Hydropower Research and Development

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PREFACE

This report represents the first attempt at developing a single point source for information on current and proposed hydropower research and development (R&D), environmental as well as engineering, being conducted by government agencies (Federal, State, local), utilities, and other private companies. It is hoped that this report will be useful to those conducting hydropower R&D, particularly during these times of declining R&D funding

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- U.S. Army Corps of Engineers, Waterways Experiment Station
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- U.S. Department of Energy - Idaho Operations Office
- U.S. Geological Survey (USGS) - Conte Anadromous Fish Research Center
- Union Electric

It is intended that this report become a living document and be updated annually. Any suggestions, recommendations, or additional information should be sent to:

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Refer to this section (Preface) or the applicable hydropower R&D information sheet in Appendix A for a definition of most acronyms used in the tables in this report.

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ABSTRACT

This report is a compilation of information on hydropower research and development (R&D) activities of the Federal government and hydropower industry. The report includes descriptions of on-going and planned R&D activities, 1996 funding, and anticipated future funding. Summary information on R&D projects and funding is classified into eight categories: Fish Passage, Behavior, and Response; Turbine-Related; Monitoring Tool Development; Hydrology; Water Quality; Dam Safety; Operations and Maintenance; and Water Resources Management. Several issues in hydropower R&D are briefly discussed: Duplication; Priorities; Coordination; Technical/Peer Review; and Technology Transfer/Commercialization. Project information sheets from contributors are included as an appendix.

EXECUTIVE SUMMARY

This report is a compilation of information received from the Federal government and the hydropower industry. Its purpose is to identify present and future research and development (R&D) projects and the funding to enhance the environmental performance and efficiency of the hydroelectric system in the U.S. This report summarizes R&D activities underway in 1996, 1996 funding, and future funding requirements. This study focuses on identification of R&D projects; no attempt is made to prioritize the concerns and potential areas of research.

Information on types of R&D activities can be considered as representative of ongoing activities, especially for the Federal government. Funding information must be viewed with caution and considered as low values because of the lack of detailed information in some responses and the low level of participation by utilities and vendors. Information was received from the following organizations and is included in the Appendices:

Federal Agencies

- Bonneville Power Administration
- U.S. Department of Energy - Hydropower Program
- Tennessee Valley Authority
- U.S. Army Corps of Engineers - North Pacific Division and Waterways Experiment Station
- U.S. Bureau of Reclamation - Research and Technology Development Program
- U.S. Geological Survey - Biological Resources Division - Conte Anadromous Fish Research Center (formerly the National Biological Service)

Utilities

- Chelan County Public Utility District
- Grant County Public Utility District
- Pacific Gas & Electric Company
- Southern California Edison

Other Organizations

- Alden Research Laboratory, Inc.
- Electric Power Research Institute
- Integrated Hydroelectric Machine Conditioning Monitoring Consortium, L.L.C.

Expenditures of \$63.5 million directed at hydropower R&D in 1996 were identified. A total of 70 hydropower R&D projects and programs were identified. Two large programs, the Bonneville Power Administration - Fish and Wildlife Program, and the U.S. Army Corps of Engineers - North Pacific Division - Anadromous Fish Evaluation Program account for the majority of these funds. The Bonneville Power Administration - Fish and Wildlife Program funded 70 individual projects totaling \$25 million in 1996 (see Appendix B). The U.S. Army Corps of Engineers - North Pacific Division -

Anadromous Fish Evaluation Program funded about 30 individual projects on a budget of \$15 million in 1996 (see Appendix C).

To continue projects between 1997 and 2000, \$311.1 million of required funds were identified. This value is considered very low because many contributors did not provide estimates to continue or complete projects for the full time period. However, two programs account for the majority of these funds: (1) the Bonneville Power Administration Fish and Wildlife Program database has \$136 million budgeted or identified to continue projects, and (2) the DOE Advanced Hydropower Turbine Program estimates \$101.6 million needed for completion.

Projects have been grouped into eight categories to facilitate understanding of expenditures:

- Fish Passage, Behavior, and Response
- Turbine-Related Projects
- Monitoring Tool Development
- Hydrology
- Water Quality
- Dam Safety
- Operations & Maintenance
- Water Resources Management

These categories are strictly for convenience and additional topics can be added. Figure 1 shows the allocation of funding for these categories in 1996. Over 80% of the identified funds were spent on Fish Passage, Behavior, and Response, and about 90% of these funds were spent in the Pacific Northwest. About 70% of the funds for Turbine-Related projects (8% of 1996 funding), were provided by the hydropower industry. The remaining 8% of the funds were used to improve Monitoring Tools, Dam Safety, Hydrology, Operations and Maintenance, Water Resources Management, and Water Quality. Figure 2 shows anticipated funding for the categories from 1997 to 2000; however, this future funding information is not very robust. Regardless, substantial increases in Turbine-Related R&D funding are anticipated. Table 1 summarizes project information.

Information obtained from this report can serve as a basis for a comprehensive hydropower R&D program to help ensure coordination of R&D, avoid duplication within the Federal government and the hydropower industry, and enhance opportunities for technical and peer review and technology transfer. Although the report is not comprehensive, review of compiled information does not reveal any obvious duplication of effort in hydropower R&D. The sponsors hope that this first effort will be recognized as a valuable tool and others engaged in hydropower R&D activities will contribute information for an update. Interested parties should contact one of the entities listed in this report or: B.N. Rinehart, Lockheed Martin Idaho Technologies Co., 2525 Fremont, Idaho Falls, ID 83415; (208) 526-1002; RINEHABN@inel.gov.

Figure 1. Hydropower R&D Funds (1996)

Figure 2. Required Hydropower R&D Funds (1997–2000)

Table 1. Hydropower Research and Development Projects

No	Project or Program, and Schedule	Org/Contact	Categories	Funding*	
				1996	Future
1	McNary Turbine Model Test. Develop model test data to improve turbine efficiency using a minimum gap replacement turbine. Results should be applicable to The Dalles and Ice Harbor. Start: End: Oct 1996	BPA Fong Grey (503) 230-4492	Turbine	\$100,000	\$0
2	3-D Cam Update. Cam recalibration to increase efficiency at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and John Day Projects. Update cams at 14 units at McNary including installing new stilling wells. Test Bonneville I and II units. Start: End: Sep 1996	BPA Fong Grey (503) 230-4492	Turbine	\$804,000	\$0
3	Fish And Wildlife Program - Monitoring Methods Development. BPA-funded program for Anadromous Fish Monitoring Methods Development. Includes three projects conducted by Federal and State agencies and the University of Washington. See Appendix B for project descriptions. Start: Ongoing End: Budget planning thru 2001	BPA See Appendix B	Monitoring Tool	\$1,266,076	\$4,000,000
4	Fish And Wildlife Program - Research/Evaluation and Monitoring. BPA-funded program for Monitoring Anadromous Fish (Production, System Level, and Tributary) and Research and Evaluation of Anadromous and Riverine Fish (Gas Supersaturation, Genetics, Life Cycle, Passage, Planning and Coordination, and Production). Includes 67 projects conducted by Federal, State, and Tribal organizations. See Appendix B for project descriptions. Start: Ongoing End: Budget planning thru 2001	BPA See Appendix B	Fish	\$24,573,761	\$132,000,000
5	Advanced Hydropower Turbine System Program. 3-phased program to develop conceptual engineering designs, build and test fully engineered models, and build and test full-scale prototypes at operating hydropower plants to improve turbine design for improved fish passage and water quality. Project No. 60 is part of this program. Start: FY-1995 End: Dec 2000	DOE Peggy Brookshier (208) 526-1403	Turbine Water Quality	\$1,000,000	\$101,600,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
6	Development of Auto-Venting Turbine Technologies. Extend research advances in aerating or venting directly through a hydroturbine from model and prototype experience at Norris Dam to other TVA turbines through 4 tasks: 1) design, test, and analyze results for additional proprietary concepts to enhance auto-venting technologies uptake; 2) develop comprehensive test procedures; 3) develop improved scaling relationships for auto venting technologies units; 4) conduct theoretical investigation of draft tube hydrodynamics to locate best injection sites, determine optimal spatial and size distributions of bubbles at draft tube entrance, and develop conceptual predictor models of DO uptake and energy loss in AVT draft tubes. Joint project with Voith Hydro, Inc. Start: FY-1997 End: FY-1997	TVA Tim Galbreth (423) 751-8447 Pat March (423) 632-1903	Turbine Water Quality	\$0	\$200,000
7	Demonstration of Kaplan Turbine Optimization. Improve the overall operating efficiency of a main river Kaplan turbine unit by 1% or more by installing a digital governor and a hardware/software system for optimizing the operation of Kaplan (adjustable blade) turbines. Joint project with Voith Hydro, Inc. Start: FY-1996 End: FY-1997	TVA Tim Galbreth (423) 751-8447 Pat March (423) 632-1903	Turbine	\$85,000	\$50,000
8	Stator Vibration Project. Measure stator and winding vibration problems at a TVA hydro project. Start: FY-1995 End: FY-1997	TVA Tim Galbreth (423) 751-8447	Turbine	\$40,000	\$15,000
9	Support to Machine Condition Monitoring Consortium. Contribution to the Machine Condition Monitoring Consortium to develop a comprehensive, fully integrated condition monitoring system (including generator, bearings, and turbine). Start: FY-1995 End: FY-1998	TVA Tim Galbreth (423) 751-8447	Monitoring Tool Turbine O&M	\$400,000	\$800,000
10	Improved Dissolved Oxygen Sensors. Laboratory and field investigations to evaluate a proprietary technology for improving reliability and stability of membrane-type dissolved oxygen sensors. Start: FY-1997 End: FY-1997	TVA Tim Galbreth (423) 751-8447 Pat March (423) 632-1903	Monitoring Tool Water Quality	\$0	\$30,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
11	Cavitation Characteristics Mapping. Develop operational guidelines for generating- and pumping-mode at a Pumped-Storage Plant that will reduce the operations and maintenance costs associated with hydroturbine cavitation. Guidelines will be based on results of prototype acoustic cavitation comparisons under a variety of heads and test conditions at Raccoon Mountain using acoustic emissions-based cavitation monitoring techniques. Start: FY-1996 End: FY-1997	TVA Tim Galbreth (423) 751-8447	O&M Monitoring Tool	\$0	\$20,000
12	Joint Development of Hydro Condition Monitoring System. Enhance existing hydroturbine condition monitoring (HCM) systems and modules; develop, improve, and demonstrate new HCM systems; configure, install, and support HCM systems; and evaluate, assess, and quantify performance benefits of HCM systems. Joint project with Voith Hydro, Inc. Commercialization of monitoring system expected to provide revenues for future R&D. Start: Jan 1996 End: Sep 1997	TVA Tim Galbreth (423) 751-8447	Monitoring Tool Turbine O&M	\$0	\$200,000
13	Zebra Mussel Control for TVA's Hydro Facilities. Evaluate water piping systems (e.g., generator cooling systems) at hydro plants to determine the potential impact from zebra mussel infestations and identify possible approaches for controlling zebra mussel infestations. Start: FY-1997 End: FY-1997	TVA Tim Galbreth (423) 751-8447	O&M	\$0	\$30,000
14	Turbines - Basecase Survival/Injury Studies. Determine mortality and injury rates due to turbine passage under current conditions and operations to help define design criteria for prototype turbine environments and baseline data to evaluate prototype. Part of Anadromous Fish Evaluation Program. Start: FY-1997 End: FY-1999	USAE-North Pacific Division Rudd Turner (503) 326-6586	Turbine	\$0	\$2,000,000
15	Turbines - Develop Methodology/Equipment for Use in Fish Distribution Studies Within Turbine Environment. Develop methods to monitor fish distribution during turbine passage. Part of Anadromous Fish Evaluation Program. Start: FY-1997 End: FY-1998	USAE-North Pacific Division Rudd Turner (503) 326-6586	Monitoring Tool Turbine	\$0	\$600,000
16	Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids. Map pressure distribution within turbines. Pressure studies of different species and sizes of fish. Part of Anadromous Fish Evaluation Program. Start: FY-1998 End: FY-1999	USAE-North Pacific Division Rudd Turner (503) 326-6586	Fish Turbine	\$0	\$600,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
17	Baseline Engineering Testing. Instrument turbine to determine performance during field testing for related projects. Part of Anadromous Fish Evaluation Program. Start: FY-1997, delay probable End: FY-2000	USAE-North Pacific Division Rod Wittinger (503) 326-6586	Turbine	\$0	\$2,000,000
18	Anadromous Fish Evaluation Program. Research projects funded by the U.S. Army Corps of Engineers - North Pacific Division budget for Columbia River Fish Mitigation Projects. About 40 projects are expected to be funded in 1997. Appendix C describes potential projects for 1997, including many ongoing projects. No funding information available for individual 1997 projects, except projects: 14-17 listed separately in this table. Future funding level is for 1997 program budget, less funding for projects 14-17. Start: Ongoing End:	USAE-North Pacific Division Rudd Turner (503) 326-6586	Fish Monitoring Tool Turbine	\$14,900,000	\$13,800,000
19	Richard B. Russell Dam Fish Entrainment Study. Develop and evaluate fish protection systems for a pumped storage operation. Protection systems included high-frequency repelling sounds, attracting lights, physical barriers, a reconfigured channel alignment to eliminate attracting hydraulic conditions at the dam, and operational guidelines. Start: Feb 1986 End: Jan 1997	USAE-Waterways Experiment Station John Nestler (601) 634-3870	Fish	\$550,000	\$300,000
20	Water Treatment Technology Program. Develop lower-cost desalination technologies. Start: FY-1992 End: FY-1997	USBR-Denver Lisa Henthorne	Water Quality	NA	\$2,000,000
21	Water Quality Protection and Enhancement. Develop monitoring techniques throughout large water systems. Includes task to develop techniques to improve water quality in reservoirs with changes in operation or installation of localized aeration system, and evaluate impacts on both reservoir and downstream water quality and aquatic ecology. Start: Before 1990 End: FY-1998	USBR-Denver Richard Roline (303) 236-6007	Monitoring Tool Water Quality	\$485,000	\$535,000
22	Regional Hydrologic Forecasting for Mid-Pacific Watersheds. Improve computer models to more accurately forecast streamflow in mid-Pacific region watersheds. The system for providing streamflow forecasts to water managers will also be improved. Start: FY-1995 End: FY-1997	USBR-Denver Jon Medina (303) 236-0123	Hydrology	\$1,080,000	\$1,040,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
23	Reservoir Water Quality Model Development and Modification. Adapt existing computer models to simulate the effect of different operations along the length of wet-climate reservoirs to arid, high-elevation sites in the western U.S. and evaluate whether the models can be used to simulate movement of metals and toxics through reservoirs. Models will be tested on Lake Powell. Start: FY-1996 End: FY-1998	USBR-Denver Robert George (303) 236-8384	Water Quality	\$170,000	\$360,000
24	Enhancement and Demonstration of Stream Water Quality Modeling/Field Studies. Develop a simplified computer model to predict water quality changes downstream of western reservoirs. Initially, model will be developed for the Colorado River downstream from the Glenn Canyon Dam. Start: FY-1996 End: FY-1998	USBR-Denver Merlynn Bender (303) 236-8384	Water Quality	\$50,000	\$120,000
25	Inflow Design Flood Parameter Study. 3-phased program to develop a computer model to determine the probability distribution for floods resulting from the probable maximum precipitation and develop flood frequency curves for the probable maximum flood. Phases include model development, calibration and testing for 3-4 watersheds, and construction of flood frequency curves. The study will also test the sensitivity of various hydrologic parameters and assumptions used in USBR flood hydrology methods. Start: Jan 1995 End: FY-1998	USBR-Denver Bob Swain (303) 236-0123	Hydrology	\$133,100	\$300,000
26	Fish Passage for Low Diversion Dams. Program with 3 major components: 1) numerical simulation of reduced-length fish ladders using transient flows and wake generated eddies, followed by development and testing physical models; 2) physical model study of low-head fish lock designs with emphasis on sturgeon passage; and 3) construction of small fish passage demonstration project(s) using results of program, followed by hydraulic and biological evaluation. Item 3 is dependent on additional funding support for construction and extended biological evaluation. Start: FY-1996 End: FY-1998	USBR-Denver Brent Mefford (303) 236-2000	Fish	\$145,000	\$290,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
27	Fish Screen Research And Technology Development Program. Program with 4 major components: 1) Small Diversion Fish Screen Technology Development includes developing and testing small diversion screens for 20-50 ft ³ /s and 5-20 ft ³ /s in laboratory and field; 2) Red Bluff Research Pumping Plant Fish Screen Evaluations includes evaluating hydraulic performance of existing angled vertical wedge-wire screens and support studies on the effectiveness of angled trashrack bars; 3) Static Overflow Fish Screen Development includes biological laboratory testing of prototype static inclined screen and a field demonstration installation; and 4) Fish Screen Evaluation Technology Development includes, developing procedures for verifying fish screening velocity criteria with an acoustic Doppler velocimeter and an acoustic Doppler current profiler. Start: FY-1996 End: FY-1998	USBR-Denver Joseph Kubitschek (303) 236-2000	Fish Monitoring Tool	\$152,000	\$250,000
28	Real-Time Optical Identification of Juvenile Fish Types. Develop computer analysis techniques for automated, optical identification of fish presence, concentration, sizes, and species or genera. Project includes design, installation, and testing of automated camera system at Red Bluff Research Pumping Bypass Channels and Evaluation Facilities. Start: FY-1996 End: FY-1997	USBR-Denver E.W. Holroyd, III (303) 236-4301	Monitoring Tool	\$47,000	\$26,000
29	Protection and Management of Reclamation Fisheries. Research program with 7 tasks, 5 in FY-1996: 1) test new fish pumps at Red Bluff; 2) research, assessment, improvement of fish collection at Tracy; 3) develop automated systems for fish identification and real-time fish monitoring at intakes and fishways; 4) telemetry studies of fish behavior and movement - Splittail at Tracy and Razorback Sucker in Lake Powell; and 5) entrainment studies at Lake Shasta and Blue Mesa. Future years include: testing new fish screens at Delta Test Facility and developing use of artificial habitat to protect and restore fish populations. Start: FY-1996 End: FY-1998	USBR-Denver Charles R. Liston (303) 236-6007	Fish Monitoring Tool Turbine	\$1,849,000	\$3,698,000
30	Watershed And River Systems Management Program. Research, develop, test, and implement database and model to integrate real-time weather, river, and power system data. Start: End: FY-2000	USBR-Denver/ USGS Donald Frevent (303) 236-0123	Hydrology	NA.	\$2,000,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
31	Use of Nuclear DNA Markers to Identify Chinook Salmon Races. Determine if nuclear DNA markers can provide a quantitative method of separating different races of chinook salmon in the Central Valley of CA. The method must not harm sampled fish and results must be available within a few days. Start: Jul 1994 End: Jun 1997	USBR- Sacramento Jim Arthur (916) 979-2472	Monitoring Tool	\$214,000	\$190,000
32	Overtopping Protection for Dams. Develop design criteria for overtopping protection methods as an alternative to providing additional spillway capacity for dams. Start: FY-1994 End: FY-1997	USBR/EPRI/CSU Kathleen H. Frizell (303) 236-2000	Dam Safety	\$113,500	\$49,000
33	Dam Foundation Erosion During Overtopping. Develop software to predict and evaluate the extent of foundation erosion when a dam is overtopped. Project includes physical model experiments and development of a computer model. Start: FY-1996 End: FY-1998	USBR/EPRI/CSU Rodney J. Wittler (303) 236-2000	Dam Safety	\$392,000	\$393,000
34	Hydraulics of Various Types of Fishways. Develop hydraulic rating curves and biologically evaluate Simple Denil and Model A deepened Alaska Steeppass fishways. Upstream migration of American shad evaluated for both fishway types. Start: Apr 1992 End: FY-1997	USGS-Conte Anadromous Fish Research Center Mufeed Odeh (413) 863-8994	Fish	\$58,000	\$70,000
35	Evaluation of Burst Swimming Performance of Upstream Migrant Fishes. Identify information gaps in the literature, develop testing flume, and evaluate volitional swimming performance for a variety of anadromous and riverine fishes. Start: FY-1995 End: FY-1999	USGS-Conte Anadromous Fish Research Center Mufeed Odeh (413) 863-8994	Fish	\$25,000	\$150,000
36	Evaluation of a Uniform Acceleration Weir for Downstream Bypass Entrances. Tested a downstream passage fish bypass weir (NU-Alden) that provided uniform water acceleration and evaluate its performance compared to a sharp-crested weir's rapid water acceleration. Each weir was evaluated for fish passage over time, orientation, and behavior for Atlantic salmon smolts and juvenile American shad. Start: FY-1993 End: FY-1997	USGS-Conte Anadromous Fish Research Center Mufeed Odeh/ Alex Haro (413) 863-8994	Fish	\$31,000	\$50,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
37	Behavior of American Shad and Blueback Herring Related to Fish Passage. Determine distributions of juvenile and adult shad, and blueback herring in a water column near weirs. Determine flow and light intensity permitting clupeid passage. Start: May 1991 End: Jun 1997	USGS-Conte Anadromous Fish Research Center Henry Boone (413) 863-8991	Fish	\$45,000	\$181,000
38	Investigation of Migratory Behaviors and Passage Technologies for Anguillid Eels. Investigate American eel migratory behavior and evaluate upstream and downstream passage structures. Study natural behaviors of migrants, response to attraction flows and turbine intakes, run characteristics, and migration timing. Start: Jun 1996 End: Sep 2001	USGS-Conte Anadromous Fish Research Center Alex Haro (413) 863-8991	Fish	\$6,000	NA
39	American Shad Energetics in the Connecticut River. Develop techniques to monitor fish respiration and generate oxygen consumption-swimming speed relationships. Develop a sonic electromyographic tag to monitor shad swimming in the field. Biochemical sampling of migrating fish and in the ocean. Profile the energetic status of adult shad from different sites on the Connecticut River. Examine the energetic costs associated with ascending a fish. Start: Apr 1993 End: Jun 1997	USGS-Conte Anadromous Fish Research Center Stephen McCormick (413) 863-8991	Fish Monitoring Tool	\$62,000	NA
40	Biological Studies of Shortnose and Other Sturgeons. Radio telemetry studies to track Shortnose sturgeon migratory activity and determine fecundity, feeding range, and spawning habitat. Additional studies of other sturgeon. Evaluation of sturgeon movement and behavior in response to water velocity, discharge, power generation cycle, illumination, cover, and substrate type. Began construction of facilities for R&D on sturgeon passage. Start: Apr 1993 End: Jun 1997	USGS-Conte Anadromous Fish Research Center Henry Boone (413) 863-8991	Fish	\$159,000	NA
41	Physiological and Endocrine Changes During Hatchery Rearing and Release of Atlantic Salmon. Develop diagnostic techniques to identify parr-smolt transformation of Atlantic salmon; sample both hatchery and wild fish; laboratory experiments to determine the effect of increased temperature on smolt development; monitor normal smolt development; and evaluate the potential of dams and bypass structures with field and laboratory studies. Start: Dec 1990 End: Sep 1998	USGS-Conte Anadromous Fish Research Center Stephen McCormick (413) 863-8991	Fish	\$95,000	NA

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
42	Physiology of Juvenile Atlantic Salmon, American Shad, and Blueback Herring Relating to Hatchery Rearing, Release, and Downstream Passage. Examine and compare physiological and endocrine differences in laboratory, hatchery, and wild Atlantic salmon, and determine if similar conditions exist in clupeid fishes. Evaluate salinity tolerance, handling stress, and temperature. Start: June 1992 End: Sep 1996	USGS-Conte Anadromous Fish Research Center Stephen McCormick (413) 863-8991	Fish	\$45,000	\$0
43	Factors Influencing Smolt Production, Overwinter Mortality, and Downstream Migration of Atlantic Salmon in the West River System, Vermont. Determine factors that affect production of Atlantic salmon smolt in-stream and the numbers that exit to the sea. Evaluate survival of hatchery fry released at different developmental stages. Start: Jan 1994 End: Apr 1999	USGS-Conte Anadromous Fish Research Center Stephen McCormick (413) 863-8991	Fish	\$143,000	\$295,000
44	Impact of Stream Habitat Improvement on Smolting, Maturation, and Survival of Atlantic Salmon. Investigate decline in Atlantic salmon smolt characteristics as water temperatures increase in the stream and survival rates for early and late migrants. Start: Nov 1995 End: Oct 1997	USGS-Conte Anadromous Fish Research Center Henry Boone (413) 863-8991	Fish	\$30,000	NA
45	Growth and Mortality of Young-of-Year Alosines: Energetics, Starvation, and Predation. Provide laboratory information on bioenergetics, starvation, and predation to construct individual-based models for young-of-year American shad and Blueback herring. Start: Aug 1996 End: Dec 1999	USGS-Conte Anadromous Fish Research Center Ben Letcher (413) 863-8991	Fish	\$82,000	NA
46	Hydraulic Model Study of Little Falls Dam (MD) Fish Passage. Construct and assess a hydraulic model of the Little Falls Dam and determine notch width, height, and configuration of labyrinth weirs for clupeids passage. Start: Mar 1994 End: Mar 1998	USGS-Conte Anadromous Fish Research Center Mufeed Odeh (413) 863-8994	Fish	\$75,100	\$38,000
47	Rocky Reach Hydroelectric Project, Fish Passage Survival through Turbines. 4-phased project to improve fish passage survival through turbines as part of a \$67 million turbine rehabilitation program. Activities include: 1) evaluation of fish mortality/injury problems; 2) conceptual design and model testing of improved turbine designs; 3) fish mortality/injury monitoring of prototype turbine; 4) refinement and biological and physical testing of model turbine. Start: 1993 End: 1996	Chelan Co. PUD Bill Christman (509) 663-8121	Turbine	\$600,000	\$0

