Onchorhynchus tshawytscha: A Comparison of Approach Angles for Fish Bypass in a Modular Rotary Drum Fish Screen. DOE/BP-62611, Bonneville Power Administration, Portland, Oregon.

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ROBERT P. MUELLER: Technical Specialist II EDUCATION: B.S., St. Cloud State University, Fisheries - Aquatic Biology, 1987EXPERIENCE: Robert Mueller has been a staff member at PNNL since January 1992. He is currently a Technical Specialist II in the Ecology Group within the Water and Land Resources Department. His research efforts have focused on GIS, GPS directed video surveys of adult salmon spawning habitat, juvenile salmon protection at screening facilities, behavior barriers, and aquatic bioassessments. He is responsible for designing, testing, and monitoring field experiments to support research being conducted at PNNL. His research interests includes; fish passage investigations, water quality assessments, video applications directed at researching current fisheries issues. Selected experience includes the following:

Yakima River Fisheries Project - Applied digital imaging and infrared lighting to enhance the U.S. Bureau of Reclamation and the Yakima Indian Nation to acquire high quality images of adult salmonid passage at fish counting sites in the Yakima Basin. Worked with engineers to modify and improve passage conditions and incorporate underwater lighting. The enhanced system uses high definition cameras, imaging software, infrared lighting, to archive fish runs and collect biological data. The data is used to predict future fish runs, evaluate passage and stock origin, and to assess meristic parameters. The system produces a complete image oriented database which is archived and available to fisheries resources managers and other interested parties.

Yakima River Basin Fish Screening Evaluations – Principal investigator in the evaluation of juvenile Salmonid passage at fish screening diversion facilities. Studies include passage rate, descaling tests, Underwater video surveys, velocity measurements, and fish impingment and screen intergrity tests. Conducted feasibility tests using infrasound as a behavior barrier using pre-smolt salmonids.

Oregon Department of Fish and Wildlife - From 1990 to 1991, Mr. Mueller worked as a technician in 1990 and was promoted to a fisheries biologist in 1991. Research projects included collecting biological data on predators of juvenile salmonids in the lower Columbia River. Data collected was used to determine species populations, fish age structure, fecundity, and sampling gear effectiveness. Mr. Mueller also directed the activities of employees to evaluate two fish screening diversion facilities on the Umatilla River. He was involved all components of the evaluations including the development of a sampling plan, design and testing of fish holding facilities, trap design and construction, fish marking, data summary, and report writing.

PUBLICATIONS

Dauble, D.D., R.L. Johnson, R.P. Mueller, W.V. Mavros, and C.S. Abernethy. 1995-1996. Surveys of Fall Chinook Spawning Areas Downstream of Lower Snake River Hydroelectric Projects, 1995-1996 Season. Prepared for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

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Mueller, R.P., C.S. Abernethy, and D.A. Neitzel. 1995. A Fisheries Evaluation of the Dryden Fish Screening Facility. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Section 10. Information/technology transfer

A large body of information relating to the impact of hydraulic facilities on anadromous fish migration exists in the form of written technical reports. As an example, we refer to (Abernethy et al. 1989, 1990; Neitzel et al. 1985, 1986, 1988, 1990 a,b,c; all cited in Task 1) which describe screen evaluations from fish screening facilities in the

Yakima River basin. These reports often contain tables of measured data, either hand-written or typed. During 1996, we developed an electronic database with a hypertext interface which provides easy access from distributed sites across electronic computer networks (Internet). We completed an assessment of the information to be provided, and how will it be used. All these reports will placed on websites available at PNNL and BPA. All new reports will be sent to BPA for hard copy distribution and be place on the web.

Additionally, new information that is developed will be discussed directly with potentially affected agencies so the information can be used immediately.