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
48	Rocky Reach Fish Bypass. Prototype development and testing of surface collection system for downstream passage of salmon and Steelhead trout. Construction costs for final preferred alternative are estimated at \$30,000,000. Start: End: Complete construction by 2001	Chelan Co. PUD Bill Christman (509) 663-8121	Fish	\$6,000,000	\$24,000,000
49	Rock Island Fish Bypass. Prototype development of surface-oriented sluicing through modified spillgates for downstream passage. Construction costs for final preferred alternative estimated at \$25,000,000. Start: End: Complete construction by 2001	Chelan Co. PUD Bill Christman (509) 663-8121	Fish	\$2,000,000	\$8,000,000
50	Enhanced Fish Passage Hydropower Turbine. Turbine improvement program including: baseline survival testing of fish passage through turbines; model testing to mitigate for impacts; manufacture and install 10 new turbines at Wanapum Dam at a cost of \$3,400,000 per turbine; survival tests of new turbine unit. Start: June 1996 End: 1999, Complete installation of new turbines in 2002	Grant Co. PUD Stephen R. Brown (509) 754-5088	Turbine	\$1,897,000	\$5,000,000
51	In Operating Hydro Turbine Imaging. Identify, evaluate, and install imaging systems to observe fish injury mechanisms inside hydro turbine. Start: 1996 End: June 1997	Grant Co. PUD Stephen R. Brown (509) 754-5088	Monitoring Tool Turbine	\$85,000	\$915,000
52	Water Resources R&D for Hydropower. Identify and evaluate methods for reducing the cost of meeting fishery objectives at hydro projects. Project includes 5 major activities for 1996-97: 1) develop improved tools for evaluating mitigation costs; 2) design a real-time control system for temperature management flows; 3) use CompMech trout model to investigate optimal flow release patterns for fisheries; 4) investigate methods for reducing costs and improving flow allocation over time and among sites for fish; and 5) participate in the Feather River Erosion Control Program Technical Advisory Committee. Start: End: Dec 1997	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	Water Resources Management	\$110,000	\$70,000
53	Conveyance Systems O&M Cost Reduction. Identify cost-effective and environmentally acceptable methods for controlling head losses due to algae growth in hydro canals and flumes. Activities include: 1) field tests of chemical, enzymatic, and mechanical algae control methods; 2) industry/utility survey of alternate liners and maintenance methods; and 3) field test of alternative liner(s). Start: End: Dec 1997	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	O&M	\$232,000	\$130,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
54	NDE for Strength Assessment of Riveted Steel Penstocks. Develop non-destructive and mechanical testing methods to evaluate erosion, corrosion, and pitting of riveted steel penstocks. Start: End: Sept 1997	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	O&M	\$138,000	\$126,000
55	Erosion Characteristics of Dam Foundations. Determine the erodibility of various dam construction material and use results to develop computer models that evaluate erosion resistance of different material under impinging jet flow associated with the safe passage of Inflow Design Flood. Start: End: Dec 1998	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	Dam Safety	\$123,000	\$0
56	Hydro Turbine Runner/Wicket Design Optimization. Test runner and wicket gate models using site-specific conditions from the Butt Valley Powerhouse. Physical models represent a potential flow turbine that optimizes efficiency and provides cavitation-free performance based on a computer model. Start: End: Aug 1996	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	Turbine	\$118,000	\$0
57	Hand-Held O&M Computers and Plant Maintenance Optimization. Refine Plant Maintenance Optimization methods. Project includes software improvements, and development and testing of field applications of wireless communications, field inspection diagnostics, and remote job order entry for use on hand-held computers. Start: End: Dec 1996	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	O&M	\$75,000	\$0
58	Mid-Term Hydro Thermal Optimization, Short-Term Weather-dependent Inflow Forecasting, and Hydro Dispatch Curve System. Create an integrated optimization-based software system to coordinate operation of both hydro and thermal electric generation facilities. Project includes tasks to improve accuracy of short-term inflow forecasts, provide an interface to send hourly flow forecasts to the short-term Hydro-Thermal Optimization program; and evaluate economic benefits and technical feasibility of improving hydro unit dispatch curves. Start: End: Dec 1996	Pacific Gas & Electric Donna S. Lindquist (510) 866-5459	O&M Hydrology	\$124,000	\$200,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
59	<p>Aquatic Resource R&D for Hydropower.</p> <p>Improve methods used to assess effects of hydro projects on resident trout and design mitigation measures. Tasks include: 1) test and improve the IFIM methods currently used to determine instream flows at 11 sites; 2) develop methods for selecting habitat suitability criteria for IFIM studies; 3) field- and model-based study of factors controlling trout recruitment in large California rivers; 4) develop and demonstrate EPRI's CompMech stream trout model at a major hydro project; 5) laboratory study of temperature effects on bioenergetics of 3 native trout strains; and 6) develop and demonstrate a temperature assessment model.</p> <p>Start: End: Dec 1998</p>	<p>Pacific Gas & Electric/Southern California Edison</p> <p>Donna S Lindquist (510) 866-5459;</p> <p>Geoff Raboni (818) 302-8951</p>	Fish	\$1,030,000	\$800,000
60	<p>Development of a More Tolerant Turbine Runner: DOE Advanced Hydropower Turbine System Program.</p> <p>Part of DOE's Advanced Hydropower Turbine System Program. Project is to design a hydraulic turbine runner to minimize fish injury and mortality at hydroelectric projects. 3-phase, 4-yr. Process of conceptual design, pilot-scale testing, and final design. Conceptual design of turbine runner based on Computational Fluid Dynamic (CFD) analyses and comparisons with performance criteria developed from available data on causes of fish injury from turbine passage. Pilot-scale testing, scheduled for 1997/98, will directly observe if fish passing through runner are injured. Final design, scheduled for completion in 1999 will be refined with additional CFD analyses and model testing. Funding for conceptual design provided by DOE, Hydropower Research Foundation, Inc., and ARL/NREC. Pilot-scale test estimated to cost about \$1 million over 2 years. Primary funding listed with DOE project 3.</p> <p>Start: End: 1999</p>	<p>Alden Research Laboratory, Inc/ Northern Research and Engineering Corp.</p> <p>George E. Hecker (508) 829-6000</p>	Turbine	\$70,000	NA
61	<p>Development of an Infrasound Generator for Protecting Fish.</p> <p>Develop a reliable particle motion generator (PMG) using very low frequency (5-50 Hertz) hydrodynamic energy to repel fish at water intakes. PMG has been evaluated in laboratory with Atlantic salmon, striped bass, and white perch. Several riverine species caged in the field. Large-scale field evaluation scheduled for the fall of 1997 at PSE&G's Salem Generating Station. Funding for initial development supplied by ARL and PSE&G. Funding for testing riverine species shared by EPRI, WI Electric Power Co., and Northern States Power Co.. Future efforts with salmon require about \$1 million over 3 years.</p> <p>Start: End: 1998, additional 2-3 years needed</p>	<p>Alden Research Laboratory, Inc.; Public Service Electric & Gas Co.</p> <p>Thomas C. Cook (508) 829-6000</p>	Fish	\$355,000	\$1,000,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
62	Guidelines: Hydro Turbine Fish Entrainment and Survival Studies. Develop peer and agency-review guidelines for hydro turbine fish entrainment and mortality studies. Start: Jan 1996 End: Mar 1997	EPRI Charles McGowin (415) 855-2445	Turbine	\$141,000	\$35,000
63	Water Resource Management and Hydropower: Collaboration and Public Involvement. Develop tools to support hydro relicensing and mitigation. Start: Jan 1994 End: Dec 1997	EPRI Charles McGowin (415) 855-2445	Water Resources Management	\$287,500	\$287,500
64	Design Criteria for Aerating Weirs. Tests to establish design criteria for straight and labyrinth weirs to enhance dissolved oxygen in discharge from hydroelectric plants. Start: End: Sep 1996	EPRI D.I. Morris (415) 855-2924	Water Quality	\$0	\$0
65	Dam Safety for Concrete Gravity Dams. Improve software. Start: End: Aug 1996	EPRI D.I. Morris (415) 855-2924	Dam Safety	\$0	\$0
66	MERLIN, Dam Safety Analysis. Software development for stability analysis of concrete dams using fracture mechanics approach. Start: End: Aug 1996	EPRI D.I. Morris (415) 855-2924	Dam Safety	\$0	\$0
67	Development of a Modular Inclined Fish Diversion Screen. Project that began in 1992 with hydraulic and biological laboratory studies to develop a cost-effective, modular, high-velocity screen for protecting fish at all types of water intakes, and can be retrofitted at existing sites or installed at new water intakes. A single module is designed to screen about 1000 cfs. Biological lab testing evaluated passage and survival of 11 species over a range of velocities from 2 - 10 ft/sec. Field evaluation was conducted in 1995/96 at the Niagara Mohawk Green Island Hydroelectric Project with six species. Research completed in 1996. Commercialization efforts will continue in 1997. Total funding from 1992-1996 was about \$3 million, provided by EPRI, Niagara Mohawk Power Corp., NY State Energy Research and Development Authority, the Empire State Electric Energy Research Corp., New England Power Co., and the CA Dept. of Water Resources. Funding for commercialization efforts have not been identified and are estimated to be about \$250,000. Start: 1992 End: 1996, commercialization efforts in 1997	EPRI: Charles Sullivan (415) 855-8948	Fish	\$600,000	\$250,000

Table 1. Hydropower Research and Development Summary (continued)

No	Project or Program, and Schedule	Org./ Contact	Categories	Funding*	
				1996	Future
68	Severe Weather Forecast Applications for Electric Utilities. Develop tools for reporting severe weather conditions for utility staff. Start: End: Mid-1997	EPRI/National Severe Storm Laboratory D.L. Morris (415) 855-2924	Hydrology	NA	NA
69	Hydroelectric Machine Condition Monitoring Project. Multi-million dollar project to define a complete R&D plan to develop new diagnostic techniques or refine existing methods for monitoring problems related to hydro generating units. Activities include automated diagnostics for different types and sizes of hydro turbine components, generators, and bearings. Smart alarm concepts for different machine states such as start-up, load change, state, shut down, and transient will be used. A graphical user interface will be developed. System will use standard devices protocols and be capable of interfacing with data acquisition and protection and control devices currently used or planned in. Consortium members include: British Columbia Hydro, Bonneville Power Administration, Electric Power Research Institute, Idaho Power Co., Manitoba Hydro, and Tennessee Valley Authority. See related TVA projects. Project is fully funded and no additional sources of funds should be required. Start: 1996 End: Dec 1998	Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C. L.J. Miller III (423) 751-3095	Monitoring Tool Turbine O&M	NA	NA
70	Fish Habitat Model Development. Develop a more accurate computer model for prediction of flows downstream of hydropower plants. Start: FY-1995 End: FY-1997	TVA Tim Galbreth (423) 751-8447, Bruce Yeager (423) 632-1799	Fish Hydrology	\$70,000	\$5000
GRAND TOTALS:				\$63,461,037	\$311,098,500

*Notes:

- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.

CONTENTS

PREFACE.....	iii
ABSTRACT.....	v
EXECUTIVE SUMMARY.....	vii
CONTENTS.....	xxv
INTRODUCTION.....	1
HYDROPOWER R&D ACTIVITIES.....	3
Summary of Funding.....	4
Overview of Projects.....	4
Fish Passage, Behavior, and Response Projects.....	5
Turbine-Related Projects.....	10
Monitoring Tool Development Projects.....	12
Hydrology Projects.....	13
Water Quality Projects.....	15
Dam Safety Projects.....	17
Operations and Maintenance (O&M) Projects.....	17
Water Resources Management Projects.....	18
Issues in Hydropower Research and Development.....	19
Duplication.....	20
Priorities.....	20
Coordination.....	20
Technical/Peer Review.....	20
Technology Transfer/Commercialization.....	21
NEXT STEPS.....	22
APPENDIX A.....	A-1
APPENDIX B.....	B-1
APPENDIX C.....	C-1
APPENDIX D.....	D-1

Figure 1. Hydropower R&D Funds (1996).....	ix
Figure 2. Required Hydropower R&D Funds (1997 - 2000).....	x
Table 1. Hydropower Research and Development Summary.....	xi
Table 2. Hydropower Coordination Team and Contributors.....	2
Table 3. Fish Passage, Behavior, and Response Project Funding.....	6
Table 4. Species Behavior, Physiology, and Habitat Projects	8
Table 5. Turbine-Related Project Funding.....	11
Table 6. Monitoring Tool Development Project Funding.....	14
Table 7. Hydrology Project Funding.....	14
Table 8. Water Quality Project Funding	16
Table 9. Dam Safety Project Funding.....	17
Table 10. Operations and Maintenance Project Funding	18
Table 11. Water Resources Management Project Funding	19

Hydropower Research & Development

INTRODUCTION

Hydropower provides over 10% of the electricity and is the largest renewable energy source in the United States. Hydropower provides a relatively low-cost, renewable source of electricity that can be used on a vast scale, in some cases to meet demands for peaking power, and to minimize overall power production costs.

Although hydropower does not discharge pollutants into the environment, it is not free from adverse environmental effects. Efforts to reduce environmental problems associated with hydropower operations, such as providing safe fish passage and improved water quality, have received considerable attention in the past decade both at Federal facilities and non-Federal facilities licensed by the Federal Energy Regulatory Commission. Improvements in water quality in the Nation's rivers and the relicensing requirements for hundreds of non-Federal hydropower facilities provide an opportunity to reexamine operations and consider the possibility of restoring fisheries. Ongoing efforts to ensure the safety of dams and use newly available computer technologies to optimize operations provide additional opportunities to improve the environment. Yet, there are many unanswered questions about how best to maintain the economic viability of hydropower in the face of increased demands to protect fish and other environmental resources.

Many agencies and utilities actively pursue research and development programs to improve the environmental performance of hydropower facilities. However, there is general acknowledgment that the level of available funding is likely to decline with reduced Federal budgets and increased deregulation of the electric utility industry.

The purpose of this report is to compile summaries of hydropower R&D activities and ascertain the level of funding directed at improved environmental protection. This report is a first step toward developing a comprehensive, national summary of hydropower R&D. It is anticipated that such a compilation can help the government and the hydropower industry to develop a program to ensure that limited available resources are directed in the most beneficial ways. That is, that there is no unnecessary duplication, that research dollars are directed at priority issues, and that activities are coordinated and have adequate provisions for high-quality work that is transferable to other sites.

The effort to prepare this report was initiated when DOE convened a workshop of the Hydropower Coordination Team, a group of Federal agency and hydropower industry representatives, in April 1996 (See Table 2). An information form was designed at the meeting and participants were encouraged to provide information on their ongoing and planned R&D activities. An initial deadline of July 1996 was set for completing the report. Delays in meeting deadlines and increased interest by the National Marine Fisheries Service, Office of Habitat Conservation, led to hiring a consultant in October 1996 to encourage participation by fish resource management agencies, analyze incoming information, and prepare this report.

This report is divided into three major parts: funding, overview of projects, and issues in hydropower R&D. Summary tables of funding for different categories of projects are included. The report concludes with a section on Next Steps towards developing a more comprehensive hydropower R&D program. Original information form responses are included as an Appendix. The Executive Summary includes a summary table with brief project descriptions, contacts, and funding information.

Table 2. Hydropower Coordination Team and Contributors

Organization	Contact(s)
Alabama Power	Mike Akridge ¹ (205) 250-1398
Alden Research Laboratory, Inc.	Ned Taft ² (508) 829-6000
Bonneville Power Administration	Bob Lohn ¹ (503) 230-4748 Fong Grey ² (503) 230-4492 Kasi Beale ² (503) 230-5885
Chelan County Public Utility District	Bill Christman ² (509) 663-8121
Columbia River Intertribal Fish Commission	Rob Lothrop ¹ (503) 238-0667 Mary Lou Sosola ¹
Edison Electric Institute	Jim Evans ¹ (202) 508-5171
Electric Power Research Institute	Chuck Sullivan ^{1,2} (415) 858-8948
Idaho National Engineering and Environmental Laboratory	Garold Sommers ¹ (208) 526-1965 Ben Rinehart ¹ (208) 526-1002
National Hydropower Association	A. Wayne Elkins ¹ (404) 526-7037
National Marine Fisheries Service	Edward Meyer ¹ (503) 230-5411 Stephen Waste ¹ (301) 713-2325
Northwest Hydro Association	Neil McDonald ¹ (206) 453-5000
Northwest Power Planning Council	Stan Grace ¹ (406) 444-3952
Oak Ridge National Laboratory	Michael Sale ¹ (423) 574-7305 Glenn Cada ¹ (423) 574-7320
Pacific Gas & Electric	Donna Lindquist ² (510) 866-5459
Public Utility District of Grant County	Stephen Brown ² (509) 754-5088
Southern California Edison	Geoff Raboni ² (818) 302-8951
Southern Company Services, Inc.	Rick Pate ¹ (202) 775-0944
Southern Services Company	Lawrence Moore ¹ (205) 877-7780
Tennessee Valley Authority	Pat March ^{1,2} (423) 632-1903
U.S. Army Corps of Engineers - North Pacific Division	Rudd Turner ^{1,2} (503) 326-6586
U.S. Army Corps of Engineers - Waterways Experiment Station	John Nestler ² (601) 634-3870
U.S. Bureau of Reclamation	Bert Milano ¹ (303) 236-5999 Sarah Winn ² (303) 236-2232
U.S. Department of Energy - Idaho Operations Office	Peggy Brookshier ^{1,2} (208) 526-1403
U.S.G.S. - Conte Anadromous Fish Research Center	Mufeed Odeh ^{1,2} (413) 863-8994 (413) 863-8991 Henry Booke ²
Union Electric	Dan Jarvis ¹ (314) 365-9322

¹ Hydropower Coordination Team

² Contributor to report

HYDROPOWER R&D ACTIVITIES

Information was received from the following organizations:

Federal Agencies

- Bonneville Power Administration
- U.S. Department of Energy (Hydropower Program)
- Tennessee Valley Authority
- U.S. Army Corps of Engineers (North Pacific Division and Waterways Experiment Station)
- U.S. Bureau of Reclamation (Research and Technology Development Program)
- U.S. Geological Survey - Biological Resources Division - Conte Anadromous Fish Research Center (formerly the National Biological Service)

Utilities

- Chelan County Public Utility District
- Grant County Public Utility District
- Pacific Gas & Electric Company
- Southern California Edison

Other Organizations

- Alden Research Laboratory, Inc.
- Electric Power Research Institute
- Integrated Hydroelectric Machine Conditioning Monitoring Consortium, L.L.C.

Although this is not a comprehensive response, especially from utilities, it is indicative of the types of research that are underway. Funding information must be viewed with caution.

A total of 70 projects and programs were identified. Review of information forms indicated that they did not reflect the full range of hydropower-related R&D activities directed at environmental improvements by the Federal government, especially in the Pacific Northwest. To obtain a more representative overview of research activities, follow-up contacts were made to two groups known to be engaged in major research programs directed at fish and hydropower issues (1) the Bonneville Power Administration - Fish and Wildlife Program, and (2) the U.S. Army Corps of Engineers - North Pacific Division - Anadromous Fish Evaluation Program. These programs are included in this report as No.3, Fish and Wildlife Program - Monitoring Methods Development; No. 4, Fish and Wildlife Program - Research/Evaluation and Monitoring; and No.18, Anadromous Fish Evaluation Program. These Bonneville Power Administration and U.S. Army Corps of Engineers programs are comprised of 113 projects that are described in Appendices B and C, respectively.

There are other major gaps in the information. Only a few utilities submitted responses, even though considerable research is underway by hydropower producers as they undertake the relicensing of their sites. However, much of this work is site-specific and may have little general applicability. Many of the non-governmental efforts to develop new passage technologies, such as lights to guide fish, are also not represented here. Information on Federal research activities is also incomplete. It is hoped that wide dissemination of this report will encourage others to submit information.

Summary of Funding

Funding information obtained for this report must be viewed with caution. The information received is not sufficiently comprehensive, especially by the private sector, to allow detailed analysis. Sources of Federal funding are not distinguished for most projects. In some cases Congressional appropriations are required, in other cases funds are derived from other sources such as the sale of power by the Tennessee Valley Authority and Bonneville Power Administration.

In 1996, expenditures of over \$63 million were directed at hydropower R&D. This value was derived by adding information compiled for this report for actual 1996 budgets and an average annual expenditure when a total budget for several years was provided. Numbers reflect the budget year for contributors, and may not be uniform. In some cases funding information was not provided or does not reflect expenditures from all participants in a project; thus, \$63 million should be considered a low estimate.

Spending on hydropower R&D is anticipated to be over \$311 million for the period from 1997 to 2000. This value should also be viewed as a low estimate. It was derived by adding funds identified for this report. Some contributors provided only future funding information actually budgeted for the next one, two, or three years. For example, the Anadromous Fish Evaluation Program only identified the \$19 million budgeted for 1997 and did not provide projections for future years. Others provided estimates of the total funding expected to complete a project, even if the source of funding was uncertain. For example, the DOE - Advanced Hydropower Turbine System Program identified \$101.6 million needed for completion. In some cases, no future funding was identified, although projects are expected to continue.

Overview of Projects

Projects identified for this report are described in the Executive Summary, Table 1, Hydropower Research and Development Summary. Table 1 provides a project or program number, name, a brief description, start and end dates, the sponsoring organization, a contact with phone number, project category, 1996 funds, and identified future funds. Completed information forms are provided in Appendix A. To facilitate understanding, projects are grouped into eight categories (see Figures 1 and 2 in the Executive Summary):

- Fish Passage, Behavior, and Response
- Turbine-Related Projects
- Monitoring Tool Development
- Hydrology
- Water Quality

- Dam Safety
- Operations & Maintenance
- Water Resources Management.

These categories were created for convenience and reflect the information that was contributed. Additional topics could be added.

Some projects are listed in more than one category because they have overlapping elements. However, to avoid double counting of funding, funds are allocated to a single primary category in Figures 1 and 2, and are presented as a range in the text. The low range value is used in the figures and represents funding for projects identified as having the category as its primary purpose. The high range value adds projects identified as having other primary purposes. Contributed information was not sufficiently detailed to allocate funds within a project to different categories. This often made it difficult to identify the primary category. Thus, funding levels by category should be viewed with caution and interpreted only as rough estimates. Each category is described in greater detail below.

Fish Passage, Behavior, and Response Projects

Fish Passage, Behavior, and Response is the largest R&D category identified, both in terms of numbers of projects and funding. This category is receiving attention because of the widespread recognition that there are major deficiencies in understanding the behavior and passage requirements for many fish species. Controversy about the effectiveness of downstream fish passage methods, such as angled trashrack bars, is a major issue in fish passage prescriptions in Federal Energy Regulatory Commission relicensing of hydropower facilities. Many of the projects listed with this category are not necessarily associated with hydropower production, however, these projects are included because of their importance and relevance to safe fish passage or fish protection that may be applicable to hydropower sites. For example, studies of physiology and behavior contribute to understanding fish response to dams and bypass structures. Also, effective screening technologies are a major issue in the Central Valley of California and other western river valleys where there are thousands of unscreened water diversions. Projects are listed in Table 3 and include:

- Design and evaluation of new passage technologies
- Design and evaluation of screening technologies to keep fish from entrainment in water diversions
- Studies of fish movements and behavior in relation to dams and passage technologies
- Field and modeling studies of habitat
- Fish physiology studies of the effects of turbine entrainment and passage technologies.

Table 4 lists species for which behavior, physiology, and habitat studies are underway.

Table 3. Fish Passage, Behavior, and Response Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
4	Fish and Wildlife Program - Research and Evaluation Monitoring. BPA	\$24,573,761	\$0	\$24,573,761	\$132,000,000	\$0	\$132,000,000
16	Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids. USAE-North Pacific Division	\$0	\$0	\$0	\$600,000	\$0	\$600,000
18	Anadromous Fish Evaluation Program. USAE-North Pacific Division	\$14,900,000	\$0	\$14,900,000	\$13,800,000	\$0	\$13,800,000
19	Richard B. Russell Dam Fish Entrainment Study. USAE-Waterways Experiment Station	\$550,000	\$0	\$550,000	\$300,000	\$0	\$300,000
26	Fish Passage for Low Diversion Dams. USBR-Denver	\$115,000	\$30,000	\$145,000	\$230,000	\$60,000	\$290,000
27	Fish Screen Research and Technology Development Program. USBR-Denver	\$102,000	\$50,000	\$152,000	\$150,000	\$100,000	\$250,000
29	Protection and Management of Reclamation Fisheries. USBR-Denver	\$1,749,000	\$100,000	\$1,849,000	\$3,498,000	\$200,000	\$3,698,000
34	Hydraulics of Various Types of Fishways. USGS-Conte Anadromous Fish Research Center	\$58,000	\$0	\$58,000	\$70,000	\$0	\$70,000
35	Evaluation of Burst Swimming Performance of Upstream Migrant Fishes. USGS-Conte Anadromous Fish Research Center	\$25,000	\$0	\$25,000	\$150,000	\$0	\$150,000
36	Evaluation of a Uniform Acceleration Weir for Downstream Bypass Entrances. USGS-Conte Anadromous Fish Research Center	\$31,000	\$0	\$31,000	\$50,000	\$0	\$50,000
37	Behavior of American Shad and Blueback Herring Related to Fish Passage. USGS-Conte Anadromous Fish Research Center	\$45,000	\$0	\$45,000	\$181,000	\$0	\$181,000
38	Investigation of Migratory Behaviors and Passage Technologies for Anguillid Eels. USGS-Conte Anadromous Fish Research Center	\$6,000	\$0	\$6,000	NA	NA	NA
39	American Shad Energetics in the Connecticut River. USGS-Conte Anadromous Fish Research Center	\$62,000	\$0	\$62,000	NA	NA	NA
40	Biological Studies of Shortnose and Other Sturgeons. USGS-Conte Anadromous Fish Research Center	\$159,000	\$0	\$159,000	NA	NA	NA
41	Physiological and Endocrine Changes During Hatchery Rearing and Release of Atlantic Salmon. USGS-Conte Anadromous Fish Research Center	\$95,000	\$0	\$95,000	NA	NA	NA

Table 3. Fish Passage, Behavior, and Response Project Funding (continued)

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
42	Physiology of Juvenile Atlantic Salmon, American Shad and Blueback Herring Relating to Hatchery Rearing, Release, and Downstream Passage. USGS-Conte Anadromous Fish Research Center	\$45,000	\$0	\$45,000	\$0	\$0	\$0
43	Factors Influencing Smolt Production, Overwinter Mortality, and Downstream Migration of Atlantic Salmon in the West River System, Vermont. USGS-Conte Anadromous Fish Research Center	\$143,000	\$0	\$143,000	\$295,000	\$0	\$295,000
44	Impact of Stream Habitat Improvement on Smolting, Maturation, and Survival of Atlantic Salmon. USGS-Conte Anadromous Fish Research Center	\$30,000	\$0	\$30,000	NA	\$0	NA
45	Growth and Mortality of Young-of-Year Alosines: Energetics, Starvation, and Predation. USGS-Conte Anadromous Fish Research Center	\$82,000	\$0	\$82,000	NA	\$0	NA
46	Hydraulic Model Study of Little Falls Dam (MD) Fish. USGS-Conte Anadromous Fish Research Center	\$75,100	\$0	\$75,100	\$38,000	\$0	\$38,000
48	Rocky Reach Fish Bypass. Chelan Co. PUD	\$0	\$6,000,000	\$6,000,000	\$0	\$24,000,000	\$24,000,000
49	Rock Island Fish Bypass. Chelan Co. PUD	\$0	\$2,000,000	\$2,000,000	\$0	\$8,000,000	\$8,000,000
59	Aquatic Resource R&D for Hydropower. Pacific Gas & Electric/Southern California Edison	\$0	\$1,030,000	\$1,030,000	\$0	\$800,000	\$800,000
61	Development of an Infrasound Generator for Protecting Fish Alden Research Laboratory, Inc.. Public Service Electric & Gas Co.	\$0	\$355,000	\$355,000	\$0	\$1,000,000	\$1,000,000
67	Development of a Modular Inclined Fish Diversion Screen. EPRI	\$0	\$600,000	\$600,000	\$0	\$250,000	\$250,000
70	Fish Habitat Model Development. TVA	\$70,000	\$0	\$70,000	\$5,000	\$0	\$5,000
Grand Total: Fish Projects		\$42,915,861	\$10,165,000	\$53,080,861	\$151,367,000	\$34,410,000	\$185,777,000

Notes:

- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriations, but may come from power sales or other sources.

Table 4. Species Behavior, Physiology, and Habitat Projects

Species	No	Project	Organization
American eel	38	Investigation of Migratory Behaviors and Passage Technologies for Anguillid Eels	USGS-Conte Anadromous Fish Research Center
American shad	34	Hydraulics of Various Types of Fishways	USGS-Conte Anadromous Fish Research Center
American shad	39	American Shad Energetics in the Connecticut River	USGS-Conte Anadromous Fish Research Center
American shad; Blueback herring	37	Behavior of American Shad and Blueback Herring Related to Fish Passage	USGS-Conte Anadromous Fish Research Center
American shad; Blueback herring	45	Growth and Mortality of Young-of-Year Alosines: Energetics, Starvation, and Predation	USGS-Conte Anadromous Fish Research Center
American shad; Blueback herring	46	Hydraulic Model Study of Little Falls Dam (MD) Fish Passage	USGS-Conte Anadromous Fish Research Center
Atlantic salmon	44	Impact of stream habitat improvement on Smolting, Maturation, and Survival of Atlantic Salmon	USGS-Conte Anadromous Fish Research Center
Atlantic salmon	43	Factors Influencing Smolt Production, Overwinter Mortality, and Downstream Migration of Atlantic Salmon in the West River System, Vermont	USGS-Conte Anadromous Fish Research Center
Atlantic salmon	41	Physiological and Endocrine Changes During Hatchery Rearing and Release of Atlantic Salmon	USGS-Conte Anadromous Fish Research Center
Atlantic salmon; American shad	36	Evaluation of a Uniform Acceleration Weir for Downstream Bypass Entrances	USGS-Conte Anadromous Fish Research Center
Atlantic salmon; American shad; Blueback herring	42	Physiology of Juvenile Atlantic Salmon, American Shad and Blueback Herring Relating to Hatchery Rearing, Release, and Downstream Passage	USGS-Conte Anadromous Fish Research Center
Atlantic salmon; Striped bass; White perch; Riverine species	61	Development of an Infrasound Generator for Protecting Fish	Alden Research Laboratory, Inc.; Public Service Electric & Gas Co
Blueback herring (primarily)	19	Richard B. Russell Dam Fish Entrainment Study	USAE-Waterways Experiment Station
Chinook salmon	31	Use of Nuclear DNA Markers to Identify Chinook Salmon Races	USBR-Sacramento
Chinook salmon; Steelhead trout; Kokanee; White sturgeon; Burbot; Rainbow trout; Smallmouth Bass; Bull trout; Westslope Cutthroat trout	4	Fish And Wildlife Program - Research/Evaluation And Monitoring	BPA
Juvenile salmonids	16	Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids	USAE-North Pacific Division
Juvenile salmonids	14	Turbines - Basecase Survival/Injury Studies	USAE-North Pacific Division
Juvenile salmonids; Steelhead trout	48	Rocky Reach Fish Bypass	Chelan Co. PUD
Juvenile salmonids; Steelhead trout	49	Rock Island Fish Bypass	Chelan Co. PUD
Native trout	59	Aquatic Resource R&D for Hydropower	Pacific Gas and Electric/ Southern California Edison
Riverine and anadromous species	35	Evaluation of Burst Swimming Performance of Upstream Migrant Fishes	USGS-Conte Anadromous Fish Research Center
Shortnose sturgeon; other sturgeons	40	Biological Studies of Shortnose and Other Sturgeons	USGS-Conte Anadromous Fish Research Center
Splittail; Razorback sucker	29	Protection & Management of Reclamation Fisheries	USBR-Denver
Sturgeon	26	Fish Passage for Low Diversion Dams	USBR-Denver

Many of the fish passage, behavior, and response projects are also categorized with Monitoring Tool Development and Turbine-Related projects. Site-specific studies of turbine mortality and injury are not listed here, but are included in the Turbine-Related projects category.

Funds to install new passage facilities are not included, but may often equal or exceed the cost of associated research. For example, Chelan County identified two Fish Bypass R&D projects. Current funding for the Rocky Reach Fish Bypass (No. 48) is about \$6 million per year, with an estimated construction cost of \$30 million. Current funding for the Rock Island Fish Bypass (No. 49) is about \$2 million per year for prototype development, with estimated construction costs of \$25 million.

About \$53 million was spent in this category in 1996 and about \$186 million will be spent between 1997 and 2000, based on the compiled information. About 90% of 1996 funds are directed at research in the Pacific Northwest. In addition to the Public Utility District downstream passage facility projects described above, Pacific Northwest funds are from two major programs: the Bonneville Power Administration - Fish and Wildlife Program (No. 4, \$24.6 million), and the U.S. Army Corps of Engineers - North Pacific Division - Anadromous Fish Evaluation Program (No. 18, \$14.9 million). These two programs are discussed below, and specific projects are summarized in Appendices B and C. The remaining 10% of 1996 funds were for 21 projects throughout the country, including projects by U.S. Army Corps of Engineers - Waterways Experiment Station, U.S. Bureau of Reclamation, U.S. Geological Survey - Conte Anadromous Fish Research Center, Pacific Gas & Electric/Southern California Edison, Alden Research Laboratory, Inc./Public Service Electric & Gas, and Electric Power Research Institute.

Bonneville Power Administration - Fish Research Projects (Appendix B):

The Bonneville Power Administration provides funds for fish research programs in the Columbia River Basin. In 1996 Bonneville Power Administration funded 70 fish monitoring and research and evaluation projects for a total of \$25,839,837. Monitoring projects account for \$12,336,151 and Bonneville Power Administration groups them as:

- Methods development (included in Monitoring Tool Development category)
- Production (related to hatcheries and relationships between wild and hatchery fish)
- System level monitoring
- Tributary monitoring.

Research and Evaluation projects for anadromous fish, primarily Chinook salmon and Steelhead trout, account for \$10,082,394. Bonneville Power Administration groups these projects into six categories:

- Gas supersaturation
- Genetics
- Life cycle
- Passage
- Planning and coordination
- Production.

Research and Evaluation projects for resident fish (Kokanee, White sturgeon, Burbot, Rainbow trout, Smallmouth bass, Bull trout, and Westslope Cutthroat trout) account for \$3,421,292.

U.S. Army Corps of Engineers - North Pacific Division - Anadromous Fish Evaluation Program (Appendix C)

The U.S. Army Corps of Engineers - North Pacific Division conducts research as part of their overall budget for the Columbia River Fish Mitigation Project. About 20% of the Columbia River Fish Mitigation Project's budget (\$14.9 million in 1996 and about \$19 million in 1997) is used for the Anadromous Fish Evaluation Program. A total of 41 projects will be undertaken in 1997 by the Portland and Walla Walla Districts related to:

- Surface collection and bypass systems at different dams
- Gas abatement
- Post - construction evaluation of mainstem passage measures
- Turbines (individual information sheets provided, see Turbine-Related Projects)
- Barge transport
- Spawning site identification
- Temperature control measures
- Reservoir draw-down alternatives
- Adult migration and dam passage.

Turbine-Related Projects

Turbine-related projects are mostly focused on modifications to hydropower turbines to reduce fish injury and mortality, without compromising efficiency of power production. Some research is also directed at improving water quality associated with turbine discharges. Projects are listed in Table 5 and include:

- Engineering design and testing physical models
- Data collection
- New monitoring tools
- Improved equipment both for power generation and fish monitoring
- Guidelines for fish entrainment studies.

Monitoring fish mortality and injury from turbine passage is a significant element of many projects, as is monitoring the pressure and flow conditions that the fish are subjected to during turbine passage.

Turbine-related projects comprise the second largest category identified in the R&D, both in terms of number of projects and funding. Funding for turbine-related research was between \$4.9 and \$22.1 million in 1996. See the Overview of Projects section above for an explanation of this funding range. Required funding of between \$110.9 and \$131.5 million was identified for 1997-2000. Both Federal agencies and the private sector are involved in turbine-related projects.

Table 5. Turbine-Related Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
1	McNary Turbine Model Test. BPA	\$100,000	\$0	\$100,000	\$0	\$0	\$0
2	3-D Cam Update. BPA	\$804,000	\$0	\$804,000	\$0	\$0	\$0
5	Advanced Hydropower Turbine System. DOE	\$500,000	\$500,000	\$1,000,000	NA	NA	\$101,600,000
6	Development of Auto-Venting Turbine Technologies. TVA	\$0	\$0	\$0	\$150,000	\$50,000	\$200,000
7	Demonstration of Kaplan Turbine Optimization. TVA	\$85,000	NA	\$85,000	\$50,000	NA	\$50,000
8	Stator Vibration Project. TVA	NA	NA	NA	\$15,000	\$0	\$15,000
9	Support to Machine Condition Monitoring Consortium. TVA	\$0	\$0	\$0	\$800,000	\$0	\$800,000
12	Joint Development of Hydro Condition Monitoring System. TVA	\$0	\$0	\$0	\$100,000	\$100,000	\$200,000
14	Turbines - Basecase Survival/Injury Studies. USAE-North Pacific Division	\$0	\$0	\$0	\$2,000,000	\$0	\$2,000,000
15	Turbines - Develop Methodology/Equipment for Use in Fish Distribution Studies Within Turbine Environment. USAE-North Pacific Division	\$0	\$0	\$0	\$600,000	\$0	\$600,000
16	Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids. USAE-North Pacific Division	\$0	\$0	\$0	\$600,000	\$0	\$600,000
17	Baseline Engineering Testing. USAE-North Pacific Division	\$0	\$0	\$0	\$2,000,000	\$0	\$2,000,000
18	Anadromous Fish Evaluation Program. USAE-North Pacific Division	\$14,900,000	\$0	\$14,900,000	\$13,800,000	\$0	\$13,800,000
29	Protection and Management of Reclamation Fisheries. USBR-Denver	\$1,749,000	\$100,000	\$1,849,000	\$3,498,000	\$200,000	\$3,698,000
47	Rocky Reach Hydroelectric Project, Fish Passage Survival through Turbines. Chelan Co. PUD	\$0	\$600,000	\$600,000	\$0	\$0	\$0
50	Enhanced Fish Passage Hydropower Turbine. Grant Co. PUD	\$0	\$1,897,000	\$1,897,000	\$0	\$5,000,000	\$5,000,000
51	In Operating Hydro Turbine Imaging. Grant Co. PUD	\$0	\$85,000	\$85,000	\$0	\$915,000	\$915,000
56	Hydro Turbine Runner/Wicket Design Optimization. Pacific Gas & Electric	\$0	\$118,000	\$118,000	\$0	\$0	\$0

Table 5. Turbine-Related Project Funding (continued)

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
60	Development of a More Tolerant Turbine Runner: DOE Advanced Hydropower Turbine System Program. Alden Research Laboratory, Inc./Northern Research and Engineering Corp.	NA	\$70,000	\$70,000	NA	NA	NA
62	Guidelines: Hydro Turbine Fish Entrapment and Survival Studies. EPRI	\$0	\$141,000	\$141,000	\$0	\$35,000	\$35,000
69	<i>Hydroelectric Machine Condition Monitoring Project. Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C</i>	NA	NA	NA	NA	NA	NA
Total: Turbine-Related Projects		\$18,578,000	\$3,511,000	\$22,051,000	\$23,613,000	\$6,300,000	\$131,513,000
<i>less other project types</i>		<i>\$17,049,000</i>	<i>\$185,000</i>	<i>\$17,234,000</i>	<i>\$19,398,000</i>	<i>\$1,215,000</i>	<i>\$20,613,000</i>
Grand Total: Turbine Projects		\$1,529,000	\$3,326,000	\$4,855,000	\$4,215,000	\$5,085,000	\$110,900,000

Notes:

- Funding for italicized entries counted in other project types.
- Inconsistent totals due to incomplete data.
- Additional funding for No. 60 provided by and allocated to No. 5.
- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriation, but may come from power sales or other sources.

Turbine research expenditures are much less than costs associated with installation of new or rehabilitated turbines. The costs of new turbines are not included in the funding tables. Some research into improved designs and operations for fish are part of much larger expenditures for turbine rehabilitation. For example, Chelan County Public Utility District spent \$1.2 million on fisheries-related research as part of a \$67 million turbine rehabilitation program (No. 47), and Grant County Public Utility District anticipates spending \$6.9 million on fisheries-related studies and \$34 million on 10 improved turbines (No. 50).

The DOE - Advanced Hydropower Turbine System Program (No. 5), jointly funded in the initial phase by the Department and the Hydropower Research Foundation, Inc.(a consortium of private industry), has one of the highest total funding levels identified. Funds are for conceptual designs, detailed design, and building and testing full-scale prototypes at operating hydropower facilities. However, funding sources beyond the design stage have not been identified. It is anticipated that \$101.6 million is needed to complete this project.

Monitoring Tool Development Projects

New monitoring equipment and systems are needed to better understand what happens to fish during turbine passage and around other passageways. To design turbines with reduced injury and mortality, and effective passage technologies, techniques are needed to identify types of fish and their distribution in the river and passage routes, as well as pressure and flow conditions to which they are exposed. Advancements in computer technology provide opportunities to develop new systems to monitor the condition and performance of turbines and associated equipment. Monitoring Tool Development projects are identified in Table 6 and include:

- Equipment and methods to monitor conditions and observe fish passage through turbines
- Techniques to distinguish fish species and races
- Methods to evaluate flow conditions around fish screens
- Equipment and methods to evaluate performance of turbines
- Methods to monitor water quality in large water systems.

Projects that involve installation of existing monitoring systems are not included in this category, nor are projects to develop or refine modeling systems. Modeling projects are categorized with the topic they are directed at, such as water quality or hydrology.

Expenditures in this category are difficult to estimate from the available information, because many of the identified activities are part of much larger projects and funding information was not available for the Hydroelectric Machine Condition Monitoring Project (No. 69). Funding for 1996 ranges between \$2.5 and \$19.5 million. See section on Overview of Projects, above, for an explanation of this funding range. Required funding for 1997–2000 was identified to range from \$7.3 to \$25.1 million. See Appendices B and C for information on projects in this category funded by the Bonneville Power Administration - Fish and Wildlife Program, and the U.S. Army Corps of Engineers - North Pacific Division - Anadromous Fish Evaluation Program, respectively.

Hydrology Projects

Hydrology projects identified for this report are listed in Table 7 and involve development of software to provide more timely and accurate information on weather and/or river flow conditions. This type of information is important for optimizing hydropower operations and can also be used to improve fish habitat downstream of dams (No. 70). Expenditures for 1996 range from \$1.3 to 1.4 million. See the Overview of Projects section above for an explanation of this funding range. Required expenditures for 1997–2000 were identified to be from \$3.3 to 3.5 million.

Table 6. Monitoring Tool Development Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
3	Fish And Wildlife Program - Monitoring Methods. BPA	\$1,266,076	\$0	\$1,266,076	\$4,000,000	\$0	\$4,000,000
9	Support to Machine Condition Monitoring Consortium. TVA	\$400,000	\$0	\$400,000	\$800,000	\$0	\$800,000
10	Improved Dissolved Oxygen Sensors. TVA	\$0	\$0	\$0	\$30,000	\$0	\$30,000
11	<i>Cavitation Characteristics Mapping.</i> TVA	\$0	\$0	\$0	\$20,000	\$0	\$20,000
12	Joint Development of Hydro Condition Monitoring System. TVA	\$0	\$0	\$0	\$100,000	\$100,000	\$200,000
15	Turbines - Develop Methodology/ Equipment for Use in Fish Distribution Studies Within Turbine Environment. USAE-North Pacific Division	\$0	\$0	\$0	\$600,000	\$0	\$600,000
18	<i>Anadromous Fish Evaluation Program.</i> USAE-North Pacific Division	\$14,900,000	\$0	\$14,900,000	\$13,800,000	\$0	\$13,800,000
21	Water Quality Protection and Enhancement. USBR-Denver	\$200,000	\$285,000	\$485,000	\$415,000	\$120,000	\$535,000
27	<i>Fish Screen Research and Technology Development Program.</i> USBR-Denver	\$102,000	\$50,000	\$152,000	\$150,000	\$100,000	\$250,000
28	Real-Time Optical Identification of Juvenile Fish Types. USBR-Denver	\$47,000	\$0	\$47,000	\$26,000	\$0	\$26,000
29	<i>Protection and Management of Reclamation Fisheries.</i> USBR-Denver	\$1,749,000	\$100,000	\$1,849,000	\$3,498,000	\$200,000	\$3,698,000
31	Use of Nuclear DNA Markers to Identify Chinook Salmon Races. USBR-Sacramento	\$50,000	\$164,000	\$214,000	\$50,000	\$140,000	\$190,000
39	<i>American Shad Energetics in the Connecticut River.</i> USGS-Conte Anadromous Fish Research Center	\$62,000	\$0	\$62,000	NA	NA	NA
51	In Operating Hydro Turbine Imaging. Grant Co. PUD	\$0	\$85,000	\$85,000	\$0	\$915,000	\$915,000
69	Hydroelectric Machine Condition Monitoring Project. Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C.	NA	NA	NA	NA	NA	NA
Total: Monitoring Tool Projects		\$18,776,076	\$684,000	\$19,460,076	\$23,489,000	\$1,575,000	\$25,064,000
<i>less other project types</i>		\$16,813,000	\$150,000	\$16,963,000	\$17,468,000	\$300,000	\$17,768,000
Grand Total: Monitoring Tool Projects		\$1,963,076	\$534,000	\$2,497,076	\$6,021,000	\$1,275,000	\$7,296,000

Notes:

- Funding for italicized entries counted in other project types.
- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriations, but may come from power sales or other sources.

Table 7. Hydrology Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
68	Severe Weather Forecast Applications for Electric Utilities. EPRI/National Severe Storm Laboratory	NA	\$0	NA	NA	\$0	NA
30	Watershed And River Systems Management Program. USBR - Denver/USGS	NA	\$0	NA	\$2,000,000	\$0	\$2,000,000
25	Inflow Design Flood Parameter Study. USBR-Denver	\$75,000	\$58,100	\$133,100	\$200,000	\$100,000	\$300,000
22	Regional Hydrologic Forecasting for Mid-Pacific Watersheds. USBR-Denver	\$1,080,000	\$0	\$1,080,000	\$1,040,000	\$0	\$1,040,000
58	<i>Mid-Term Hydro Thermal Optimization, short-Term Weather-dependent Inflow Forecasting, and Hydro Dispatch Curve System Pacific Gas & Electric</i>	\$0	\$124,000	\$124,000	\$0	\$200,000	\$200,000
70	<i>Fish Habitat Model Development. TVA</i>	\$70,000	\$0	\$70,000	\$5,000	\$0	\$5,000
Total: Hydrology Projects		\$1,225,000	\$182,100	\$1,407,100	\$3,245,000	\$300,000	\$3,545,000
<i>less other project types</i>		\$0	\$124,000	\$124,000	\$5,000	\$200,000	\$205,000
Grand Total: Hydrology Projects		\$1,225,000	\$58,100	\$1,283,100	\$3,240,000	\$100,000	\$3,340,000

Notes:

- Funding for italicized entries counted in other project types.
- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriations, but may come from power sales or other sources.

Water Quality Projects

Recent attention has been directed at improving water quality both within reservoirs and downstream of dams by making operational and structural changes. Although the impact of changes on aquatic life of some conventional water quality parameters, such as dissolved oxygen and temperature, are fairly well understood, the impact of other water quality parameters like metals and other toxic pollutants are not well understood. More cost effective methods are also needed to improve dissolved oxygen discharges at hydropower facilities, water quality in reservoirs, and desalination. Gas supersaturation is a major issue in the Pacific Northwest and is being addressed in the Bonneville Power Administration - Fish and Wildlife Program, and the U.S. Army Corps of Engineers - Anadromous Fish Evaluation Program projects (see Appendices B and C, respectively).

Water Quality projects are listed in Table 8 and include:

- Engineering design
- Computer modeling
- Monitoring tools for large reservoirs
- Desalination technologies for water supply and water treatment.

Most of the modeling work involves modifying existing models for humid, eastern reservoirs to arid, high elevation western conditions.

Funding ranges for Water Quality are very large because of projects identified as having other primary purposes (No. 5, Turbine-Related and No. 21, Monitoring Tool Development). The 1996 range is from \$0.2 to \$1.7 million. See the Overview of Projects section above for an explanation of this funding range. The required funding range for 1997–2000 was identified to be from \$2.5 to \$48.2 million.

Table 8. Water Quality Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
5	<i>Advanced Hydropower Turbine System. DOE</i>	\$500,000	\$500,000	\$1,000,000	Na	Na	\$101,600,000
6	<i>Development Of Auto-Venting Turbine Technologies. TVA</i>	\$0	\$0	\$0	\$150,000	\$50,000	\$200,000
10	<i>Improved Dissolved Oxygen Sensors. TVA</i>	\$0	\$0	\$0	\$30,000	\$0	\$30,000
20	Water Treatment Technology Program. USBR-Denver	Na	Na	Na	\$2,000,000	Na	\$2,000,000
21	<i>Water Quality Protection And Enhancement. USBR-Denver</i>	\$200,000	\$285,000	\$485,000	\$415,000	\$120,000	\$535,000
23	Reservoir Water Quality Model Development And Modification. USBR-Denver	\$170,000	\$0	\$170,000	\$360,000	\$0	\$360,000
24	Enhancement And Demonstration Of Stream Water Quality Modeling/Field Studies. USBR-Denver	\$50,000	\$0	\$50,000	\$120,000	\$0	\$120,000
64	Design Criteria For Aerating Weirs. EPRI	\$0	\$0	\$0	\$0	\$0	\$0
Total: Water Quality Projects		\$920,000	\$785,000	\$1,705,000	\$3,075,000	\$170,000	\$104,845,000
Less Other Project Types		\$700,000	\$785,000	\$1,485,000	\$595,000	\$170,000	\$102,365,000
Grand Total: Water Quality Projects		\$220,000	\$0	\$220,000	\$2,480,000	\$170,000	\$2,480,000

Notes:

- Funding for italicized entries counted in other project types.
- Inconsistent totals due to incomplete data.
- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require congressional appropriation, but may come from power sales or other sources.

Dam Safety Projects

Federal and State Dam Safety Programs have identified many dams with hydrologic deficiencies. In some cases these deficiencies are probably real and require structural or operational changes, in other cases they may be a result of overly conservative analytical techniques that don't accurately reflect site conditions. Better tools for understanding and analyzing dam safety problems, so that cost effective solutions can be implemented, are the focus of the Dam Safety projects identified in Table 9. These projects include:

- Software development
- Physical model testing.

About \$0.6 million was spent in this area in 1996 and about \$0.4 million will be spent on these dam safety research projects from 1997 to 2000.

Table 9. Dam Safety Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
32	Overtopping Protection for Dams. USBR/EPRI/CSU	\$106,000	\$7,500	\$113,500	\$49,000	\$0	\$49,000
33	Dam Foundation Erosion During Overtopping. USBR/EPRI/CSU	\$187,000	\$205,000	\$392,000	\$215,000	\$178,000	\$393,000
55	Erosion Characteristics of Dam Foundations. Pacific Gas & Electric	\$0	\$123,000	\$123,000	\$0	\$0	\$0
65	Dam Safety for Concrete Gravity Dams. EPRI	\$0	\$0	\$0	\$0	\$0	\$0
66	MERLIN, Dam Safety Analysis. EPRI	\$0	\$0	\$0	\$0	\$0	\$0
Grand Total: Dam Safety Projects		\$293,000	\$335,500	\$628,500	\$264,000	\$178,000	\$442,000

Notes:

- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriation, but may come from power sales or other sources.

Operations and Maintenance (O&M) Projects:

Attention to O&M is a high priority for hydropower operators. Advancements in computer technology have led to new opportunities to develop new tools and methods for O&M. Increased attention to protecting fish and other environmental resources necessitates evaluation of standard practices and possible changes. O&M projects are listed in Table 10 and include:

- Improved methods to identify and address specific maintenance problems
- Software applications to optimize operations and maintenance.

Some projects are directed at identifying methods that are environmentally acceptable. About \$0.6 million was spent in 1996 by one non-Federal power producer. Required expenditures for 1997-2000 were identified to range from \$0.5 to \$1.5 million. See the Overview of Projects section above for an explanation of this funding range.

Table 10. Operations and Maintenance Project Funding

No	Project/Program/Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
9	<i>Support to Machine Condition Monitoring Consortium. TVA</i>	\$400,000	\$0	\$400,000	\$800,000	\$0	\$800,000
11	Cavitation Characteristics Mapping. TVA	\$0	\$0	\$0	\$20,000	\$0	\$20,000
12	<i>Joint Development of Hydro Condition Monitoring System. TVA</i>	\$0	\$0	\$0	\$100,000	\$100,000	\$200,000
13	Zebra Mussel Control for TVA's Hydro Facilities. TVA	\$0	\$0	\$0	\$30,000	\$0	\$30,000
53	Conveyance Systems O&M Cost Reduction. Pacific Gas & Electric	\$0	\$232,000	\$232,000	\$0	\$130,000	\$130,000
54	NDE for Strength Assessment of Riveted Steel Penstocks. Pacific Gas & Electric	\$0	\$138,000	\$138,000	\$0	\$126,000	\$126,000
57	Hand-Held O&M Computers and Plant Maintenance Optimization. Pacific Gas & Electric	\$0	\$75,000	\$75,000	\$0	\$0	\$0
58	Mid-Term Hydro Thermal Optimization, short-Term Weather-dependent Inflow Forecasting, and Hydro Dispatch Curve System. Pacific Gas & Electric	\$0	\$124,000	\$124,000	\$0	\$200,000	\$200,000
69	<i>Hydroelectric Machine Condition Monitoring Project. Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C.</i>	NA	NA	NA	NA	NA	NA
Total: O&M Projects		\$400,000	\$569,000	\$969,000	\$950,000	\$556,000	\$1,506,000
<i>less other project types</i>		<i>\$400,000</i>	<i>\$0</i>	<i>\$400,000</i>	<i>\$900,000</i>	<i>\$100,000</i>	<i>\$1,000,000</i>
Grand Total: O&M Projects		\$0	\$569,000	\$569,000	\$50,000	\$456,000	\$506,000

Notes:

- Funding for italicized entries counted in other project types.
- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriation, but may come from power sales or other sources.

Water Resources Management Projects

Increased attention to protecting fish and other environmental resources and values during relicensing of hydropower facilities has led to new ways of approaching the relicensing process and hydropower operations. Two Water Resources Management projects listed in Table 11 were identified:

- Tools for public involvement in hydropower licensing activities
- Tools to reduce costs of meeting fishery objectives.

About \$0.4 million of non-Federal funds was identified for these projects in 1996. The same level of funding was identified to complete these projects in 1997.

Table 11. Water Resources Management Project Funding

No	Project or Program, and Organization	1996 Funding			Future Required Funding		
		Federal	Other	Total	Federal	Other	Total
52	Water Resources R&D for Hydropower. Pacific Gas & Electric	\$0	\$110,000	\$110,000	\$0	\$70,000	\$70,000
63	Water Resource Management and Hydropower. Collaboration and Public Involvement EPRI	\$0	\$287,500	\$287,500	\$0	\$287,500	\$287,500
Grand Total: Management Projects		\$0	\$397,500	\$397,500	\$0	\$357,500	\$357,500

Notes:

- Funding information not available for all projects or programs.
- Funding for all participants may not be included. Available information is displayed.
- Future funding levels do not reflect same time period for all projects and programs.
- All required future funding to complete project may not be identified.
- Federal funding does not necessarily require Congressional appropriations, but may come from power sales or other sources.

Issues in Hydropower Research and Development

The original purpose of this compilation of Hydropower R&D activities was to identify ongoing and planned R&D directed at improving the environmental performance of hydroelectric generation and determine whether or not there was any duplication of effort. Review of compiled information does not reveal any obvious duplication of effort in hydropower Research and Development among Federal agencies.

Lack of duplication may, in part, be attributed to the numerous ongoing efforts at consultation and coordination such as the congressionally mandated Interagency Research Coordination Conference established in 1960; the U.S. Department of Energy Advanced Hydropower Turbine System Program; the U.S. Army Corps of Engineers Turbine Working Group; and activities underway in the Pacific Northwest to coordinate the protection and restoration of salmon. However, the existence of such activities does not eliminate the need for continued diligence to avoid duplication and ensure coordination and the dissemination of high quality research to enhance the environmental performance of hydropower.

This report on Federal and industry R&D projects provides an opportunity to consider other issues, particularly at this time when both Federal and industry expenditures for research are thought to be declining. Although this compilation of activities is not complete, it does provide an indication of the kinds of R&D and levels of spending that are underway, especially by Federal agencies. It is a first step and raises the possibility of providing a comprehensive view of Hydropower R&D activities and ensuring that available funding is directed at priority issues. Other issues relate to ensuring that R&D activities achieve the best possible results through coordination, technical/peer review, and technology transfer.

Duplication

Although similar work appears to be underway at different sites, such as the work to develop new fish bypass systems (No. 48 and No. 49) and work to improve fish survival through turbines (No. 47 and No. 50), this cannot be construed as duplicative because of the site-specific nature of each hydropower facility and/or the species-specific behavior of fish. Additional evidence against duplicative work is the effort made, especially in Hydrology and Water Quality projects, to take advantage of existing models and adapt them to other conditions.

Priorities

All groups involved in hydropower R&D are constrained by available funding to limit their activities and set priorities. For the most part, priorities are established within individual agencies and organizations. To some extent, especially in the Pacific Northwest, priorities are determined in conjunction with other groups, legal agreements, and/or as a result of technical workshops to define needs. The key issue about priorities is whether research needs are not being met because of the existing system for hydropower R&D funding.

Coordination

Information sheets did not provide information on coordination among research activities. Although some projects indicated support for a study by other agencies, questions arose about coordination and the comprehensiveness of some studies. For example, are fish protection needs addressed in work related to improving operations and designs for dam safety?

Other coordination issues relate to the efficiency of research activities. Are there economies of scale that could be achieved by adding objectives to a project? Do research activities answer questions regulatory and industry decision-makers need to know? Once a project is completed, are there adequate opportunities for other researchers to take advantage of experimental facilities, such as physical models?

Technical/Peer Review

A major concern about some hydropower Research and Development activities is the technical acceptability of the results and the requirements for applying new technologies at hydropower facilities. This is particularly true for R&D activities related to fish passage, including efforts to reduce turbine entrainment. The issue of fish passage is highly contentious in several regions of the country. Much of the controversy relates to relicensing non-Federal hydropower facilities by the Federal Energy Regulatory Commission and the authority of the National Marine Fisheries Service and the U.S. Fish and Wildlife Service to prescribe fish passage requirements for the protection of species listed under the Endangered Species Act. Fish passage prescriptions have been particularly controversial in the Northeast and Midwest. Fish passage and protection are also controversial in the Pacific Northwest for both Federal and non-

Federal hydropower operations in the Columbia River System due to concerns about declining salmon populations. In the Southwest, especially California, fish protection at water diversions (not necessarily hydropower) is very contentious.

The Congressional Office of Technology Assessment identified a critical need for good science and independent evaluation of technologies in order to advance fish passage technology.² The Office of Technology Assessment went on to describe what was meant by good science:

Research gains credibility and acceptability through the use of a sound scientific approach to designing, executing, and evaluating work. The elements of high quality research include the establishment of clear objectives, agreement amongst all parties on the study design including quantifiable standards of acceptability that are measurable in the studies, and a protocol that lends itself to repeatability. Studies should be designed by an interdisciplinary team including not only those knowledgeable about fisheries, hydrology, hydraulics, and hydropower operations, but also biologists knowledgeable about fish behavior and sensory response. In addition, there must be a proper accounting of environmental variability and documentation of underlying assumptions. Studies should span multiple seasons in order to collect adequate data and include appropriate statistical evaluation. Regular communication among stakeholders should occur throughout the study process. Evaluative reports on the work should be peer reviewed by credible professionals with no vested interest in the results, and then published. Agreement on performance criteria and standards prior to study will facilitate acceptance of data and recommendations. (p.7)

Although most of the projects identified follow many of these elements of good science, few devote the resources to peer review and publication. Peer review is becoming a tool for some agencies that base regulatory and policy decisions on scientific information, such as the U.S. Environmental Protection Agency, to bolster their decisions, especially those that may be challenged in court. Peer review is considered to be distinct from review by stakeholders and other experts, in that peer reviewers are expected to be totally objective, despite any potential conflicts of interest. It is expected that research and development activities which are subjected to critical peer review will result in technologies that will be more acceptable to decision-makers and regulators that determine whether or not to use the technology at a specific site.

Technology Transfer/Commercialization

Many projects, especially those related to Monitoring Tool Development, have the potential to develop new analytical tools that could be applied at many locations. A key issue is whether there are mechanisms in place to make newly developed instruments and analytical methods widely available. Commercialization efforts were noted for four projects including: the Electric Power Research Institute's development of a Modular Inclined Fish Diversion Screen (No. 67), and three projects related to the Integrated Hydroelectric Machine Conditioning Monitoring Consortium (No. 9, No. 12, and No. 69).

² U.S. Congress, Office of Technology Assessment, *Fish Passage Technologies: Protection at Hydropower Facilities*, OTA-ENV-641 (Washington DC: U.S. Government Printing Office, September 1995). Report is also available at <http://www.wss.princeton.edu/~ota/>

Three TVA projects represent agency/industry collaborations to merge existing technologies, jointly develop new ones, and commercialize the technologies (No. 6, No. 7, and No. 12).

NEXT STEPS

At the Hydropower Coordination Team Workshop in April 1996, it was suggested that this compilation of hydropower R&D activities be updated annually. Future efforts could potentially yield a larger response and result in a more comprehensive picture of ongoing activities and funding levels. While the current summary provides a fairly good indication of the types of research activities that are underway, funding levels are less accurate because of the relatively small numbers of projects that are represented.

Another meeting of the Hydropower Coordination Team members is planned for April 1997 to discuss:

- Value of this report and suggestions for future reports
- Ways to increase participation
- Whether there are any major gaps in research activities
- Research priorities
- Other issues in hydropower R&D, such as duplication, coordination, technical/peer review, and technology transfer
- Future directions for the Hydropower Coordination Team.

This type of discussion would be another step towards a more comprehensive hydropower research and development program.

APPENDIX A

Hydropower R&D Information Sheets

Hydropower R&D Information Sheets

FEDERAL AGENCIES

Bonneville Power Administration (BPA)

- 1 McNary Turbine Model Test
- 2 3-D Cam Update
- 3 Fish And Wildlife Program - Monitoring Methods Development (see App. B)
- 4 Fish And Wildlife Program - Research And Evaluation And Monitoring (see App. B)

U. S. Department Of Energy (DOE)

- 5 Advanced Hydropower Turbine System Program

Tennessee Valley Authority (TVA)

- 6 Development of Auto-Venting Turbine Technologies
- 7 Demonstration of Kaplan Turbine Optimization
- 8 Stator Vibration Project
- 9 Support to Machine Condition Monitoring Consortium
- 10 Improved Dissolved Oxygen Sensors
- 11 Cavitation Characteristics Mapping
- 12 Joint Development of Hydro Condition Monitoring System
- 13 Zebra Mussel Control for TVA's Hydro Facilities
- 70 Fish Habitat Model Development

U.S. Army Corps Of Engineers (USAE) - North Pacific Division

- 14 Turbines - Basecase Survival/Injury Studies
- 15 Turbines - Develop Methodology/Equipment for Use in Fish Distribution Studies Within Turbine Environment
- 16 Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids
- 17 Baseline Engineering Testing
- 18 Anadromous Fish Evaluation Program (see App. C)

U.S. Army Corps Of Engineers (USAE) - Waterways Experiment Station

- 19 Richard B. Russell Dam Fish Entrainment Study

U.S. Bureau Of Reclamation (USBR) *[Information Sheets Not Provided]*

- 20 Water Treatment Technology Program
- 21 Water Quality Protection and Enhancement
- 22 Regional Hydrologic Forecasting for Mid-Pacific Watersheds
- 23 Reservoir Water Quality Model Development and Modification
- 24 Enhancement and Demonstration of Stream Water Quality Modeling/Field Studies
- 25 Inflow Design Flood Parameter Study
- 26 Fish Passage for Low Diversion Dams
- 27 Fish Screen Research and Technology Development Program
- 28 Real-Time Optical Identification of Juvenile Fish Types
- 29 Protection and Management of Reclamation Fisheries
- 30 Watershed and River Systems Management Program
- 31 Use of Nuclear DNA Markers to Identify Chinook Salmon Races
- 32 Overtopping Protection for Dams
- 33 Dam Foundation Erosion During Overtopping

U.S. Geological Survey (USGS) - Conte Anadromous Fish Research Center

- 34 Hydraulics of Various Types of Fishways
- 35 Evaluation of Burst Swimming Performance of Upstream Migrant Fishes
- 36 Evaluation of a Uniform Acceleration Weir for Downstream Bypass Entrances
- 37 Behavior of American Shad and Blueback Herring Related to Fish Passage
- 38 Investigation of Migratory Behaviors and Passage Technologies for Anguillid Eels
- 39 American Shad Energetics in the Connecticut River
- 40 Biological Studies of Shortnose and Other Sturgeons
- 41 Physiological and Endocrine Changes During Hatchery Rearing and Release of Atlantic Salmon
- 42 Physiology of Juvenile Atlantic Salmon, American Shad and Blueback Herring Relating to Hatchery Rearing, Release, and Downstream Passage
- 43 Factors Influencing Smolt Production, Overwinter Mortality, and Downstream Migration of Atlantic salmon in the West River System, Vermont
- 44 Impact of Stream Habitat Improvement on Smolting, Maturation, and Survival of Atlantic Salmon
- 45 Growth and Mortality of Young-of-Year Alosines: Energetics, Starvation, and Predation
- 46 Hydraulic Model Study of Little Falls Dam (MD) Fish Passage

UTILITIES

Chelan County Public Utility District (PUD)

- 47 Rocky Reach Hydroelectric Project, Fish Passage Survival through Turbines
- 48 Rocky Reach Fish Bypass
- 49 Rock Island Fish Bypass

Grant County Public Utility District (PUD)

- 50 Enhanced Fish Passage Hydropower Turbine
- 51 In Operating Hydro Turbine Imaging

Pacific Gas & Electric (PG&E)

- 52 Water Resources R&D for Hydropower
- 53 Conveyance Systems O&M Cost Reduction
- 54 NDE for Strength Assessment of Riveted Steel Penstocks
- 55 Erosion Characteristics of Dam Foundations
- 56 Hydro Turbine Runner/Wicket Design Optimization
- 57 Hand-Held O&M Computers and Plant Maintenance Optimization
- 58 Mid-Term Hydro Thermal Optimization, short-Term Weather-dependent Inflow Forecasting, and Hydro Dispatch Curve System

Pacific Gas & Electric/ Southern California Edison

- 59 Aquatic Resource R&D for Hydropower

OTHER ORGANIZATIONS

Alden Research Laboratory, Inc. (ARL)

- 60 Development of a More Tolerant Turbine Runner: DOE Advanced Hydropower Turbine System Program
- 61 Development of an Infrasound Generator for Protecting Fish Electric Power Research Institute (EPRI)
- 62 Guidelines: Hydro Turbine Fish Entrainment and Survival Studies
- 63 Water Resource Management and Hydropower: Collaboration and Public Involvement
- 64 Design Criteria for Aerating Weirs
- 65 Dam Safety for Concrete Gravity Dams
- 66 MERLIN, Dam Safety Analysis
- 67 Development of a Modular Inclined Fish Diversion Screen
- 68 Severe Weather Forecast Applications for Electric Utilities

Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C.

- 69 Hydroelectric Machine Condition Monitoring Project
Blank Hydropower Research and Development project form.

#1

Current Hydropower Research and Development

Date: June 7, 1996
Organization: Bonneville Power Administration
Principal Contact: Fong Grey
Address: Federal Hydro Project-MGC Federal Hydro Project-MGC
911 NE 11th Ave. P.O. Box 3621
Portland, Oregon 97232 Portland, Oregon 97208-3621
Phone Number: (503) 230-4492
Fax Number: (503) 230-3752
Internet address: ffgrey@bpa.gov

Project/Program Title: McNary Turbine Model Test

Purpose and Objective:

To verify and develop turbine model test data of performance for a replacement turbine runner for the McNary Powerhouse using a "minimum gap" turbine design. This data will be used to establish a technical basis for turbine performance improvement predictions for replacement of runners at projects with features similar to those of the McNary project.

Benefits:

Model test data for Bonneville I turbine runner replacement with the minimum gap feature shows an additional 1 to 1.25% efficiency improvement. This improvement is an overall improvement from the 1930's design to the "base case" 1995 design is about 6% and for the "minimum gap" 1996 design about 7.25% of improvement. The Corps' Water Management is currently running calculations to determine the actual anticipated benefits from installing the true minimum gap turbine runner in Bonneville I over a new runner without the minimum gap feature. McNary has a similar intake system as The Dalles, and Ice Harbor. Information obtained the McNary Turbine Model can be applied to these projects.

Brief Description of Activity:

Perform model testing of the "minimum gap" turbine runner replacement design in the existing high head test stand.

Deliverables:

Provide a report that will document the work performed and summarized conclusions of testing. The report shall suggest an optimum design based on test results.

Schedule:

October 31, 1996 is the completion date for this activity.

Project Funding and Source of Funding (not more than five years out):

#1

Directly funded by Bonneville Power Administration authorized Section 2406 of National Energy Policy Act of 1992 funds to the US Army Corps of Engineers. Total cost of the project is estimated at \$100,000.

#2

Current Hydropower Research and Development

Date: Jun 7, 1996
Organization: Bonneville Power Administration
Principal Contact: Fong Grey
Address: Federal Hydro Project-MGC Federal Hydro Project-MGC
911 NE 11th Ave. P.O. Box 3621
Portland, Oregon 97232 Portland, Oregon 97208-3621

Phone Number: (503) 230-4492
Fax Number: (503) 230-3752
Internet address: fgrey@bpa.gov

Project/Program Title: 3-D Cam Update

Purpose and Objective:

The US Army Corps of Engineers' eight hydroelectric projects on the Lower Columbia and Snake Rivers are equipped, or are being equipped, with electronic 3-D cams. Units at these projects operated with and without fish screens installed. Index tests performed on these units indicate that with fish screens in place there is a reduction in power capability, the optimum turbine angles are different, and there is an apparent relative efficiency. Physical calibration data and test results obtained through index test of representative units at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and John Day projects could be accomplished for more efficient operation with and without fish screens installed. The cams of 14 units at McNary project will be updated to increase efficiency by installing new stilling wells for net head sensing and conversion of the electronic 3-D cams to take two sets of data to obtain optimum gate and blade angle relationships. Index testing of units at Bonneville I and II will be accomplished to enable recalibration and reprogramming of 3-D cams.

Benefits:

Based on information on index testing of units at Bonneville II and The Dalles, we have applied the 1.3% efficiency improvement as appropriate to each Kaplan machine in the data base. The estimated amount of additional energy available under critical water is 58.6 aMW (Federal System equals 35.4 aMW and Non-Federal System equals 23.2 aMW).

Brief Description of Activity:

Cams at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and John Day projects will be recalibrated for efficiency gain. Calibration involves optimum turbine blade angle to wicket gate position for operation at a specific head with and without fish screens installed. The cams of 14 units at McNary project will be updated to increase efficiency by installing new stilling wells for net head sensing and conversion of the electronic 3-D cams to take two sets of data to obtain optimum gate and blade angle

#2

relationships. Index testing of units at Bonneville I and II will be accomplished to enable recalibration and reprogramming of 3-D cams.

Deliverables:

Cam data verification; calibration and programming at 37 units; calibration, programming and index testing at Bonneville I & II with and without fish screens.

Schedule:

September 1996 is the completion date for this activity.

Project Funding and Source of Funding (not more than five years out):

Directly funded by Bonneville Power Administration authorized Section 2406 of National Energy Policy Act of 1992 funds to the US Army Corps of Engineers. Total cost of the project is estimated at \$804,000

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: February 12, 1997

Organization:

Principal Contact: Peggy Brookshier

Name

850 Energy Drive, MS 1220, Idaho Falls, ID 83401-1563

Address

(208) 526-1403

Phone No.

(208) 526-5964

Fax No.

Project/Program Title: Advanced Hydropower Turbine System Program

Purpose and Objective: The purpose of this program is to cost share with industry in high priority, high risk R&D projects to address fish passage and water quality issues. The objective is to design, develop, build and test environmentally friendly hydropower turbine systems. The program will explore innovative solutions, develop new concepts, apply cutting-edge technology and utilize applied engineering to develop new equipment. The goal is to bring hydropower turbine technology into the 21st century.

Brief Description of Activity: The Advanced Hydropower Turbine system Program is planned in three phases, as follows: Phase I - develop conceptual engineering designs; Phase II - develop biological criteria and build and test engineered models and Phase III - build and test full-scale prototypes of the most promising models in actual operating hydropower plants. Each phase of work will be cost shared by industry and DOE. Phase I was initiated by an agreement between DOE and the Hydropower Research Foundation, Inc. This foundation is a non-profit organization representing the participants of the industry who are providing funds for Phase I. The contracts for Phase I were awarded to Alden Research Laboratory, Inc. and Voith Hydro, Inc. A technical team consisting of experts from various entities provides evaluations, guidance and peer review of the progress.

Schedule: The Phase I contracts were initiated October 1995. The conceptual designs are scheduled for completion April 1997.

Several Phase II activities are scheduled to be initiated about April 1997. Phase II is estimated to take about two years.

Phase III is scheduled to run from January 1999 through December 2000.

1

Current Funding and Source of Funding: The Phase I is funded at \$1,000,000 (DOE \$500,000 and industry \$500,000). The DOE funds are part of the hydropower program identified for this activity. The industry funds were provided by the Hydropower Research Foundation, Inc. The industry participants include:

- Chelan County PUD
- Electric Power research Institute
- Georgia Power Company
- Grant County PUD
- Idaho Power Company
- New England Power
- Niagara Mohawk Power Corp.
- Tennessee Valley Authority
- Washington Water Power Company

Projected Funding and Source of Funding: Phase II and III are planned to be cost shared by DOE and industry. Each phase is estimated as follows:

- Phase II - \$46,600,000
- Phase III - \$55,000,000

(Sources of funding are to be determined)

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

Principal Contact(s):

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Tennessee Valley Authority

Technology Advancements

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Phone: 423-632-1903

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E-mail (office): pmarch@tva.gov

E-mail (home): pmarch@sprynet.com

Project/Program Title:

Development of Auto-Venting Turbine Technologies

Background, Purpose, and Objective:

Approximately 70% of TVA hydro projects contain releases with low DO. Of all the methods to increase the level of dissolved oxygen (DO) in reservoir releases, TVA has found that those involving aeration or venting directly through a hydroturbine are usually the most cost-effective. This project addresses issues related to the development of improved aerating and venting turbine technologies.

Brief Description of Activity:

TVA expertise with auto-venting turbine (AVT) technologies is based primarily on the model and prototype experience at Norris Dam. The scope of this project includes tasks to extend this expertise to units with characteristics widely different from those of Norris. This will help in the design and implementation of turbine upgrades for projects in TVA's Hydro Modernization program that are considered good candidates for turbine aeration (e.g., Fontana, Douglas, Cherokee, Hiwassee, Apalachia, Blue Ridge, Nottely, South Holston, Boone, Watauga, and Chatuge).

Tasks include: (1) Design, test, and analyze results for additional proprietary concepts to enhance AVT uptake; (2) Develop comprehensive test procedures and submit to PTC18 as draft test code for AVT units; (3) Develop improved model-to-prototype and prototype-to-prototype scaling

#6

relationships for AVT units based on additional data from ongoing tests; (4) Conduct theoretical investigation of draft tube hydrodynamics to locate the best injection sites, determine optimal spatial and size distributions of bubbles at draft tube entrance, and develop conceptual predictor models of DO uptake and energy loss in AVT draft tubes.

Schedule:

October 1, 1996, through September 30, 1997

Current Funding and Source of Funding:

Current funding of \$150,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program. This work is conducted as a joint development with Voith Hydro, Inc., and additional funding of \$50,000 is provided by Voith.

Projected Funding and Source of Funding:

Future funding is uncertain.

#7

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

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Norris, TN 37828

Phone: 423-632-1903

Fax: 423-632-1840

E-mail (office): pmarch@tva.gov

E-mail (home): pmarch@sprynet.com

Project/Program Title:

Demonstration of Kaplan Turbine Optimization

Background, Purpose, and Objective:

The objective of this project is to improve the overall operating efficiency of a main river Kaplan unit by 1% or more.

Brief Description of Activity:

During FY96, TVA initiated the installation on Kentucky Unit 4 of a digital governor and a hardware/software system for optimizing the operation of Kaplan (adjustable blade) turbines. FY97 activities include completing the installation and comprehensive testing to evaluate the operational benefits of the optimization system.

Schedule:

October 1, 1995, through September 30, 1997

Current Funding and Source of Funding:

Current funding of \$50,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program. This work is conducted as a joint development with Voith Hydro, Inc., and additional support is provided by Voith Hydro.

Projected Funding and Source of Funding:

The project is scheduled for completion in FY97.

#

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

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Warehouse Row, 1100 Market Street
Chattanooga, TN 37402
Phone: 423-751-8447
Fax: 423-751-2463

Project/Program Title:

Stator Vibration Project

Purpose and Objective:

The objective of this project is to accurately measure stator and winding vibration problems in extremely high electro-magnetic fields at a TVA hydro project.

Brief Description of Activity

The project was substantially completed during FY-1996. FY-1997 activity includes preparation of a final report.

Schedule:

October 1, 1995 through September 30, 1997.

Current Funding and Source of Funding:

Current FY-1997 funding of 15,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

Project is scheduled for completion during FY-1997.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

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Fax: 423-751-2463

Project/Program Title:

Support to Machine Condition Monitoring Consortium (MCMC)

Purpose and Objective:

TVA is a member of the MCMC, which is finding a multi-year, strategic R&D project to develop a comprehensive, fully integrated condition monitoring system (including generator, bearings, and turbine).

Brief Description of Activity

The project represents TVA's annual contribution to the MCMC.

Schedule:

1995 through 1998.

Current Funding and Source of Funding:

Current FY-1997 funding of 450,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

TVA is providing \$450,000 per year, for four years to the MCMC.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

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E-Mail (office): pmarch@tva.gov

E-Mail (home): pmarch@sprynet.com

Project/Program Title:

Improved Dissolved Oxygen Sensors

Purpose and Objective:

Approximately 70% of TVA hydro projects contain releases with low DO. Calibration and maintenance of dissolved oxygen sensors represent a significant expense to TVA.

Brief Description of Activity:

This project will use laboratory and field investigations to evaluate a proprietary technology for improving reliability and stability of membrane-type dissolved oxygen sensors.

Schedule:

October 1, 1996, through September 30, 1997.

Current Funding and Source of Funding:

Current FY-1997 funding of 30,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

Future funding will be determined by results from FY-1997 investigations.

#11

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

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Fax: 423-632-1840

E-mail (office): pmarch@tva.gov

E-mail (home): pmarch@sprynet.com

Project/Program Title:

Cavitation Characteristics Mapping

Purpose and Objective:

The objective for this project is to reduce the operations and maintenance costs associated with hydroturbine cavitation.

Brief Description of Activity:

Acoustic emissions-based cavitation monitoring techniques are used to make prototype acoustic cavitation comparisons under a variety of heads and test conditions at the Raccoon Mountain Pumped-Storage Plant. Results are compared to measurements and observations during the original model testing. Operational guidelines for generating mode and pumping mode will be developed.

Schedule:

October 1, 1996, through September 30, 1997

Current Funding and Source of Funding:

Current FY97 funding of \$20,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

Project is scheduled for completion in FY97.

#12

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

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Phone: 423-632-1903

Fax: 423-632-1840

E-mail (office): pmarch@tva.gov

E-mail (home): pmarch@sprynet.com

Project/Program Title:

Joint Development of Hydro Condition Monitoring System

Purpose and Objective:

A primary objective of this project is to improve the overall operating efficiencies of main river Kaplan units by 1% or more and the overall operating efficiencies of Francis, propeller, and diagonal flow units by 2% or more. An additional objective is the optimization of hydraulic, mechanical, and environmental performance for individual hydroturbines, for individual hydro plants, and for hydro and water resource systems.

Brief Description of Activity:

This activity is a joint development by TVA and Voith to enhance TVA's and Voith's existing hydroturbine condition monitoring (HCM) systems and modules; to develop, improve, and demonstrate new HCM systems; to configure, install, and support HCM systems; and to evaluate, assess, and quantify users' performance benefits resulting from application of these systems. The primary emphasis for FY97 is on providing quantitative feedback for cavitation performance and mechanical condition.

Schedule:

January 1, 1996, through September 30, 1997

Current Funding and Source of Funding:

Current funding of \$100,000, provided by TVA's Resource Group, is derived from the TVA power program. This work is conducted as a joint development effort with Voith, and additional funding of \$100,000 is provided by Voith.

Projected Funding and Source of Funding:

Future R&D funding will be generated from revenues associated with the TVA/Voith joint commercialization of the monitoring system.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

Principal Contact(s):

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Tennessee Valley Authority
Technology Advancements
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E-Mail (office): pmarch@tva.gov
E-Mail (home): pmarch@sprynet.com

Project/Program Title:

Zebra Mussel control for TVA's Hydro Facilities

Purpose and Objective:

The objective for this project is to reduce the additional operations and maintenance costs associated with the impact of zebra mussels on TVA's hydroelectric generating facilities.

Brief Description of Activity:

This project evaluates water piping systems (generator cooling systems, for example) at hydro plants and population dynamics to determine the potential impact from mussel infestations and identify possible approaches for controlling zebra mussel infestations.

Schedule:

October 1, 1996, through September 30, 1997.

Current Funding and Source of Funding:

Current FY-1997 funding of 100,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

Future funding will be determined by results from FY-1997 investigations.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Organization:

Tennessee Valley Authority

Principal Contact(s):

Tim Galbreth,
Tennessee Valley Authority
Technology Advancements
Warehouse Row, 1100 Market Street
Chattanooga, TN 37402
Phone: 423-751-8447
Fax: 423-751-2463

Project/Program Title:

Fish Habitat Model Development

Purpose and Objective:

The objective of this project is to develop a more accurately computer model for prediction of flows downstream of hydro plants.

Brief Description of Activity:

As a result of upgrades to TVA's hydro plants, downstream river flows will increase. The current computer model is most accurate for low river flows and is believed to over predict velocities near the river bottom, which in turn over predicts adverse impacts on river bottom fish.

Schedule:

October 1, 1995 through September 30, 1997.

Current Funding and Source of Funding:

Current FY-1997 funding of 15,000, provided by TVA's Technology Advancements organization, is derived from the TVA power program.

Projected Funding and Source of Funding:

Project is scheduled for completion in FY-1997.

#14

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: 20 September 1996

Organization: U.S. Army Corps of Engineers
North Pacific Division

Principle Contact: Rudd Turner

Address: CENPD-ET-PR
P.O. Box 2870
Portland, OR 97208

Phone: (503) 326-6586
Fax: (503) 326-7328

Project/Program Title: Basecase Survival/Injury Studies

Purpose and Objective: The purpose of this testing is to determine the differential direct and indirect mortality rates (and injury) due to turbine passage under current conditions and operations. The methodologies are expected to include Hi-Z tags as well as PIT tags.

Benefits: This study will provide a better understanding of fish survival/injury resulting from passage through turbines. Baseline data will be used for development and evaluation of prototype turbine improvements.

Brief Description of Activity: The available information regarding fish survival and injury due to turbine passage is varied in the literature and may not be completely applicable to turbine operation in the Columbia and Snake Rivers. A more complete understanding of fish passage through turbines is required for efficient operation of the projects for fish passage and for rehab studies. The basecase testing will include testing of an existing turbine unit to help define design criteria for prototype turbine environments as well as some baseline data for evaluation of the prototype. During prototype testing this will include comparisons of the existing unit operations and other operating points of the turbines. The study will be coordinated with the DOE Advanced Hydro-Turbine work group as well as regional resource agencies to ensure study design and methods that will adequately evaluate fish condition and survival.

Deliverables: Data on differential direct and indirect mortality rates and injury.

Schedule: Current scheduled start is FY 1997 with completion in FY 1999. This schedule will likely slip at least a year because the dedicated test unit will not be instrumented and calibrated until the last quarter of FY 1997 if all goes well.

Projected Funding and Source of Funding: Total cost of this study is estimated to be \$2,000,000. Funding will be provided through the construction general appropriations for the Columbia River Juvenile Fish Mitigation Program.

#15

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: 20 September 1996

Organization: U.S. Army Corps of Engineers
North Pacific Division

Principle Contact: Rudd Turner

Address: CENPD-ET-PR
P.O. Box 2870
Portland, OR 97208

Phone: (503) 326-6586

Fax: (503) 326-7328

Project/Program Title: Develop Methodology/Equipment for Use in Fish Distribution Studies Within the Turbine Environment

Purpose and Objective: The purpose of this testing is to develop a methodology (and associated equipment) for use within a turbine to determine fish distribution during passage. The methodology will be prototype tested to determine fish distribution within a turbine under a range of operations and fish trajectories will be compared to physical modeling results to evaluate the reliability of these models to evaluate runner designs.

Benefits: This study will provide a better understanding of fish distribution during passage through turbines. Baseline data will be used for development and evaluation of prototype turbine improvements.

Brief Description of Activity: There is a need for information regarding fish distribution within the turbine environment during passage. There is no existing methodology to allow this study, however, there are some technologies that may be applicable such as sound and visual equipment, light emitting tags, and infra-red video. This study will apply these technologies (or develop new technologies) to assist in determining fish distribution within the turbine.

Deliverables: Development of methodology (and associated equipment), data on fish distribution within a turbine under a range of operations, and comparison of fish trajectories to physical modeling.

Schedule: Current scheduled start is FY 1997 with completion in FY 1998.

Projected Funding and Source of Funding: Total cost of this study is estimated to be \$600,000. Funding will be provided through the construction general appropriations for the Columbia River Juvenile Fish Mitigation Program.

#16

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: 20 September 1996

Organization: U.S. Army Corps of Engineers
North Pacific Division

Principle Contact: Rudd Turner

Address: CENPD-ET-PR

P.O. Box 2870

Portland, OR 97208

Phone: (503) 326-6586

Fax: (503) 326-7328

Project/Program Title: Study Effects of Pressure Changes Within the Turbine Environment on Juvenile Salmonids

Purpose and Objective: The purpose of this testing is to determine the pressures and pressure changes at specific locations within the turbine under various operations and cycles, evaluate fish of various sizes and species under similar conditions, and relate this information to the fish trajectories determined in the distribution studies.

Benefits: This study will provide a better understanding of pressure effects on fish relative to distribution for evaluation of potential changes to operations and/or runner design.

Brief Description of Activity: This study will include mapping pressures at various locations, and under various operations, within the turbine in concert with basecase testing of survival/injury. Pressure taps will be installed at selected points within the turbine at sites to be determined in coordination with biological pressure studies, hydraulic model studies, and others. The pressure measurements will aid in verifying pressure cycles that fish are subjected to.

Deliverables: Data on pressures and pressure changes at specific locations within a turbine under various operations and on effects of pressure cycling on various sizes and species of fish.

Schedule: Current schedule is FY 1997, however, may be affected by probable delay in the basecase study.

Projected Funding and Source of Funding: Total cost of this study is estimated to be \$600,000. Funding will be provided through the construction general appropriations for the Columbia River Juvenile Fish Mitigation Program.

#1

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT**Date:** 20 September 1996**Organization:** U.S. Army Corps of Engineers
North Pacific Division**Principle Contact:** Rod Wittinger**Address:** CENPD-ET-HD
P.O. Box 2870
Portland, OR 97208**Phone:** (503) 326-3840**Fax:** (503) 326-3791**Project/Program Title:** Baseline Engineering Testing

Purpose and Objective: Initial index testing will be performed to assure turbine operating conditions are consistent with design and operating parameters. Long-term installation of instrumentation and data acquisition equipment will monitor turbine operation to maintain definable conditions during biological and turbine modification field testing.

Benefits: Assure turbine operations within design and current operating parameters to allow associated biological and turbine field studies to be conducted under definable conditions.

Brief Description of Activity: Index measurement equipment will consist of a set of transducers, data acquisition and recording equipment and computer monitoring, reporting and data reduction equipment. The turbine intake will be instrumented with sonic measurement equipment suitable for determination of the quantity of flow and estimation of water velocity profiles. In coordination with the biological studies, imaging equipment will be evaluated and a methodology (and associated equipment) will be developed to assist in biological field passage route/distribution studies. Pressure taps will be installed at selected points within a prototype turbine to provide measurements to indicate absolute pressures and aid in verifying pressure cycles that fish are exposed to.

Deliverables: Information to assure consistent operating conditions and on cam operation during field testing, including index measurements, flow and velocity profiles, turbine imaging, and pressure distributions and cycles.

Schedule: Current schedule is FY 1997 through FY 2000. Schedule may slip to FY 1998 depending on when a dedicated test unit can be instrumented and calibrated.

Projected Funding and Source of Funding: Total cost of this study is estimated to be \$2,000,000. Funding will be provided through the construction general appropriations for the Columbia River Juvenile Fish Mitigation Program.

#19

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: 8 November 1996

Organization: USAE Waterways Experiment Station

Principal Contact: John M. Nestler CEWESES-Q
Name

3909 Halls Ferry Rd, Vicksburg, MS 39180
Address

(601) 634-3870
Phone No. Fax No.

nestlerj@ex1.wes.army.mil
E-mail

Project/Program Title: Richard B. Russell Dam Fish Entrainment Study

Purpose and Objective: Provide best information to Savannah District for wise decision-making regarding pumped-storage operation.

Benefits: 1) Quantified entrainment patterns of fishes over time through pumpunits
2) Developed fish protection system that integrates structural, behavioral, and operational components

Brief Description of Activity: Used conventional fish collection gear to collect baseline data to identify fish species likely to be impacted by pumping operation. Developed fish protection systems using high frequency repelling sounds, attracting lights, physical barriers, a reconfigured channel alignment to eliminate attracting hydraulic conditions at the dam, and operational guidelines. Documented patterns of entrainment over a multi-phase testing period to test both our predictions of impact and the performance of the fish protection system.

Deliverables: Completion reports documenting each phase and plans for the protection system.

Schedule: Completion report for the last phase due on 31 January 97. The protection system is completed.

Current Funding and Sources of Funding: FY96 funding is about 550K from Savannah District of the CE.

Projected Funding and Sources of Funding (not more than five years out): 150K/FY98, 150K/FY99 from Savannah District.

#20 - 33

U.S. Bureau of Reclamation - Information sheets not submitted. Summary information prepared from Project Proposal information. See Table ~~ES~~1 for descriptions.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

#32

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: Enbankment Dam Overtopping Protection Systems

Purpose and Objective: To determine design criteria for protection systems evaluated by earlier research investigation

Benefits: \$2 million -relatively inexpensive method compared to alternative

Brief Description of Activity: Tests for destruction of wedgeblock and rip-rap systems in test flume

Deliverables: Report with data

Schedule: Probably December 1996*

Current Funding and Source of Fundings: No current funding, completion of project.

Projected Funding and Source of Funding (not more than five years out): None

* EPRI cofunded this project with the Bureau of Reclamation, Denver who conducted the analysis in cooperation with Colorado State.

33

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: Dam Foundation Erosion

Purpose and Objective: To develop a code that predicts foundation erosion due to overtopping or spill, in time and space.

Benefits: Difficult to assess at this time, site specific

Brief Description of Activity: Series of tests of laboratory and prototype models for a range of foundation materials.

Deliverables: Software and Manual

Schedule: Probably 1997 or 1998. Depends on level of project funding

Current Funding and Source of Fundings: No current EPRI base funding.
Bureau of Reclamation and Colorado State funding

Projected Funding and Source of
Funding (not more than five years out): Not defined

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: November 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Mufeed Odeh
Name
One Migratory Way, Turners Falls, MA 01376
Address
413-863-8994 x43 413-863-9810
Phone No. Fax No.

Project/Program Title: Hydraulics of Various Types of Fishways

Purpose and Objective: Development of the much needed hydraulic rating curves for Denil and Steeppass type fishways. Biological evaluation of these fishways using actively migrating anadromous fishes. The objective was to assist fishway designers in understanding the various types of fishways available to them for passing fish upstream around hydropower dams and other river obstructions.

Brief Description of Activity: Simple Denil and Model A deepened Alaska Steeppass fishways were hydraulically rated. Hydraulic head versus flow rating curves for both fishways were established at several slope settings, and mathematical equations were derived. During three upstream migration seasons of American shad (*Alosa sapidissima*) both fishways were biologically evaluated. Fish were introduced at the bottom and allowed to volitionally ascend each fishway.

Schedule:	Hydraulic evaluation	April 1992
	Biological Evaluation	May 1993-May 1996

Current Funding and Source of Funding:	92-93 USDA-Region 10	\$15,500
	94-96 USFWS&NBS	\$175,000
Projected Funding and Source of Funding:	1997 USGS-CAFRC	\$70,000

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: November 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Alex Haro & Mufeed Odeh

Name

One Migratory Way, Turners Falls, MA 01376

Address

413-863-8994 x43

Phone No.

413-863-9810

Fax No.

Project/Program Title: Evaluation of Burst Swimming Performance of Upstream Migrant Fishes

Purpose and Objective: Knowledge of locomotory and energetic capabilities of upstream migrant fishes is essential for determining their ability to negotiate and ascend riverine obstructions and passage structures, where water velocities can be high. Although some estimates are available for sustained, critical, and burst (>10 body lengths/sec) swimming speeds for a variety of riverine and anadromous species, many of the data are incomplete, underestimated, or valid only for individuals of a particular size. The main objective of this study is to determine reliable estimates of volitional swimming performance (primarily in burst mode) for a variety of riverine and anadromous fishes.

Brief Description of Activity: A literature search has been conducted to compile data regarding known burst swimming performance of riverine and anadromous fish species. Target species to be tested have been identified. A model (1:5 scale) flume has been constructed and hydraulically tested to determine operation parameters and ranges of water velocities that can be generated. A full-scale prototype flume is being designed; tests with live fish will begin in the spring of 1997.

Schedule:	Hydraulic evaluation	1995 - 1996
	Biological Evaluation	1997 - 1999

Current Funding and Source of Funding:	1995-6 NBS	\$50,000
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Projected Funding and Source of Funding:	1997-1999 USGS-CAFRC	\$150,000
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HYDROPOWER RESEARCH AND DEVELOPMENT

Date: November 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Mufeed Odeh & Alex Haro
Name

One Migratory Way, Turners Falls, MA 01376
Address

413-863-8994 x43 413-863-9810
Phone No. Fax No.

Project/Program Title: Evaluation of a Uniform Acceleration Weir for Downstream Bypass Entrances

Purpose and Objective: A ^{test} ~~state-of-the-art~~ fish bypass weir was developed to provide uniform water acceleration as opposed to the rapid acceleration that occurs as water passes over a sluice gate (sharp crested weir). The weir was evaluated for percent of fish passed over time and fish orientation and behavior.

Brief Description of Activity: Distributions of cumulative passage between the uniform acceleration (NU-Alden) and sharp-crested weirs were significantly different for both Atlantic salmon smolts (Salmo salar) and juvenile American shad (Alosa sapidissima). Within the first 30 min after release, significantly more smolts passed the NU-Alden weir than the sharp-crested weir, but no differences in passage rate were noted for juvenile shad. More smolts and juvenile shad were passed by the NU-Alden weir in groups of two or more than were passed by the sharp-crested weir. Most individuals of both species that passed the NU-Alden weir maintained positive rheotaxis and strong swimming throughout the length of the weir. Although both species exhibited avoidance behaviors within both weir types, the NU-Alden weir offers significant improvements in passage performance over the sharp-crested weir in terms of reduction of delay time before passage and maintenance of school integrity

Schedule:	Hydraulic evaluation	Fall 1993
	Biological Evaluation	1993 - 1996

Current Funding and Source of Funding:	1993-95 Northeast Utilities	\$15,000
	93-96 USFWS&NBS	\$125,000
Projected Funding and Source of Funding:	1997 USGS-CAFRC	\$50,000

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: January 3, 1997

Organization: Northeast Utilities (NU) Alden Research Laboratory, Inc. (ARL)

Principal Contact: **Name:** George E. Hecker, President
 Address: Alden Research Laboratory, Inc.
 30 Shrewsbury Street
 Holden, MA 01520
 Phone: 508-829-6000 **FAX:** 508-829-5939
 E-mail: geh@aldenlab.com

Project/Program Title: Development of the NUAlden Weir

Purpose/Objective: To develop a fish bypass weir that eliminates adverse hydraulic conditions that causes fish avoidance with existing, sharp-crested weirs.

Benefits: Many fish bypasses are being installed at hydroelectric projects that fish will not readily enter, resulting in migration delays and increased predation. The NUAlden weir is a reasonably simple device that creates hydraulic conditions which reduce avoidance. Such weirs have many applications at existing and future downstream fish bypasses.

Brief Description of Activity: Development activities are mostly completed. The weir has been tested with fish at the Conte Anadromous Fish Research Laboratory and NU's Hadley Fall Hydroelectric Project. Future activities would involve construction, installation and testing of the NUAlden Weir at one or more sites, including a hydroelectric project which must move salmonid species safely downstream and a site where an existing sharp-crested weir is not providing adequate passage for riverine species.

Deliverables: A proven weir design that quickly and effectively bypasses fish around hydraulic turbines.

Schedule: Two to three years project duration.

Current Funding and Sources of Funding (not more than five years out): No current funding.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Booke

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Behavior of American shad and blueback herring related to fish passage.

Purpose and Objective: Understanding the behavior of fish in the river and in fishways will lead to improved design and operation of fish passage facilities.

Benefits: Information to improve designs of fishways and improve passage results for American shad and Blueback herring. Conclusions about downstream migrant adult shad response to louver barriers, impact of illumination intensity on louver response, and shad exit weir opening and water velocity preferences.

Brief Description of Activity: Determine distributions of juvenile and adult shad and blueback herring in a water column near weirs. Determine flow and light intensity permitting clupeid passage.

Deliverables: 7 papers/presentations completed. 2 additional papers submitted to refereed journal and 2 in preparation.

Schedule: May 1991 - June 1997

Current Funding and Sources of Funding: 1996 Funding - \$45,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - \$181,000.

#38

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Investigation of migratory behaviors and passage technologies for Anguillid eels.

Purpose and Objective: To characterize up- and downstream migratory behavior of the American eel to mitigate passage problems.

Benefits: Biological data to support design criteria for eel passage structures to enhance the coastal freshwater and inland American eel population.

Brief Description of Activity: Investigate American eel migratory behavior and evaluate upstream and downstream passage structures. Study natural behaviors of migrants, response to attraction flows and turbine intakes, run characteristics, and migration timing.

Deliverables:

Schedule: June 1996 - September 2001

Current Funding and Sources of Funding: 1996 Funding - \$6,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: American shad energetics in the Connecticut River

Purpose and Objective: To characterize the changes in energy utilization as migrating shad ascend the river and to investigate energetic challenges presented to fish by fishways.

Benefits: Information to help determine the maximum attainable distance American shad can migrate up the Connecticut River and determine whether adult fish passage success is related to energetic/physiological parameters or strictly to behavioral preferences.

Brief Description of Activity: Develop techniques to monitor fish respiration and generate oxygen consumption-swimming speed relationships. Develop a sonic electromyographic tag to monitor shad swimming in the field. Biochemical sampling of migrating fish and in the ocean. Profile the energetic status of adult shad sampled from different sites on the Connecticut river, ranging from the estuary (mile 1) to the maximum migratory distance upriver (mile 180). Examine the energetic costs associated with ascending the Cabot Station fish passage facility at Turners Falls, MA.

Deliverables: ⁵ presentations/published abstracts completed.

Schedule: April 1993 - June 1997

Current Funding and Sources of Funding: 1996 Funding - \$62,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

#40

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Booke

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Biological studies of shortnose and other sturgeons

Purpose and Objective: To provide life history information on sturgeon for endangered species recovery.

Benefits: Information on sturgeon to determine critical feeding and spawning habitats for endangered species recovery.

Brief Description of Activity: Radio telemetry studies to track shortnose sturgeon migratory activity and determine fecundity, feeding range, and spawning habitat. Additional studies of Atlantic sturgeon and Chinese sturgeon. Evaluation of sturgeon movement and behavior in response to water velocity, discharge, Cabot Station generation cycle, and illumination, cover, and substrate type. Began construction of facilities for R&D on sturgeon passage.

Deliverables: 9 papers/presentations completed.

Schedule: April 1993 - September 1997

Current Funding and Sources of Funding: 1996 Funding - \$159,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Physiological and endocrine changes during hatchery rearing and release of Atlantic salmon

Purpose and Objective: To define and determine the physiological and endocrine changes that occur during the Atlantic salmon parr-smolt transformation.

Benefits: Knowledge of the timing of physiological, biochemical, and endocrine changes during the parr-smolt transformation can provide two important advances: 1) 'markers' of developmental change to determine whether changes in timing and extent of development are related to migratory rates, downstream passage, and return rates; and 2) track the development of the parr-smolt transformation to optimize the time of release.

Brief Description of Activity: Develop diagnostic techniques to identify parr-smolt transformation of Atlantic salmon; sample both hatchery and wild fish; laboratory experiments to determine the effect of increased temperature on smolt development; monitor normal smolt development; and evaluate the potential impact of dams and bypass structures with field and laboratory studies.

Deliverables: 14 papers/presentations completed.

Schedule: December 1990 - September 1998

Current Funding and Sources of Funding: 1996 Funding - \$95,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Physiology of juvenile Atlantic salmon, American shad and blueback herring relating to hatchery rearing, release, and downstream passage.

Purpose and Objective: To examine and compare physiological and endocrine differences in laboratory, hatchery, and wild Atlantic salmon, and determine if similar conditions exist in clupeid fishes.

Benefits: Knowledge of the timing of physiological, biochemical, and endocrine changes during the parr-smolt transformation for wild Atlantic salmon, juvenile clupeids, and hatchery Atlantic salmon after release. This information can provide two important advances: 1) 'markers' of developmental change to determine whether changes in timing and extent of development are related to migratory rates, downstream passage, and return rates; and 2) track the development of the parr-smolt transformation to optimize the time of release.

Brief Description of Activity: Physiological studies of juvenile American shad; hatch and rear American shad in laboratory; laboratory experiments on salinity tolerance, handling stress, and temperature.

Deliverables: 4 presentations/published abstracts completed.

Schedule: June 1992 - September 1996

Current Funding and Sources of Funding: 1996 Funding - \$45,000

Projected Funding and Sources of Funding (not more than five years out): Project complete in 1996.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Factors influencing smolt production, overwinter mortality, and downstream migration of Atlantic salmon in the West River System, Vermont

Purpose and Objective: To determine smolt production, overwinter mortality of age-1+ parr and migration timing of smolts.

Benefits: Information that could lead to increased efficiency of USFWS husbandry program for Atlantic salmon.

Brief Description of Activity: Determine factors that affect production of Atlantic salmon smolt in-stream and the numbers that exit to the sea. Evaluate survival of hatchery fry released at different developmental stages.

Deliverables:

Schedule: January 1994 - April 1999

Current Funding and Sources of Funding: 1996 Funding - \$143,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete -\$295,000.

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Impact of stream habitat improvement on smolting, maturation, and survival of Atlantic salmon.

Purpose and Objective: To determine growth rate for Atlantic salmon fry and the role of energy acquisition on growth and migration timing as it affects smolting.

Benefits: Biological data to support stream habitat improvements.

Brief Description of Activity: Investigate decline in smolt characteristics as water temperatures increase in the stream and survival rates for early and late migrants.

Deliverables:

Schedule: November 1995 - October 1997

Current Funding and Sources of Funding: 1996 Funding - \$30,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

#45

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone

Name

One Migratory Way, Turner's Falls, MA 01376

Address

413-863-8991

Phone No.

413-863-9810

Fax No.

Project/Program Title: Growth and mortality of young-of-year alosines: energetics, starvation, and predation.

Purpose and Objective: To develop population models for young of year American shad and Blueback herring suitable to track growth and survival of individuals in the population under various environmental conditions.

Benefits: A tool for managers to predict population size and begin to understand resource partitioning between American shad and Blueback herring.

Brief Description of Activity: Conduct laboratory studies to provide details of bioenergetics, and the two main sources of mortality, starvation and predation, over a range of fish sizes and temperatures. These studies will provide necessary data to construct individual-based models for young-of-year American shad and Blueback herring.

Deliverables:

Schedule: August 1996 - December 1999

Current Funding and Sources of Funding: 1996 Funding - \$82,000

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

#46

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 6, 1996

Organization: USGS - Conte Anadromous Fish Research Center

Principal Contact: Henry Boone
Name

One Migratory Way, Turner's Falls, MA 01376
Address

413-863-8991
Phone No.

413-863-9810
Fax No.

Project/Program Title: Hydraulic model study of Little Falls Dam (MD) fish passage

Purpose and Objective: To determine if notch modification to the Little Falls Dam will provide attraction flows to upstream migrating fish.

Benefits: An adequate fish passage design at Little Falls would open up 8 miles of habitat for migratory fish.

Brief Description of Activity: Construct and assess a hydraulic model of the Little Falls Dam at the Conte Hydraulic Laboratory. Determine notch width, height, and configuration of labyrinth weirs for passage of clupeids.

Deliverables: Final report and 1 presentation completed.

Schedule: March 1994 - March 1998

Current Funding and Sources of Funding: 1996 Funding - \$75,100

Projected Funding and Sources of Funding (not more than five years out): Funding to complete - not provided.

#47

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: September, 1996

Organization: Chelan County Public Utility District

Principal Contact: Bill Christman
P.O. Box 1231
Wenatchee, WA 98807-1231
(509) 663-8121, Fax (509) 664-2881

Project/Program Title: Rocky Reach Hydroelectric Project, Fish Passage Survival through Turbines

Purpose and Objective: The purpose of this program is to develop cost effective turbine designs which improve turbine passage survival of downstream migrating juvenile salmon and steelhead trout as a part of the overall Rocky Reach Turbine Rehabilitation Project.

Brief Description of Activity: The program has proceeded in several phases as follows: The first phase included prototype test estimations of the fish passage survival through the existing Rocky Reach turbines, the predominant mortality/injury types, and recognition of the predominant causal factors suspected to lead to fish passage mortality/injury. The results of the first phase included recognition of gaps within the turbine machinery as the likely predominant mortality/injury causal factor. The second phase included: Conceptual design of several alternatives intended to eliminate the predominant causal factor without significantly degrading turbine efficiency or increasing cavitation potential; model testing of the alternatives; and selecting the leading alternative for prototype testing. The third phase included prototype testing of the leading alternative, using live, balloon-tagged fish, and comparing the survival/injury rates to the test results derived from the existing turbine(s). The fourth phase included: Identifying potential additional improvements; prototype testing of the leading alternatives (again using live fish) to estimate potential for further improving fish passage survival; and, model testing of the final design alternative to assess its effect upon overall turbine generating efficiency and cavitation potential (no impact). The resulting estimated fish passage survival is relatively high and cost effective. The activities do not include specific determinations of why the improvements increase fish passage survival or to what extent the improvements are applicable to other hydropower turbine environments.

Schedule: The program was initiated in 1993 and is nearing completion.

Current Funding and Source of Funding: The program, including the selected installed enhancements cost about \$2.4M. The program cost was significantly reduced from what a more global, strickly research and development program may cost since it was pursued in conjunction with a turbine rehabilitation project costing upwards of \$67M. The program was funded by Chelan County Public Utility District.

Projected Funding and Source of Funding: No further research and design is contemplated at this time.

#48

Attachment 1

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: 12/1996

Organization: CHELAN COUNTY PUBLIC UTILITY DISTRICT

Principal Contact: BILL CHRISTMAN

Name

P.O. BOX 1231 WENATCHEE, WA 988

Address

509-663-8121

Phone No.

664-2881

Fax No.

Project/Program Title: ROCKY REACH FISH BYPASS

Purpose and Objective: TO PROVIDE AN ATTRACTIVE, SAFE PASSAGE ROUTE AROUND THE DAM FOR DOWNSTREAM MIGRATING SALMON AND STEELHEAD TROUT...

Brief Description of Activity:

TO DATE, PROTOTYPE TESTING OF A SURFACE COLLECTION ALTERNATIVE HAS BEEN VERY ENCOURAGING.

Schedule:

PRESENTLY, THE SCHEDULE IS FOR COMPLETION BY 2001

Current Funding and Source of Funding:

CURRENT FUNDING IS ABOUT \$60M PER YEAR FOR DEVELOPMENT OF AN ESTIMATED CONSTRUCTION COST OF \$30M

Projected Funding and Source of Funding:

FOR FINAL PREFERRED ALTERNATIVE FUNDING IS 100% CHELAN COUNTY PUD AND ITS POWER PURCHASERS.

49

Attachment 1

HYDROPOWER RESEARCH AND DEVELOPMENT

Date:

Organization:

Principal Contact:

Name

Address

Phone No.

Fax No.

Project/Program Title: ROCK ISLAND FISH BYPASS

Purpose and Objective: SAME AS RR

Brief Description of Activity: CURRENTLY, SURFACE-ORIENTED SLUICING THROUGH MODIFIED SPILGATES IS THE PREFERRED ALTERNATIVE

Schedule: CURRENT SCHEDULE IS TO ACHIEVE 95% OVERALL PASSAGE SURVIVAL AT THE DAM BY 2001.

Current Funding and Source of Funding:

CURRENT PROTOTYPE DEVELOPMENT COSTS ARE ABOUT \$2M PER YEAR W/ AN ESTIMATED CONSTRUCTION COST OF

~~Projected Funding and Source of Funding:~~ ABOUT \$25M FOR FINAL PREFERRED ALTERNATIVE. FUNDING IS 100% CHELAN COUNTY PUD AND ITS POWER PURCHASERS.

#50

HYDROPOWER RESEARCH AND DEVELOPMENT**Date:** September 19, 1996**Organization:** Public Utility District of Grant County**Principal Contact:** Stephen R. BrownNameP.O. Box 878, Ephrata, WA, 98832Address(509) 754-5088 ext 3117Phone No.(509) 754-5074Fax No.**Project/Program Title:** Enhanced Fish Passage Hydropower Turbine**Purpose and Objective:** The purpose is to develop a improve fish passage through a hydropower turbine with the objective of enhancing the fish passage at the Hydroelectric facilities..**Brief Description of Activity:** Assess possible impacts to fish survival in a hydropower turbine and perform model tests to mitigate for the impacts. Manufacture and install ten Enhanced Fish Passage Hydropower Turbines at Wanapum Dam.**Schedule:** Assessment of possible impacts to fish survival has been completed with one baseline survival test being completed and one operational condition. Two additional baseline survival tests are to be conducted in 1997. Model testing began June of 1996 and will complete October 1996 with the final configuration tests. Manufacture will begin December 1996 with the first unit installed August 1998 and the tenth unit installed in 2002. Fish survival tests of the new turbine will be conducted in 1998 or 1999 after the first unit is installed.**Current Funding and Source of Funding:** Public Utility District of Grant County.**Projected Funding and Source of Funding:** Each phase is estimated below:

Model Testing	\$ 897,000
First Baseline Survival Test	\$ 1,000,000
Additional Baseline Survival Tests	\$ 2,000,000
Fish Enhancement Modifications	\$ 3,450,000 per unit
Survival Tests	\$ 3,000,000.

#51

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: September 19, 1996

Organization: Public Utility District of Grant County

Principal Contact: Stephen R. Brown

Name

P.O. Box 878, Ephrata, WA, 98832

Address

(509) 754-5088 ext 3117

Phone No.

(509) 754-5074

Fax No.

Project/Program Title: In Operating Hydro Turbine Imaging

Purpose and Objective: To view fish passing through the water passage of a operating hydro turbine. This will allow visual observations of fish injury mechanisms inside the hydro turbine. This information will be used to design or modify existing hydro turbines to improve fish passage.

Brief Description of Activity: First is to determine what technology exists that will be capable of or may be further developed to provide in operating turbine imaging. Then field test the most probable imaging systems for use in full scale test. Finally install the selected system at strategically selected locations in the turbine water passage..

Schedule:	Determine capability of technology	through October 1996
	Field test imaging system(s)	Nov. 1996 - Dec. 1996
	Install system in water passage	Jan 1997- April 1997
	Observe fish in turbine	April 1997 - June 1997

Current Funding and Source of Funding: \$1,000,000 from the Public Utility District of Grant County.

Projected Funding and Source of Funding: Each phase is estimated below:

Determine capability of technology	\$ 10,000
Field test imaging system(s)	\$ 75,000
Install system in water passage	\$ 765,000
Observe fish in turbine	\$ 150,000

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
Fax 866 3164

Project title:

Water Resources R&D for Hydropower

Purpose and Objectives:

Improve water resource management for hydropower; allow environmental benefits to be provided with less cost to hydro generation. Research is focused on watershed restoration and efficient allocation of flows for instream benefits.

Benefits:

Reduce costs of providing instream environmental benefits; reduce impacts of watershed degradation on hydro operations; and improve community relations in hydro watersheds.

Description:

Specific study objectives were identified through a PG&E-specific R&D prioritization process. These are to identify and evaluate methods for reducing the cost of meeting fishery objectives at hydro projects, and to provide PG&E technical expertise to the Feather River Erosion Control Program.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Develop improved tools for evaluating mitigation costs: Dec. 1996.
2. Design a real-time control system for temperature management flows: Dec. 1996.
3. Use the CompMech trout model to investigate optimal flow release patterns for fisheries: Dec. 1997.
4. Investigate the applicability to PG&E of several methods for providing fisheries benefits at lower cost by improving the allocation of flow over time and among sites: Dec. 1997.
5. Participate in the Feather River Erosion Control Program Technical Advisory Committee.

Current Funding:

1996 PG&E budget: \$110k

Projected Funding:

#52

1997 PG&E budget: \$70k

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
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Project title:

Conveyance Systems O&M Cost Reduction

Purpose and Objectives:

Maintain full flow capacity of hydroelectric power production canals by reducing growth of aquatic vegetation in cost effective, environmentally safe manner, and extending life of existing canal and flume structures by evaluating linings and maintenance practices to reduce repair and replacement costs.

Benefits:

Extend the life and improve the service of existing hydroelectric power production canals by avoiding reductions in generation, while reducing O&M costs associated with joint repairs and canal cleaning, control of aquatic vegetation, minimizing water leakage, and improved water quality.

Description:

Identify cost-effective and environmentally acceptable methods for controlling head losses due to algae growth in hydro conveyances; investigate and evaluate linings and maintenance practices for hydroelectric canals and flumes.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Field tests of three chemical, one enzymatic, and one mechanical algae control approaches: Dec. 1996.
2. Industry/utility survey of alternate liners and maintenance methods of existing liners: Dec. 1996.
3. Cost estimate comparison, selection of field demo area, and field test of alternative liner(s): Dec. 1997

Current Funding:

1996 PG&E budget: \$232k

Projected Funding:

1997 PG&E budget: \$130k

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
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Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
Fax 866 3164

Project title:

NDE for Strength Assessment of Riveted Steel Penstocks

Purpose and Objectives:

Develop a way to determine actual mechanical strength of joints in riveted penstocks as loaded in service to use actual strength in penstock evaluations, rather than an overconservative assumed value.

Benefits:

Reduce costs associated with penstock breaks and extended outage time required for repair, as well as provide safer, more reliable conveyance of water to powerhouses fed by riveted steel penstocks.

Description:

Inspection technologies for evaluating erosion, corrosion, and pitting of riveted steel penstocks will be investigated, testing procedures developed, and qualification of test methods to verify accuracy of various methods for acceptability of use in penstock evaluation.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Literature search and industry survey of testing technologies: August 1996.
2. Procedures for non-destructive and mechanical testing of riveted joints: November 1996.
3. Results of NDE testing: June 1997.
4. Final report - results of NDE and mechanical testing w/ review and comparison of methods: Sept. 1997

Current Funding:

1996 PG&E budget: \$138k

Projected Funding:

1997 PG&E budget: \$126k

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
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Research and Development
2303 Camino Ramon, Suite 200
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510 866 5459
Fax 866 3164

Project title:

Erosion Characteristics of Dam Foundations

Purpose and Objectives:

Determine the erodibility of various dam construction materials and use results to develop numerical models that accurately and reliably evaluate erosion resistance of geological materials under impinging jet flow associated with the safe passage of Inflow Design Flood.

Benefits:

Reduce construction and mitigation costs associated with meeting State and Federal Dam Safety Regulations regarding dam overtopping and erosion potential of dam foundations and abutments.

Description:

Tests and experiments will be conducted on a prototype model to simulate erosion characteristics of various materials used in dam construction. Various materials, sizes, shapes and orientations will be used in testing. Tests results will be used to develop numerical models.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Prototype Model - Non-Erodible Jet Characteristics Test - June 1996.
2. Numerical Model - Prototyping Phase 1 - June 1996.
3. Prototype Model - Clear Water Correlation Test, Pit 4 Foundation Simulation Test, Cubical Elements Test: September 1996.
4. Prototype Model - Vertically Oriented Slab Test, Upstream and Downstream Oriented Slab Experiment: July 1997
5. Numerical Model - Prototyping Phase 2 - September 1997.
6. Verification of Model - Test Numerical Model Using Scaled and Prototype Model: December 1998.

Current Funding:

1996 PG&E budget: \$123k

#55

Projected Funding:
1997 PG&E budget: \$0k

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
Fax 866 3164

Project title:

Hydro Turbine Runner/Wicket Design Optimization

Purpose and Objectives:

Demonstration of method of optimizing turbine efficiency and providing cavitation-free performance, confirming theory of potential flow technology.

Benefits:

Lower cost of production would result by increasing the unit efficiency, as well as reduce or eliminate repairs to the runner, associated with cavitation damage.

Description:

Tests will be conducted on runner and wicket gates models using site specific conditions found at Butt Valley Powerhouse. The models represent a potential flow turbine that optimizes efficiency and provides cavitation-free performance based on a computer model utilizing the method of singularities.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Complete fabrication of turbine wicket gate, stay ring and draft tube cone models: March 1996.
2. Complete assembly of model and ready for testing: May 1996.
3. Results of acceptance testing: August 1996.

Current Funding:

1996 PG&E budget: \$118k

Projected Funding:

1997 PG&E budget: \$0k

Current Hydropower Research and Development

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Principal contact:

Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
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Project title:

Hand Held O&M Computers and Plant Maintenance Optimization

Purpose and Objectives:

Apply effective maintenance on hydroelectric power plant components that preserve the high priority functions of the system, through development of Plant Maintenance Optimization (PMO) methods; collect and manipulate data for PMO process by using hand held computers.

Benefits:

Optimization of O&M expenditures by determining optimal level of PMO through development of methods to evaluate and prioritize maintenance practices. Savings in the routing and manipulation of data currently taken manually by operators by eliminating paper forms and manual input of data, as well as providing historical data and trends for operator to use during data collection to facilitate on the spot follow-up and problem diagnosis when off normal values are encountered.

Description:

Refine PMO guidelines, examine cost effectiveness and means of maximizing effect of PMO, and modify/optimize Hydro PMO workstation software.. Develop and test advanced field applications such as wireless communications, field inspection diagnostics, and remote job order entry for use on hand held computers.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Evaluation of potential and means of maximizing effect of PMO: December 1996.
2. Modify/optimize Hydro PMO workstation software: December 1996.
3. Second draft of pilot HYDRO data collection software and first draft of pilot HYDRO desktop interface will be completed: December 1996.

Current Funding:

1996 PG&E budget: \$75k

#57

Projected Funding:
1997 PG&E budget: \$0k

Projected Funding:
1997 PG&E budget: \$0k

Current Hydropower Research and Development

Date:
5/30/96

Organization:
Pacific Gas and Electric Company
Department of Research and Development

Principal contact:
Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
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Project title:
Mid-Term Hydro Thermal Optimization (MTHTO), Short-Term Weather-dependent Inflow Forecasting (SWIFT), and Hydro Dispatch Curve System (HyDisC)

Purpose and Objectives:
Develop state-of-the-art analysis and optimization methodologies and computer tools to coordinate weekly and monthly generation of hydro resources with other generation over one to two year period; improve accuracy of short-term inflow forecasting models for PG&E reservoirs; provide single and consistent set of systemwide processes for updating hydro unit input/output (I/O) and incremental water rate (IWR) curves.

Benefits:
Enable Hydro Generation and Power Market Planning to plan operation of electric generation system to minimize production costs, optimizing scheduling and dispatch of both hydro and thermal resources.

Description:
Form an integrated optimization-based software system, known as Stochastic Optimal Coordination of River-basin and Thermal Electric Systems (SOCRATES), taking into account the uncertainty in future streamflows; extend applicability and improve accuracy of short-term inflow forecasts using SWIFT, and provide an interface to send hourly flow forecasts to the short-term Hydro-Thermal Optimization (HTO) program; evaluate economic benefits and technical feasibility of improving hydro unit dispatch curves.

Deliverables and schedule:
The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Software for use of SOCRATES as a simulation model: October 1996.
2. Report on testing of coordination module: October 1996.
3. Revised computer implementation which will shape daily flow forecasts to diurnal pattern of historical flows: September 1996.
4. Quality daily flow data for three additional sites: December 1996.

5. Economic benefit and technical feasibility analysis of the Hydro Dispatch Curve System: July 1996.

Current Funding:

1996 PG&E budget: \$124k

Projected Funding:

1997 PG&E budget: \$0k

#59

**Current Hydropower Research and Development
Pacific Gas & Electric**

Date:

5/30/96

Organization:

Pacific Gas and Electric Company
Department of Research and Development

Southern California Edison Company
Environmental Research

Principal contacts:

Donna S. Lindquist
Pacific Gas and Electric Company
Research and Development
2303 Camino Ramon, Suite 200
San Ramon, CA 94583
510 866 5459
Fax 866 3164

Geoff Rabone
Southern California Edison
Hydro Generation
2244 Walnut Grove Ave.
Rosemead CA 91770
818 302 8951

Project title:

Aquatic Resource R&D for Hydropower

Purpose and Objectives:

Improve the methods used to assess effects of hydro projects on aquatic resources and to design mitigation measures. The project is focused on effects of instream flow, water temperature, and downstream passage on resident trout. Work is jointly conducted by both utilities under a California Utilities Research Council (CURC) agreement, to eliminate duplicate costs to ratepayers.

Benefits:

Reduce costs of environmental compliance and enhancement; reduce environmental impacts; and improve regulatory relations and compliance.

Description:

Specific study objectives were identified through a California-specific R&D prioritization process. These are: testing and improvement of the IFIM methods currently used to determine instream flows, development of methods for selecting appropriate habitat suitability criteria for IFIM studies, development and demonstration of an advanced model (EPRI's CompMech stream trout model) of how flows and temperature

affect fisheries, and development of a model of temperature effects on growth of California native trout strains.

Deliverables and schedule:

The following are key remaining deliverables; products delivered prior to 1996 are not included.

1. Test and evaluation of IFIM-based instream flow predictions at 11 sites: July 1998.
2. National Biological Service report documenting a workshop on ecological factors causing variation in habitat suitability criteria: Dec. 1997.
3. Field- and model-based study of factors controlling trout recruitment in large California rivers: Dec. 1997.
4. Demonstration of the CompMech trout model at a major hydro project: Dec. 1998.
5. Laboratory study of temperature effects on bioenergetics of 3 native trout strains: Dec. 1996.
6. Demonstration of a temperature assessment model: Dec. 1996.

Current Funding:

1996 PG&E budget: \$605k

1996 SCE budget: \$425k

Total direct funding: \$1030k

Work on the CompMech stream trout model (Deliverable 4) is cooperative with EPRI; EPRI effort on this project is not included here. Likewise, research on habitat suitability criteria (Deliverable 2) is cooperative with the NBS Midcontinent Ecological Sciences Center; their budget is not included here.

Projected Funding:

1997 PG&E budget: \$400k

1997 SCE budget: \$400k

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: January 3, 1997

Organization: Alden Research Laboratory, Inc. / Northern Research and Engineering Corporation

Principal Contact: Name: Mr. George E. Hecker, President
Address: Alden Research Laboratory, Inc.
30 Shrewsbury St.
Holden, MA 01520
Phone No.: (508)829-6000 Fax: (508)829-5939
E-mail: geh@aldenlab.com

Project/Program Title: Development Of A More Fish Tolerant Turbine Runner
Department of Energy - Advanced Hydropower Turbine Project

Purpose/Objective: The objective of the research program is to design a hydraulic turbine runner which will minimize fish injury and mortality at hydroelectric projects.

Benefits: The new runner will offer an alternative turbine design and an alternative protection and diversion method for passing fish at power projects. The runner could be important in river systems with endangered fish species.

Brief Description of Activity: Design of the new runner is being conducted in three phases: 1) Conceptual Design; 2) Pilot Scale Testing; and, 3) Final Design. Conceptual design was based on the use of Computational Fluid Dynamic (CFD) analyses to evaluate flow characteristics through different runner geometries. The flow characteristics were compared to performance criteria, which were developed from available data on causes of injury to fish passing through conventional turbines, and the runner shape was refined to provide the best conditions for fish passage. Results of the CFD analyses indicate that the runner has characteristics which should provide safe fish passage at an overall turbine efficiency of about 90%. The next phase of the program is a pilot scale test to directly observe if fish passing through the runner sustain any injury. After the benefits of the turbine to fish have been proven, additional CFD analyses and model testing will be conducted to refine the runner final design.

Deliverables: A final report on the conceptual design of the new runner will be submitted in January 1997. Reports will be prepared to present the results of the pilot scale test evaluation and the final design of the new runner.

Schedule: Conceptual design of the runner has recently been completed with the final report submittal to the Department of Energy by January 31, 1997. Construction of a pilot scale test facility will be completed during 1997 with testing of the new runner with fish in 1998. Final design of the runner will be completed in 1999.

Current Funding and Sources of Funding (not more than five years out): The Advanced Hydropower Turbine Program Phase I - Develop Conceptual Engineering Designs, has funded \$288,400 through an agreement between the U.S. Department of Energy and the Hydropower Research Foundation, Inc. This foundation is a non-profit organization with participants from Chelan County PUD, Electric Power Research Institute, Georgia Power Company, Grant County PUD, Idaho Power Company, New England Power, Niagara Mohawk Power Corporation, Pacific Gas & Electric, Tennessee Valley Authority, and Washington Water Power Company. In addition, ARL/NREC has cost-shared \$70,000 to prepare the conceptual design. The pilot scale test is estimated to cost about \$500,000 in 1997 and about \$500,000 in 1998.

#61

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: January 3, 1997

Organization: Alden Research Laboratory, Inc. (ARL)/Public Service Electric & Gas Company

Principal Contact: **Name:** Thomas C. Cook
 Address: Alden Research Laboratory, Inc.
 30 Shrewsbury Street
 Holden, MA 01520
 Phone: 508-829-6000 **FAX:** 508-829-5939
 E-mail: arlmail@aldenlab.com

Project/Program Title: Development of an Infrasound Generator for Protecting Fish

Purpose/Objective: Very low frequency (5-50 Hertz), hydrodynamic energy (referred to as infrasound or particle motion) has recently been shown to elicit strong responses in several species of fish that have not responded to higher frequency acoustic stimuli. The purpose of the program is to develop an effective and reliable particle motion generator (PMG) for application as a fish repellent at water intakes.

Benefits: The PMG represents a low-cost alternative to expensive structural measures (e.g., screens) that are currently used to protect fish at hydroelectric projects. Its early success in repelling salmon smolts in the laboratory makes the PMG of particular benefit to large-scale projects in the Pacific northwest where existing technologies often have proven less effective than desired.

Brief Description of Activity: The PMG has been evaluated at ARL with Atlantic salmon, striped bass and white perch. Additional cage-type testing has been conducted in the field with several riverine species. A large-scale field evaluation of the PMG is scheduled for the fall of 1997 at PSE&G's Salem Generating Station. ARL is currently soliciting interest in additional field studies, particularly with salmonids. (Note: The U.S. Army Corps of Engineers is pursuing infrasound work on a parallel course with ARL.)

Deliverables: A low-cost, biologically effective fish repelling device that can be used alone or in conjunction with other protection systems to improve their efficiency.

Schedule: Currently-funded research will end in early 1998. Additional research with salmonids would require 2 - 3 years effort.

Current Funding and Sources of Funding (not more than five years out): Funding for initial development has been supplied by ARL (~\$150,000) and PSE&G (~\$135,000). Funding for testing with riverine species (~\$70,000) was shared by EPRI, Wisconsin Electric Power Company, and Northern States Power Company. Future efforts with salmon will require ~\$1 million over 3 years.

#62

Enclosure 1

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT**Date:** June 21, 1996**Organization:** Electric Power Research Institute**Principal Contact:** Dr. Charles R. McGowin
Renewable and Hydro Business Unit,
EPRI, 3412 Hillview Avenue, P.O. Box 10412 Palo Alto, CA 94303
(415) 855-2445 (Fax: x8501)**Project/Program Title:** *Guidelines for Hydro Turbine Fish Entrainment and Survival Studies***Purpose and Objective:** Develop peer and agency-reviewed guidelines and protocols for planning, conducting, analyzing data from, and reporting results of hydro turbine fish entrainment and mortality studies.**Benefits:** Increase agency acceptance of study plans and reduce cost of studies.**Brief Description of Activity:** Alden research Laboratory was selected to develop guidelines in 1995. Contractor developed electronic databases of relevant literature/reports and procedures/consultants/vendors, critically reviewed existing procedures, developed study protocols for tailrace netting, hydroacoustic monitoring, and balloon tagging techniques, and prepared draft study guideline; peer review is underway by fisheries biologists, consultants, and agencies; EPRI workshop scheduled for September 1996 to review guidelines before they are finalized.**Deliverables:** (1) electronic databases on relevant literature and vendors/consultants; (2) draft and final Guideline report; (3) EPRI *Hydro Turbine Fish Entrainment and Survival Study Guidelines Workshop*, Cambridge, MA, September 24-25, 1996.**Schedule:** Project initiated January 1996; expected completion March 1997**Project Funding and Source of Funding (not more than five years out):**

EPRI:	\$165,000
Utilities:	\$11,000

#63

Enclosure 1

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT**Date:** June 21, 1996**Organization:** Electric Power Research Institute**Principal Contact:** Dr. Charles R. McGowin
Renewable and Hydro Business Unit,
EPRI, 3412 Hillview Avenue, P.O. Box 10412 Palo Alto, CA 94303
(415) 855-2445 (Fax: x8501)**Project/Program Title:** *Water Resource Management and Hydropower: Collaboration and Public Involvement***Purpose and Objective:** Develop tools and processes to help hydropower operators reduce time required for and cost of relicensing, improve communications with hydro stakeholders, and reduce loss of generation resulting from license terms.**Benefits:** Reduced cost of hydro relicensing and mitigation, improved relations with stakeholders, public support for hydropower.**Brief Description of Activity:** Two contractors selected by RFP in 1993. Kearns and West is developing processes and tools to support stakeholder communications and public involvement, and resources for the Future developed software tool, the *Water Resources Evaluation Framework (WREF)*, to evaluate alternate water management plans in collaborative setting with stakeholders. Draft *Guidebook* on stakeholder collaboration and public involvement, utility case study report, prototype WREF software completed in 1995. Case study applications are continuing in 1996.**Deliverables:** (1) *Water Resource Management and Hydropower: Guidebook for Collaboration and Public Involvement*, EPRI TR-104858, December 1995; (2) Case Study Status Report, EPRI TR-106084, December 1995; (3) *Water Resources Evaluation Framework User Documentation*, Draft Report, EPRI Project 3713, February 1996; (4) EPRI *Hydro Relicensing Strategy Workshop*, Cambridge, MA, September 26-27, 1996.**Schedule:** Project initiated January 1994; expected completion December 1997**Project Funding and Source of Funding (not more than five years out):**

EPRI:	\$900,000
Utilities:	\$250,000

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

#64

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: Design Criteria for Aerating Weirs

Purpose and Objective: To establish design criteria for straight and labyrinth weirs to enhance dissolved oxygen in discharge from hydroelectric plants.

Benefits: \$0.5 to 1.0 million. Depends on effect of D.O. limits on plant operation or on cost of other D.O. enhancement methods

Brief Description of Activity: Series of tests influences to verify and extend design criteria identified in literature search.

Deliverables: Report

Schedule: Report release September 1996

Current Funding and Source of Fundings: No current funding, completion of project.

Projected Funding and Source of
Funding (not more than five years out): None

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT #6

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: CG Dams. Dam Safety for Concrete Gravity Dams

Purpose and Objective: A simple to use finite-element stability analysis approach that meets all FERC & federal agency concepts

Benefits: Approximately \$1 million for dams not meeting criteria

Brief Description of Activity: Enhanced version of existing code to improve input of atypical dam profiles

Deliverables: Software PC, users manual & reports

Schedule: August 1996

Current Funding and Source of Fundings: No current funding, completion of project.

Projected Funding and Source of
Funding (not more than five years out): None

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

#66

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: MERLIN, Dam Safety Analysis

Purpose and Objective: Fracture Mechanics approach to concrete dams for stability analysis

Benefits: Approximately \$1 million for dams not meeting criteria

Brief Description of Activity: Software for PC Laboratory testing of uplift pressure in cracks and crack propagation

Deliverables: Software and users manual. Report.

Schedule: Release -probably August 1996

Current Funding and Source of Fundings: No current funding, completion of project.

Projected Funding and Source of Funding (not more than five years out): None

#67

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: January 3, 1997

Organization: Electric Power Research Institute

Principal Contact: Name: Charles W. Sullivan
Address: Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA
Phone: 415-855-8948 FAX: 415-855-8501

Project/Program Title: Development of a Modular Inclined Fish Diversion Screen

Purpose/Objective: To develop a cost-effective, high-velocity screen alternative for protecting fish at all types of water intakes. The modular design and high-velocity aspects of the screen make it a compact structure that can be easily retrofitted at existing sites or installed at new water intakes.

Benefits: The Modular Inclined Screen (MIS) has proven highly effective in diverting the early life stages of a wide variety of salmonid and non-salmonid fish species. It has the potential for wide-scale application at hydroelectric projects to reduce the existing losses of fish occurring as a result of turbine injury and mortality. A single module is designed to screen ~ 1000 cfs; additional modules are added to size a screening facility for a specific site.

Brief Description of Activity: Hydraulic and biological laboratory studies were conducted in 1992/1993 at Alden Research Laboratory, Inc. to develop and refine the initial design concept. Biological testing involved evaluation of the passage and survival of 11 species over a range of velocities from 2 to 10 ft/sec. A field evaluation of the MIS was conducted at Niagara Mohawk Power Corporation's Green Island Hydroelectric Project in 1995/1996 with six species. In most cases, diversion efficiency approached 100%, injury rates were low, and latent survival was high. EPRI is currently pursuing commercialization of the screen in order to realize its full potential as a cost-effective fish protection concept.

Deliverables: The MIS has been developed to the point where it can be considered an "available" technology for protecting fish at hydroelectric projects. Several EPRI reports are available. The remaining deliverable is a commercialized design that can be applied with minimal site-specific effort.

Schedule: All research efforts were completed at the end of 1996. Commercialization efforts will continue in 1997.

Current Funding and Sources of Funding (not more than five years out): Funding for the laboratory and field evaluations of the MIS conducted between 1992 and 1996 were provided by EPRI, Niagara Mohawk Power Corporation, NY State Energy Research and Development Authority, the Empire State Electric Energy Research Corporation, New England Power Company and the California Department of Water Resources (~\$3 million expended). Commercialization efforts are estimated to be on the order of \$250,000. Sources of funding for this effort have not been identified.

#68

CURRENT HYDROPOWER RESEARCH AND DEVELOPMENT

Date: June 12, 1996

Organization: Electric Power Research Institute

Principal Contact: D. I. Morris
P.O. Box 10412, Palo Alto, CA 94303
415/855-2924 fax: 8501

Project/Program Title: Severe Weather Forecast Applications for Electric Utilities

Purpose and Objective: To develop a display system and approach to reporting severe weather conditions so that utility staff can mitigate the effects or benefit from the knowledge.

Benefits: Repair crew scheduling, generation rescheduling

Brief Description of Activity: Demonstration of on-going research in utility control room

Deliverables: Report

Schedule: mid-1997

Current Funding and Source of Fundings: No current EPRI funding, completion of project. National Severe Storm Laboratory funding next 12 months.

Projected Funding and Source of
Funding (not more than five years out): None

#6

HYDROPOWER RESEARCH AND DEVELOPMENT

Date: December 20, 1996

Organization: Integrated Hydroelectric Machine Condition Monitoring Consortium, L.L.C.

Principal Contact: L. J. Miller III, Project Manager
P. O. Box 11521
Chattanooga, Tennessee 37401

Phone: (423) 751-3095
FAX: (423) 751-7926
E-mail: ljmiller@tva.gov

Project/Program Title: Hydroelectric Machine Condition Monitoring Project

Purpose and Objective:

Various MCM Consortium members have been involved in defining a complete plan for hydro plant machine condition monitoring(MCM) and determining areas where R&D investment in MCM technology can cost-effectively accelerate the implementation of condition driven maintenance. These efforts have clearly identified a strong opportunity to reduce costly outages, improve predictive maintenance capabilities, and get more value out of hydro generating equipment through the intelligent application of modern sensing and monitoring technologies and through the use of diagnostic techniques to provide knowledge, not just data/information, regarding equipment status and impending problems.

The Consortium goals for the project are:

- ☐ A system that provides results and knowledge as opposed to information or more data;
- ☐ A commercially viable system which can be used in a very competitive industry;
- ☐ System cost that is appropriate for the configuration used in each unique application;
- ☐ Useable, application ready, layered system depending on the user and,
- ☐ An integrated open architecture modular system that can accommodate the inputs of multiple vendors and a choice of sub-modules.

Brief Description of Activity:

The Consortium will seek to develop an integrated machine condition monitoring system for hydroelectric generating units. This work will involve research to develop new diagnostic techniques or refine existing methods for monitoring problems related to hydro generating units. The activities will include automated diagnostics of various hydro turbine components, generators and bearings for different types and size of units. The system will utilize the smart alarm concept by recognizing different alarm patterns (and monitoring different modes) for different machine states such as start-up, load change, steady state, shut down and transient. A graphical user interface (GUI) will be developed for interaction with different levels of users who will have need of the information.

The MCM system will use standard communication devices and protocols (e.g. Ethernet, TCP/IP, RDA) and be capable of being interfaced with data acquisition and protection and control (P&C) devices that are currently being used or planned in plants. The Consortium will seek opportunities to integrate component monitoring systems developed by several companies.

Schedule:

In 1996 a developer was selected by the Consortium. Work is underway to identify the specific development activities. The development and field-testing phases are expected to be completed by December 1998.

Current Funding and Source of Funding:

The following members of the consortium have committed funding of this project through 1998:

British Columbia Hydro
Bonneville Power Administration
Electric Power Research Institute
Idaho Power Company
Manitoba Hydro
Tennessee Valley Authority

Projected Funding and Source of Funding:

At this time the project is fully funded and no additional sources of funds should be required.

HYDROPOWER RESEARCH AND DEVELOPMENT

Date:

Organization:

Principal Contact:

Name

Address

Phone No.

Fax No.

Project/Program Title:

Purpose and Objective:

Brief Description of Activity:

Schedule:

Current Funding and Source of Funding:

Projected Funding and Source of Funding:

APPENDIX B

Bonneville Power Administration (BPA)

Fish and Wildlife Program

Selected Funds for Fish

Appendix B: BPA - Fish and Wildlife Program - Selected Funds for Fish

CATEGORY	BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT		1996	97-00 FUNDS
Anadromous Fish Monitoring				
Methods Development				
	8331900	NEW FISH TAG SYSTEM	\$681,800	
	Determine the biological and technical feasibility of using PIT-tag technology to passively obtain information on juvenile and adult salmonids and develop ancillary equipment to expand the PIT-tag system's capabilities of meeting this objective.			
NMFS		Earl Prentice 206/553-4219		
	9207300	AN AUTOMATED FISH MARKING AND TAGGING SYSTEM	\$414,324	
	Develop an automated mass-marking technique for juvenile salmonids that removes adipose fin and/or applies coded-wire tag without human handling or anesthetic.			
WDFW		Lee Blankenship 206/902-2748		
	8910700	EPIDEMIOLOGICAL SURVIVAL METHOD	\$169,952	
	Improve monitoring and evaluation capabilities by developing better measurement tools to estimate juvenile and adult survival. Develop statistical methods for PIT-tag release studies to determine survival rates and behavior of outmigrating smolts. Analyze tagging studies to determine survival relationships useful in improving mitigation.			
	University of Washington	Dr. John Skalski 206/616-4851		
Summary for Methods Development (3 detail records)			\$1,266,076	\$4,000,000
Production				
	8906600	ANN CD WIRE TAG PROG-MISSING PROD WA HTCH (WDF)	\$0	
	Use coded-wire tags to evaluate hatchery production.			
WDFW		Howard Fuss 360/902-2664		
	9202200	WILD SMOLT BEHAVIOR/PHYSIOLOGY (ESA)	\$370,850	
	Document the physiological development of spring chinook salmon that will serve as a goal for the hatchery production of more "wild-type" juvenile salmon.			
NMFS		Walt Dickoff 206/860-3234		
	9602000	PITTAG HATCHERY FISH - MULTIPLE STATES	\$9,223	
WDFW		Dorothy Extein 360/902-2435		

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	8812008	FISHERIES TECHNICIAN FIELD ACTIVITIES	\$627,288	
		Retrain 14 Yakama employees to assist in field data collection, task activities/assignments, and special fishery related projects consistent with the overall objectives of YKFP. Retain 4 temporary employees to work the separator at Chandler.		
		Yakama Indian Nation Mel Sampson 509/865-6262		
	8805303	HOOD RIVER PRODUCTION PROGRAM - CTWS - M&E	\$480,208	
		Implement actions outlined in the Hood River and Pelton Ladder Master Plans pertaining to acclimation and habitat. Coordinate Pelton Ladder production.		
		CTWSIR Mick Jennings 503/296-6866		
	9506300	YAKIMA/KLICKITAT MONITORING AND EVALUATION PROGRAM	\$186,886	
		Monitor and evaluate the effectiveness of the Cle Elum spring chinook hatchery and other aspects of the Yakima Fisheries Project in enhancing the fishery for the Yakama Indian Nation and other harvesters through supplementation.		
		TBD		
		Summary for Production (6 detail records)	\$1,674,455	\$16,000,000
		System Level		
	8201300	CODED-WIRE TAG RECOVERY	\$1,251,738	
		Continue support for the coded wire tag (CWT) recovery program used to track progress in increasing run sizes for anadromous Columbia River salmonid populations, including stocks listed under the Endangered Species Act (ESA) and Pacific Salmon Treaty (PST) indicator stocks.		
		PSMFC Pam Kahut 503/650-5400		
	8906500	ANNUAL FISH MARKING - MISSING HATCHERY PROD'N GROUPS	\$353,773	
		Mark various groups of fish for BPA funded projects using mobile fish marking trailers at federal and state hatcheries in the Columbia River basin. Provide base data from hatchery releases used to evaluate survival, contribution and hatchery goals.		
		USFWS Walt Ambrogetti 360/696-7605		
	9008000	COLUMBIA BASIN PIT-TAG INFORMATION SYSTEM	\$2,069,096	
		Develop, operate, maintain, and enhance a long-term Columbia River Basin database on PIT Tag information.		
		PSMFC Carter Stein 503/650-5400		

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
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	8332300	SMOLT CONDITION & ARRIVAL TIMING AT LWR GRANITE	\$308,679	
		Operate fish traps; monitor migration timing, relative passage index and smolt condition; tag groups of juvenile chinook and steelhead to provide in-season travel time information from traps through Lower Granite and Little Goose reservoirs.		
IDFG		Ed Buettner 208/799-5010		
	8712700	SMOLT MONITORING BY NON-FEDERAL ENTITIES	\$1,346,612	
		Monitor smolt migration in the Lower Snake and Columbia Rivers as they leave the tributaries and pass through the dams.		
PSMFC		Pam Kahut 503/650-5400		
	8740100	TRAVEL TIME AND SURVIVAL SMOLT PHYSIOLOGY	\$469,445	
		Provide annual information on smoltification and prevalence of disease in groups of juvenile salmon and steelhead used in integrated Smolt Monitoring Program and other mainstream passage monitoring and research projects.		
NBS		Alec Maule 509 538-2299		
	8401400	SMOLT MONITORING AT FEDERAL DAMS	\$633,500	
		Monitor migration of juvenile salmon and steelhead at Bonneville and John Day Dams.		
PSMFC		Pam Kahut 503/650-5400		
	8810804	STREAMNET (CIS/NED)	\$791,833	
		Compile, maintain, and disseminate regionally standardized graphic and tabular data critical to the implementation of the Program and other compatible regional efforts through StreamNet.		
PSMFC		Stan Allen 503/650-5400		
	9403300	FISH PASSAGE CENTER	\$957,357	
		Provide regional resource to successfully interface between fishery agencies, Tribes, and FCRPS operators. Analyze and report smolt monitoring data and recommend operations for fish passage.		
PSMFC		Pam Kahut 503/650-5400		
	8906900	ANN CD WIRE TAG PROG-MISSING PROD OR HTC (ODFW)	\$125,689	
		Expand coded wire tag program to include all ODFW Columbia Basin hatchery coho and chinook salmon production releases not tagged by other programs. Use data to evaluate trends in hatchery survival, hatchery rearing and release strategies, and as input to fishery management decisions.		
ODFW		Mark Lewis 541/737-7637		
	8816300	EFFECTS OF CODED WIRE TAGGING ON SPRING CHINOOK	\$157,473	
		Measure differential survival and growth between tagged and untagged spring chinook.		
WDFW		Lee Blankenship 360/902-2748		
Summary for System Level (11 detail records)			\$8,465,195	\$38,000,000

CATEGORY	BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
Tributary	8612400 INSP SERV FOR LITTLE FALL CREEK PASS RE:86-090 Provide for the operation, maintenance, and repair of the Little Fall Creek passage facilities.	\$1,955	
ODFW	Sharon Conyers 503/229-5410		
	9102800 MONITORING SMOLT MIGRATION OF WILD SNAKE RIVER SP/SUM CHINOOK Collect time series information to examine migrational characteristics of wild ESA-listed Snake River chinook salmon stocks. Mark wild spring/summer chinook parr with PIT tags; intercept and decode tagged smolts as they pass Snake and Columbia Rivers dams.	\$185,700	
NMFS	Gene Matthews, 206/860-3251 Steve Acord		
	8812005 FISH PASSAGE VIDEO MONITORING Provide fish passage information in the Yakima Basin via video monitoring. Data collected includes: enumeration of fish passage by species, identification of external marks, weekly fish passage counts, run timing and fish length data. Information is also recorded pertaining to fish viewing conditions at each of the ladders.	\$92,949	
Yakama Indian Nation	Mel Sampson 509/865-6262		
	9107300 IDAHO NATURAL PROD. MONITORING/EVAL 83-7(ESA) Evaluate and monitor chinook salmon and steelhead trout smolt production from 6-8 important indicator streams in Idaho. Developed models to estimate the number of wild/natural chinook salmon and steelhead trout smolts that will arrive at Lower Granite Dam the following spring. Update and refine these models annually.	\$649,821	
IDFG	Al Van Vooren 208/334-3791		
Summary for Tributary (4 detail records)		\$930,425	\$4,000,000
Summary for Monitoring (24 detail records)		\$12,336,161	\$62,000,000

CATEGORY**BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT****1996 97-00 FUNDS****Research and Evaluation****Gas Supersaturation**

	9300802 GAS BUBBLE TRAUMA IN SNAKE AND COLUMBIA RIVER SALMON	\$505,794	
	Determine the relationships between supersaturation levels, flow rates, fish movements, fish distribution, and symptoms. Develop sample techniques, logistics, schedules, and collecting preliminary data for use in design of future experiments to determine occurrence of symptoms among out migrating smolts.		
CRITFC	Dr. Tom Backman 503/731-1267		
	9602100 GAS BUBBLE DISEASE MONITORING AND RESEARCH	\$550,961	
	Monitor juvenile salmonids for signs of GBT at dam and other locations. Conduct experiments to determine the progression and diminution of GBT signs in juvenile salmonids exposed to water with high total dissolved gas (TDG). Determine the effects of water with high TDG on the ability of juvenile salmonids to resist disease, respond to stress, etc.		
NBS	Dr. Alec G. Maule 509/538-2299		
	9602400 GBD: CHANGES IN SIGNS/EFFECTS ON SURVIVAL	\$251,600	
	PIT-tagged hatchery fish will be exposed to water containing supersaturated dissolved atmospheric gases, examined for signs of GBD, and released into the forebay of Little Goose Dam. A percentage of these fish will be recaptured at the Little Goose Dam collection facility and reexamined. The survival of the fish not collected at Little Goose Dam will be compared to control fish as they pass downstream dams.		
NMFS	Earl Dawley 509/861-1853		
	9602200 EFFECTS OF DISSOLVED GAS SUPERSAT ON RESIDENT FISH	\$205,500	
	Evaluation of the effects of dissolved gas supersaturation on fish in Priest Rapids Reservoir, and downstream from Bonneville and Ice Harbor Dams.		
NMFS	Robert Iwamoto 206/860-3270		
	Summary for Gas Supersaturation (4 detail records)	\$1,513,855	\$6,000,000

Genetics

	8909600 GENETIC M&E OF SNAKE RIVER SALMON AND STEELHEAD	\$230,800	
	Evaluate the genetic consequences of using hatchery fish to supplement natural populations of chinook salmon and steelhead in the Snake River.		
NMFS	Robin Waples 206/860-3254		

CATEGORY	BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	9009300 GENETIC ANALYSES OF ONCORHYNCHUS NERKA (ESA) Provide biological and genetic information on O. nerka samples collected throughout the Snake and Columbia River Basins to be used in the overall recovery effort of the Snake River Sockeye Salmon. Univ/ID, subcontractor WSU Dr. Ernest Brannon 208/885-5830	\$125,000	
Summary for Genetics (2 detail records)		\$355,800	\$2,000,000
Life Cycle			
	9403400 ASSESS SUMMER/FALL CHINOOK RESTORATION -- SNAKE RIVER BASIN Assess summer and fall chinook spawning, incubation, growth, outmigration timing, and survival for evaluating recovery and restoration potential through supplementation in major Snake River tributaries: Clearwater River and major tributaries, Grande Ronde, Salmon, and Imnaha Rivers. Nez Perce Tribe Bill Arnsberg 208/476-7296	\$225,953	
	8910800 MONITORING AND EVALUATION MODELING SUPPORT Provide analytical tools and databases required to evaluate the effectiveness of hydrosystem operations and other mitigation measures for improved fish survival as required to meet obligations of the ESA, NEPA, and NW Power Act. University of Washington James Anderson 206/543-4772	\$699,892	
	9203200 LIFE-CYCLE MODEL DEVELOPMENT AND APPLICATION Improve decision-support tools for (1) assessing overall program effectiveness, and more specifically (2) assessing the impacts of land-use activities on resident and anadromous salmonids. USFS Danny Lee 208/364-4386	\$50,000	
	9303701 TECHNICAL ASSISTANCE WITH THE LIFE CYCLE MODEL Evaluate biological impacts of hydro operations through life cycle modeling. Charlie Paulsen Charlie Paulsen 503/245-8186	\$215,105	
	9600600 PATH - FACILITATION, TECH ASSISTANCE & PEER REVIEW Facilitation, technical assistance and peer review for PATH (Plan for Analyzing and Testing Hypotheses). PATH is an iterative process of defining and testing hypotheses underlying key salmon management decisions in the Columbia River Basin with scientists/managers from BPA, NPPC, NMFS, state and tribal agencies, as well as independent peer reviewers. Essa Technologies Ltd. Dave Marmorek 604/733-2996	\$500,489	
	9601700 TECHNICAL SUPPORT FOR PATH - CHAPMAN CONSULTING, INC. Don Chapman Consultants, Inc. 208/383-3401	\$98,979	

CATEGORY	BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	9600800 PATH - PARTICIPATION BY STATE AND TRIBAL AGENCIES	\$498,598	
	State agency and tribal participation in PATH (Plan for Analyzing and Testing Hypotheses). PATH is an iterative process of defining and testing hypotheses underlying key salmon management decisions in the Columbia River Basin with scientists/managers from BPA, NPPC, NMFS, Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife(WDFW), and the Columbia River Inter-Tribal Fish Commission (CRITFC) and their member tribes, as well as independent peer reviewers.		
ODFW	Howard Schaller 503/872-5310		
	9102900 LIFE HISTORY OF FALL CHIN IN COL RIVER BASIN	\$989,947	
	Identify the physical and biological factors influencing spawning, rearing, seaward migration, and survival of fall chinook salmon. Examine post-release attributes of hatchery fall chinook salmon released into the Snake River to evaluate supplementation strategies. Conduct M & E of supplementation releases from Snake River acclimation facilities.		
NBS	Dennis Rondorf 509/538-2299		
	Summary for Life Cycle (8 detail records)	\$3,278,963	\$13,000,000
	Passage		
	8902401 EVAL UMATILLA BASIN PRJ - 3-MILE/WEID CANAL SCR	\$138,304	
	Determine migration characteristics, migrant abundance, survival, and health of outmigrating natural and hatchery juvenile salmonids in the Umatilla River; investigate relationships between environmental parameters and migration; determine effective routes of passage at Three Mile Falls Dam.		
ODFW	Richard Carmichael 541/962-3777		
	9302900 SURVIVAL ESTIMATION FOR DAM/RESERVOIR PASSAGE	\$750,500	
	Provide measurements of survival of juvenile salmon as they pass through dams and reservoirs		
NMFS	Dr. John Williams, Dr. Bob Iwamoto, Bill Muir 206/860-3277		
	8200300 SELECTIVE PREDATION/DEVELOPMENT OF PREY PROTECTION	\$367,946	
	Assess the relative vulnerability of juvenile salmonids of varying condition to predation and develop measures that will protect outmigrating juvenile salmonids from resident fish predators, particularly northern squawfish.		
NBS	Matthew Mesa/Tom Poe 509/538-2299		

CATEGORY	BPA # NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	9402600 PACIFIC LAMPREY RESEARCH AND RESTORATION PROJECT Assess status and survival limitations of Pacific lamprey, develop restoration plans and implement in Northeast Oregon and Southeast Washington.	\$334,560	
CTUIR	Gary James 541/276-4109		
	9007800 SIGNIFICANCE OF PREDATION AND EVALUATION OF PREDATION CONTROL Estimate the relative magnitude of juvenile salmonid loss to northern squawfish throughout the Columbia River Basin. Describe squawfish spawning and rearing ecology with the goal of understanding when year-class strength may be determined and the mechanisms underlying recruitment.	\$444,145	
NBS	Dena Gadomski/ 509/538-2299 Tom Poe		
	9204101 EVALUATE ADULT MIGRATION IN LWR COL. RIVER AND TRIBUTARIES Assess the success of adult salmon and steelhead passage at the four dams and reservoirs in the lower Columbia River and into the tributaries; evaluate specific flow and spill conditions on adult fish migration, and the various measures under taken to improve adult fish passage in the lower Columbia River.	\$334,739	
US Army COE			
	Summary for Passage (6 detail records)	\$2,370,194	\$10,000,000
	Planning and Coordination		
	9600500 OPERATION OF THE INDEPENDENT SCIENTIFIC ADVISORY BOARD Provide the administrative and fiscal support to the ISAB established by the NPPC and NMFS. Reimburse the ISAB members for time and expenses.	\$0	
CBFWF	Tom Giese 503/326-7031		
	8907201 INDEPENDENT SCIENTIFIC GROUP SUPPORT Provides funding for one member of the Independent Scientific Group through a contract with DOE.	\$99,163	
Oak Ridge National Laboratory	Dr. Charles 615/576-6830 Coutant		
	Summary for Planning and Coordination (2 detail records)	\$99,163	\$3,000,000

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
Production				
	9506402	UPPER YAKIMA SPECIES INTERACTION STUDIES		\$204,094
		Establish the baseline status of resident trout, steelhead, and spring chinook salmon and associated species; implement experiments to help define the competitive and ecological interactions that may occur between resident trout and supplemented anadromous species.		
WDFW		Bill Hopley 360/902-2749		
	9000501	UMATILLA BASIN NATURAL PRODUCTION M&E		\$0
		Evaluate the success of natural production of salmon and steelhead resulting from the Umatilla Fisheries Restoration Program. Specifically evaluate the implementation of the Umatilla Hatchery Master Plan with respect to adult salmon and steelhead passage, natural production, and Tribal harvest.		
CTUIR		Gary James 541/276-4109		
	9506401	REFINEMENT OF MARKING METHODS FOR YKFP		\$410,610
		Identify, evaluate and develop a suite of marking tags that can satisfy the needs of the YKFP. This task is critical to success of the YKFP.		
WDFW		Bill Hopley 360/902-2749		
	9005200	PERF/STOCK PROD IMPACTS OF HATCHERY SUPPL		\$400,000
		Evaluate costs and benefits for alternative sources of hatchery broodstocks in supplementation programs, test for domestication selection, and determine whether various modifications of the hatchery program can improve fitness of hatchery fish for reproducing and rearing and natural streams.		
NBS		Reg Reisenbichler 206/526-6282		
	8909802	SALMON SUPPLEMENTATION STUDIES IN ID RV - NEZ PERCE TRIBE		\$230,805
		Determine the best outplanting strategy for spring and summer chinook salmon to restore or augment natural production, and evaluate the effects of supplementation on the survival and fitness of existing wild/natural populations in the Salmon and Clearwater River basins.		
Nez Perce Tribe		Jay Hesse 208/476-9502		
	8909801	SALM SUPPLEMENTATION STUDIES IN IDAHO RIVERS - USFWS		\$91,098
		Evaluate out planting strategies for hatchery spring chinook salmon to restore or augment natural production, and assess the effects of hatchery supplementation on the survival and genetic fitness of existing natural populations in the Clearwater River basin.		
USFWS		Ralph B. Roseberg 208/476-7242		

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	8816000	WILLAMETTE HATCHERY OXYGEN SUPPLEMENTATION Determine if chinook salmon can be reared at increased densities with oxygen supplementation without detrimental effects on the returns of adult salmon. Examine the effects of density, oxygen supplementation, and raceway design on water quality, rearing, and survival of chinook salmon at Willamette Hatchery, Oakridge, Oregon.	\$94,811	
ODFW		Harry Lorz 541/757-4186		
	8909803	SALMON SUPP. STUDIES IN ID RIVERS - SHO-BANN TRIBES Determine the best method to maintain and rehabilitate Idaho's chinook salmon. Compare adult returns, productivity, and genetic composition between treatment and control streams, over time, throughout the Salmon and Clearwater basins. Broodstock management and lifestage at release will vary between treatment streams.	\$183,000	
Shoshone-Bannock Tribes		Mike Rowe 208/238-3757		
	8909800	IDAHO SUPPLEMENTATION STUDIES (ISS) Determine the best method to rebuild spring and summer chinook salmon by determining optimum supplementation practices to increase and maintain natural production in the Salmon and Clearwater basins. Compare life stage survival, productivity, adult returns, and genetic composition between supplemented and unsupplemented populations.	\$850,001	
IDFG		Al VanVooren 208/334-3791		
Summary for Production (9 detail records)			\$2,484,419	\$13,000,000
Summary for Research and Evaluation (31 detail records)			\$10,082,394	\$47,000,000
Summary for Anadromous Fish (55 detail records)			\$22,418,545	\$109,000,000
Resident Fish Research and Evaluation				
	9501100	CHIEF JOSEPH KOKANEE ENHANCEMENT PROJECT Determine the status of kokanee stock above Chief Joseph and Grand Coulee Dams.	\$500,000	
Colville Confederated Tribes		Kirk Truscott, 509/634-8845 Biologist		
	9101901	HUNGRY HORSE FISHERIES MITIGATION - SALISH AND KOOTENAI TRIBES Monitor changes in the fish community of Flathead Lake to verify biological responses to Hungry Horse Dam Mitigation measures. Evaluate techniques to reintroduce kokanee to Flathead Lake and attainment of criteria that define success of kokanee reintroduction. Develop stream restoration projects.	\$55,424	
Confederated Salish & Kootenai Tribes		Barry Hansen, 406/675-2700 Joe DosSantos		

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	9401200	KOOTENAI RIVER WHITE STURGEON - M&E		\$0
		Increase the monitoring and evaluation of sturgeon migration and spawning activities in the Kootenai River in relation to flow augmentation from Libby Dam.		
IDFG/KTOI		Vaughn L. 503/230-5061 Paragamian, IDFG and Paul Anders, KTOI		
	9404300	LAKE ROOSEVELT MONITORING / DATA COLLECTION PROGRAM		\$870,006
		Monitor and evaluate the effects of mitigation activities and Columbia River Operations on the biota in Lake Roosevelt. Based on the information collected by this and other projects, develop biological / integrated rule curves.		
Spokane Tribe		Keith Underwood 509/258-7020		
	8806500	KOOTENAI RIVER FISHERIES INVESTIGATIONS		\$503,494
		Determine status of sturgeon, burbot and rainbow stocks in the Kootenai River and effects of water fluctuations on these stocks. Research nutrient dynamics. Study tagged sturgeon in Kootenay Lake by telemetry.		
IDFG		Vaughn L. 208/769-1414 Paragamian		
	9404900	KOOTENAI RIVER ECOSYSTEM IMPROVEMENTS STUDY		\$232,353
		Assess resident fish populations in the Idaho portion of the Kootenai River and identify fisheries enhancement opportunities.		
Kootenai Tribe		Diane Richards 208/267-3620		
	8740700	DWORSHAK IMPACTS/M&E & BIO-INT RULE CURVES		\$172,554
		Assess losses of resident fishery at Dworshak Dam and undertake studies of rianbow trout and smallmouth bass. Gather thermal/physical/chemical data, primary productivity, zooplankton and benthic data for M&E of impacts from Dworshak operations. Apply data to formulate biological/integrated rule curves.		
Nez Perce Tribe		Dave Statler 208/476-7417		
	9405400	BULL TROUT STUDIES IN CENTRAL AND NE OREGON		\$244,102
		Determine status, life history, genetic, habitat needs, and limiting factors for bull trout populations in the Deschutes, Hood, Grande Ronde, John Day, and Umatilla basins.		
ODFW		Dave Buchanan 541/737-7634		
	8605000	WHITE STURGEON PRODUCTIVITY STATUS AND HABITAT REQ.		\$0
		Investigate the early life history and define habitat used by spawning and rearing white sturgeon and quantify the habitat available in the Columbia and Snake River reservoirs downstream from Priest Rapids and Lower Granite Dams.		
ODFW		Kirk Beiningen 503/657-2035		

CATEGORY	BPA #	NAME/DESCRIPTION/ORGANIZATION/CONTACT	1996	97-00 FUNDS
	8346700	LIBBY RESERVOIR LEVELS/KOOTENAI IFIM Use Instream Flow Incremental Methodology Models and field techniques to relate hydraulic conditions in the Kootenai River to fish, habitat and food production requirements for riverine fish assemblages; link river model to existing reservoir model to balance hydro operations; examine options to mitigate the effects of Libby Dam.	\$298,249	
MDFWP		Brian Marotz 406/751-4546		
	8346500	LIBBY AND HUNGRY HORSE MODELING TECHNICAL ANALYSIS Evaluate the impacts of drawdowns at Libby and Hungry Horse reservoirs on important game fish in the various parts of their life cycle. Develop/refine IRCs, maintain model code, modify program utilities and run simulations using the Montana reservoir models LRMOD and HRMOD. Construct optimization programs to link IFIM river models with existing reservoir models.	\$29,872	
MDFWP		Brian Marotz 406/751-4546		
	9501600	GENETIC INVENTORY WESTSLOPE CUTTHROAT TROUT Conduct a genetic inventory of westslope cutthroat trout in the North Fork Clearwater River Drainage to determine the genetic status, including the extent of introgression by introduced rainbow trout.	\$164,000	
Nez Perce Tribe		Dave Statler 208/476-7417		
	9405300	BULL TROUT ASSESSMENT - WILLAMETTE/MCKENZIE Determine life history, distribution and habitat use of bull trout populations in western Oregon, with emphasis on the Middle Fork Willamette and McKenzie Rivers.	\$58,151	
ODFW		Jeff Ziller 541/726-3515		
	8709900	DWORSHAK DAM IMPACTS ASSESSMENT Optimize the resident fishery of the reservoir which is severely limited by entrainment losses. Limit losses to keep kokanee densities at 30 -50 adult fish/ha. Explore ways to avoid losses using selective water withdrawal or behavioral devices. Develop reservoir resident fish loss assessments due to the operation of Dworshak Dam.	\$169,020	
IDFG		Melo Maiolle 208/769-1414		
	9500400	LIBBY RESERVOIR MITIGATION PLAN Compile loss/gain statement, Libby fisheries mitigation options and site plans, criteria for selecting and prioritizing mitigation projects, for public scoping and submittal to NPPC.	\$124,067	
MDFWP		Brian Marotz 406/751-4546		
Summary for Resident Fish (15 detail records)			\$3,421,292	\$27,000,000
Grand Total			\$25,839,83	\$136,000,000
Source: Bonneville Power Administration Database				

APPENDIX C

**Anadromous Fish Evaluation Program
Potential 1997 Projects
U.S. Army Corps of Engineers - North Pacific Division**

Appendix C: Anadromous Fish Evaluation Program - Potential 1997 Projects, U.S. Army Corps of Engineers - North Pacific Division

Category	Agency Code	Project
Fish	SCD-97(2)-1	<p><u>Surface Collection at the Dalles - Laboratory Analysis of Salmonid Behavior and Reaction/Response to Flow Fields/Gradients</u></p> <p>Proposed 4-yr. study to complement field information on surface collector bypass systems. 3 major elements: 1) identify flow components critical to juvenile salmonid passage via surface collectors and design laboratory evaluations to predict responses to hydraulics; 2) conduct laboratory tests and develop criteria to determine optimal flow fields for surface collection systems; 3) apply criteria to design and construct prototype surface bypass devices.</p>
Monitoring Tool Development	SCD-97(2)-2	<p><u>Surface Collection at the Dalles - Direct Capture Evaluations of Fish Passage in Ice/Trash Sluiceways and Sluiceways</u></p> <p>Proposed 3-yr. continuing study to develop and test a prototype PIT tag detector net and video camera system to monitor downstream passage through ice and trash sluiceways and avoid mortality problems associated with direct capture techniques and operational problems associated with hydroacoustics. Study also includes application of the system at other locations.</p>
Fish	SCD-97(3)-3	<p><u>Surface Collection at the Dalles - Hydroacoustic Evaluations of Fish Passage</u></p> <p>Continuing study to use hydroacoustics to evaluate fish passage behavior under different operating conditions that may increase sluiceway passage and reduce turbine entrainment at the Dalles Dam. Information from this study will be used to design and locate a prototype surface collection system currently scheduled for 1998.</p>
Fish	SCD-97(3)-4	<p><u>Surface Collection at the Dalles - Radio Telemetry for Fine Scale Behavioral Information of Juvenile Salmonids</u></p> <p>On-going radio telemetry study to evaluate juvenile fish behavior as fish approach and pass the Dalles Dam in relation to flow conditions, predator distribution, and other physical and biological parameters.</p>
Fish	SCB-97(3)-1	<p><u>Surface Collection at Bonneville - Hydroacoustic Evaluations of Fish Passage</u></p> <p>Continuing study to use hydroacoustics to evaluate fish passage behavior under different operating conditions and with a three-unit prototype surface collector at Bonneville Dam. Information from this study will be used to design and locate a prototype surface collection system currently scheduled for 1998.</p>
Fish	SCB-97(3)-2	<p><u>Surface Collection at Bonneville - Radio Telemetry for Fine Scale Behavioral Information of Juvenile Salmonids</u></p> <p>On-going radio telemetry study to evaluate juvenile fish behavior as fish approach and pass Bonneville Dam in relation to flow conditions, predator distribution, and other physical and biological parameters.</p>
Fish	SCJ-97(3)-1	<p><u>Surface Collection at John Day - Hydroacoustic Evaluations of Fish Passage</u></p> <p>Proposed 4-yr. study to use hydroacoustics to evaluate fish passage behavior under different operating conditions and with an overflow weir at the John Day Dam. Information from this study will be used to design and locate a prototype surface collection system that would reduce passage delays and improve spill efficiency.</p>

Category	Agency Code	Project
Fish	SCJ-97(3)-2	<u>Surface Collection at John Day - Radio Telemetry for Fine Scale Behavioral Information of Juvenile Salmonids</u> On-going radio telemetry study to evaluate juvenile fish behavior as fish approach and pass the John Day Dam in relation to flow conditions, predator distribution, and other physical and biological parameters.
Fish, Monitoring Tool Dev.	ILC -97(4)-1	<u>Improvements at Lower Columbia Projects - Acoustic Technology: Modifying Fish Behavior Using Sound Fields</u> Multi-year study to evaluate infrasound technologies to modify downstream migrant behavior in lab and field; continue development of a pressure sensing probe; evaluate effects of sound fields on fish health; design and conduct full-scale evaluations at Columbia R. Dams.
Fish, Monitoring Tool Dev.	DGAS-97(2)-1	<u>Gas Abatement - Evaluate Horizontal/Vertical Distribution of Juvenile Salmonids in the Lower Snake and Columbia Rivers to Determine Exposure Histories Relative to TDG</u> On-going, 2 - phased study to develop and implement a model to allow predictions of the biological benefits of different strategies to reduce total dissolved gases and gas bubble trauma in juvenile fish.
Fish, Monitoring Tool Dev.	DGAS-97(2)-2	<u>Gas Abatement - Evaluation of Salmonid Inriver GBT Symptomology and Mortality Via Exposure Controlled from Predation</u> Proposed 3-yr. study to evaluate the relationship of exposure history of fish to various levels of dissolved gas to different causes of mortality. Study is expected to develop new analytical tools to aid in analysis of alternative actions for controlling Total Dissolved Gas Supersaturation.
Fish, Monitoring Tool Dev.	DGAS-97(3)-5	<u>Gas Abatement - Determine Range of Spill Efficiencies Across Range of Operating Flows for Lower Columbia and Snake River Dams</u> Proposed 2-yr. study to evaluate percentage of juvenile yearling and subyearling Chinook salmon that use spillways and those that are entrained in turbines at different spill patterns and volumes. The Dalles and Lower Granite were evaluated in FY96. Bonneville, John Day, Lower Monumental, and Little Goose proposed for FY97. McNary and Ice Harbor proposed for FY98.
Fish, Monitoring Tool Dev.	JDE-97(1)-1	<u>JDA Extended Screens - Evaluation of Extended Length Bar Screens, OPE, and Incidence of Descaling</u> Continuing study to evaluate whether extended length screens can improve fish passage performance at John Day dam as they have in testing at The Dalles and McNary Dams. Also, determine impact of extended length screens at John Day on Oriface Passage Efficiency and descaling. Determine the relationship between hydroacoustic and fyke net estimates of Fish Guidance Efficiency.
Fish	ADLT-97(4)-1	<u>Adult Passage - Radio Telemetry for Behavioral, Passage and Survival Information of Adult Salmonids through Adult Passage Routes in the Lower Columbia River</u> Continuing/proposed new 5-yr. study at Bonneville, The Dalles, John Day, and McNary Dams, to use radio telemetry to obtain information on destinations, survival, travel times, passage use, and fall back of adult salmonids, under different flows, spill volumes and patterns, powerhouse operations, and Bonneville Navigation Lock operations. Study also includes analysis of impact of water quality on adult salmonid migration in the John Day tailrace and forebay, evaluations of lamprey passage, and the impacts of the adult shad fishery at the Dalles Dam on salmonid migration.

Category	Agency Code	Project
Monitoring Tool Dev.	MPE-97(2)-1	<u>Juvenile Fish Monitoring Facilities - Post Construction Evaluation</u> Proposed 2-yr. study to evaluate performance of new monitoring facilities and ensure downstream migrants and adult fallbacks are not adversely impacted.
Fish	MPE-92-1	<u>Transport - Evaluate Transportation of Juvenile Fish Downstream of Skamania Light Buoy</u> On-going, multi-year study to evaluate impact of transporting juvenile salmon and steelhead further downstream on returning adults. Evaluate effect on homing when adult PIT tag detection systems are in place throughout the River system. Project began with the transport of steelhead smolts from 1992 - 1994. Returns of these fish are monitored from 1993 - 1999. Tests on chinook depend on beneficial results for steelhead.
Fish, Monitoring Tool Dev.	MPE-95-1	<u>Transport - Evaluation of Transported Fish Compared to Inriver Migrating Fish</u> On-going, multi-year study to compare the benefit of transportation of juvenile salmonids to inriver passage under conditions that are maximized using whatever operational flexibility can be provided. Returning adults will be monitored using PIT and coded wire tags and freeze brands at the fish ladder at Lower Granite Dam. Combination of tags will be used to verify the in-ladder PIT tag detector. Project also includes evaluation of juvenile fish survival and migratory behavior using PIT tag trawler detection methodology under development.
Fish	MPE-95-3	<u>Transport - Evaluation Procedures for Collection, Transportation, and Downstream Passage of Outmigrating Salmon</u> On-going multi-year study to determine the cumulative physiological response to passage through multiple dams; compare the physiological response of wild and hatchery Spring Chinook smolts to barge transportation; compare the effects of handling on the physiology and performance of wild and hatchery Fall Chinook juveniles; and document post-transport behavior of Chinook salmon and comparative survival of transported versus run-of-river fish to the estuary, including predator response.
Monitoring Tool Dev.	MPE-95-2	<u>Transport - Estuary PIT Tag Recovery</u> On-going multi-year study to develop and test a prototype trawler net equipped with a PIT tag detector and assess the relative abundance and timing in the estuary environment of PIT-tagged juvenile Chinook salmon release for the evaluation of transportation from Lower Granite Dam and other release groups.
Fish	LSRF-95-1	<u>Lower Snake River - Juvenile Fall Chinook Reach Survival</u> On-going multi-year study of subyearling Fall Chinook salmon to collect baseline survival, travel-time, and guidance efficiency estimates; field test and evaluate models for the estimation of survival probabilities and determine post-detection bypass mortality in the Snake R.; and coordinate with other survival research by USFWS and NBS for Lower Granite Reservoir and the Nez Perce Tribe for the Clearwater R.
Fish	LSRF-96-1	<u>Lower Snake River - Juvenile Fall Chinook Rearing Characteristics</u> On-going multi-year study to: quantify the predatory influence of mallmouth bass on juvenile fall chinook salmon in Lower Granite Reservoir; evaluate interactions of resident fish and migratory juvenile salmon; quantitatively and qualitatively determine preferred food items of rearing and migrating Chinook juveniles; and determine distributional response and cues causing rearing Fall Chinook transition into active migrating behavior.

Category	Agency Code	Project
Fish	LSRF-97-1	<u>Lower Snake River - Reach Survival of Juvenile Salmon Above Lower Granite Reservoir</u> Proposed 3-yr. study to: estimate survival of wild and hatchery yearling Chinook salmon smolts released in the Snake R. basin through free-flowing river reaches, and partition mortality between sections of these reaches; and investigate the role of various physical and biological factors on smolt survival rates, especially the effects of drawdowns.
Fish	SBC-96-1,2,3,4	<u>Surface Bypass/Lower Granite - Test Prototype Surface Bypass and Collection Device at Lower Granite Dam</u> On-going multi-year study to: determine the relative passage rate of juvenile fish through the powerhouse, spillway, and prototype surface collector and compare with passage rate in previous years; determine effectiveness of various prototype surface bypass and collection system configurations; evaluate behavior of smolts as they approach the dam with emphasis on their response to the prototype; determine distributional response of adult Chinook salmon and predator populations to deployment and operation of prototype; evaluate the external physical condition of smolts passing through prototype.
Fish	SBC-96-6	<u>Surface Bypass/Lower Granite - Infrasound Method to Redistribute Smolts in Dewatering Structures</u> On-going multi-year study to: prove capability to film smolt movement in the bypass channel with video cameras; test effectiveness of eliciting smolt avoidance responses; map flow through the side and vertical dewatering sections; develop accelerometer device; map sound fields produced by infrasound.
Fish	SBC-96-5	<u>Surface Bypass/Ice Harbor - Testing/Planning in Preparation for Testing Effectiveness of Floating Curtain as Fish Guidance Device</u> On-going multi-year study to: evaluate telemetry methodology to detect passage through all routes; evaluate exit behavior of adult steelhead and salmon; complete model testing of removing scallops, adjusting attachment site, finalizing adult exit gap/juvenile detector.
Fish	MPE-96-2	<u>Post-Construction Evaluation/Ice Harbor - New Juvenile Fish Bypass</u> On-going multi-year study to: verify efficiency of the new bypass system for juvenile and adult salmonids (including adult handling facility) and identify any mechanical problems; determine condition of juvenile fish using the new bypass system and observe how different parts of the system affect physiology; determine reliability and efficiency of facility sampling system; visually inspect outfall pipe to determine if it is likely to safely pass juvenile salmonids; evaluate reliability and efficiency of new PIT-tag detection system; and verify adult fallback rates through the juvenile fish facility bypass system.
Fish; Monitoring Tool Dev.	MPE-97-5	<u>Post-Construction Evaluation/Little Goose - Juvenile Fish Guidance System Improvements</u> Proposed 2-yr. study to: verify efficiency of bypass system improvements including during operation of units outside 1% operating efficiency range; evaluate effects of extended screen operation on adult fallback rates through turbines v. juvenile fish facility; determine condition of juvenile fish using bypass system; determine fish guidance efficiency if consensus reached on methodology.
Fish	MPE-96-3	<u>Post-Construction Evaluation/Lower Granite - Juvenile Fish Guidance System Improvements</u> On-going multi-year study to: verify efficiency of bypass system improvements including during operation of units outside 1% operating efficiency range; evaluate effects of extended screen operation on adult fallback rates through turbines v. juvenile fish facility; determine condition of juvenile fish using bypass system; monitor debris and orifice operation.

Category	Agency Code	Project
Fish; Monitoring Tool Dev.	MPE-94-1	<u>Post-Construction Evaluation - Effects of Descaling on Short-Term Survival of Migrating Juvenile Salmonids</u> On-going multi-year study to: review existing juvenile salmonid descaling studies; determine best methods to experimentally examine effects of descaling on short-term survival of migrating juvenile salmonids; conduct tests to determine effects of descaling on short-term survival of juvenile salmonids; evaluate new methods of investigating non-lethal internal injuries (including serum enzyme analysis); evaluate impact of Hi-Z tags on internal injuries and tissue damage.
Fish; Water Quality	MPE-97-1	<u>Post-Construction Evaluation/Ice Harbor - Spillway Deflectors</u> Proposed 4-yr. study to: evaluate adult fish passage performance after installation of deflectors and verify total dissolved gas levels; evaluate juvenile fish survival, condition, and injury in bays with and without deflectors.
Fish	MPE-97-4	<u>Post-Construction Evaluation/Little Goose - Outfall Pipe</u> Proposed 2-yr. study to: determine effects of outfall pipe passage on injury, descaling, and mortality of juvenile salmonids; document with radio tracking immediate downstream post-outfall release behavior under spill conditions that create eddies; radio-tag and monitor squawfish activity at release sites.
Fish	MPE-97-3	<u>Post-Construction Evaluation/McNary - Juvenile Fish Guidance System Improvements</u> Proposed 3-yr. study to: verify efficiency of bypass system improvements including during operation of units outside 1% operating efficiency range; evaluate effects of extended screen operation on adult fallback rates through turbines v. juvenile fish facility; determine condition of juvenile fish using bypass system.
Fish	MPE-97-2	<u>Post-Construction Evaluation/Little Goose - Survival of Juvenile Salmonids in the Bypass System, Turbines, and Spillway</u> Proposed 5-yr. study to: determine survival of spring and summer juvenile salmonid passing through bypass system, turbines, and spillway; evaluate recovery of adults returning from juvenile releases at Little Goose Dam.
Fish; Water Quality	DGAS-96-1	<u>Gas Abatement/Lower Snake and Columbia Rivers - Evaluate Gas Bubble Trauma for In-River Horizontal and Vertical Exposure Histories of Free-Swimming Juvenile Salmonids to Near Threshold Levels of Total Dissolved Gas Supersaturation</u> Proposed 4-yr. study to: statistically determine relationship between inriver total dissolved gas (TDG) levels, movement and distribution of actively migrating smolts, and gas bubble trauma (GBT) symptoms. Project includes: radio tracking, population-at-large sampling using high detection instrument magnification, and PIT tag recovery of juvenile salmonids; hydroacoustic information on fish distribution at the population level, spatial and temporal data on TDG levels, water velocity, temperature, dissolved oxygen and other parameters to allow multi-factor analysis of GBT data; and full-scale, multi-factor experiments to study occurrence of GBT as related to TDG, spill volume, flow, and juvenile salmonid behavior.
Fish; Water Quality	DGAS-97-1	<u>Gas Abatement - Evaluation of Salmonid In-River Gas Bubble Trauma Symptomology and Mortality Via Exposure Controlled from Predation</u> Proposed 4-yr. study to: statistically determine and separate cumulative direct (GBT) and indirect (predation) depth-related reach survival of juveniles during high v. moderate v. low spill rates. Project includes: use of floating net pens to laterally confine juvenile salmonids and resident predator species and PIT tag recovery of juvenile salmonids.

Category	Agency Code	Project
Fish; Water Quality	DGAS-97-2	<u>Gas Abatement/Little Goose through John Day Dams - PIT-tag Survival of Total Dissolved Gas Challenged Smolts</u> Proposed 3-yr. study to: statistically determine direct and indirect between-dam survival of actively migrating juvenile salmonids and hatchery juvenile salmonids with experimentally-induced signs of GBT v. control replicates; determine whether hatchery fish with experimentally-induced GBT signs retain same prevalence and severity of signs following passage through juvenile fish bypass systems and between dams; determine relative survival and behavioral distribution of a parallel replicate sample of radio-tracked juveniles from release above the Lower Monumental forebay through the McNary juvenile bypass system; PIT tag recovery of juvenile salmonids.
Fish; Monitoring Tool Dev.; Water Quality	DGAS-97-3	<u>Gas Abatement/Lower Snake R. through McNary Dams - Evaluate and Implement Non-Lethal Gas Bubble Trauma Symptom Detection Methods for Migrating Adult Salmonids</u> Proposed 5-yr. study to: investigate methods to detect non-lethal GBT symptoms such as medical scopes to inspect retinas and interior blood vessels of eyes; test new methods in laboratory and in-river experiments on trapped hatchery adults and develop sampling protocols for use at the population-at-large level; evaluate effects of various TDG concentrations on hatchery adults with tissue injured by a variety of sources that may or may not be related to TDG like marine mammal bites; implement full-scale multi-factor experiments to study occurrence of GBT as related to TDG, spill volume, water velocity, and adult salmonid behavior to determine prespawning mortality.
Fish; Water Quality	DGAS-97-4	<u>Gas Abatement/Lower Snake R. Dams - Determine Range of Spill Efficiencies Across Range of Operating Flows</u> Proposed 3-yr. study to: determine spill efficiency and effectiveness of juvenile salmonids under various revised spill patterns and volumes; estimate temporal variation of spill efficiency for different juvenile salmonid stocks at least at the seasonal resolution and across low v. moderate v. high spill volumes for voluntary v. involuntary spill operational flow year scenarios.
Fish; Monitoring Tool Dev.; Water Quality	DGAS-97-5	<u>Gas Abatement/Little Goose - Smolt Survival of Flow Deflector Spillbay Versus Nondeflector Spillbay Passage</u> Proposed 3-yr. study to: statistically determine direct and indirect survival of juvenile salmonids passing through spillway bays with and without flow deflectors; correlate recovery of adults returning from juvenile releases at Little Goose Dam. Direct sampling not limited to Hi-Z turbine tags, radio tracking, and PIT tag recovery will be used.
Fish; Water Quality	DGAS-97-6	<u>Gas Abatement - Deep Tank Pathology and Behavioral Response to Dissolved Gas Supersaturation</u> Proposed 4-yr. study to: conduct laboratory evaluations of fish behavior and physiological ability at TDG levels from 110 - 125% (determined by water depth) and at temperatures of 8 - 21 degrees Centigrade. Photographic observations will be made of hatchery salmonid smolts, smallmouth bass and Northern squawfish, and their interactions. Experimentally determine dose-response relationships between behavioral distribution from an available shallow water bench v. a deep water zone at different TDG levels and temperatures for hatchery salmonids and predators; evaluate symptomology using accepted protocols reviewed by NMFS Gas Expert Panel and regional TDG/GBD Technical Working Group, plus swimbladder distention and/or rupture.
Fish	MPE-96-4	<u>Barge Exit Evaluation - Development of Design Criteria to Reduce Delay of Fish in Areas of Accelerating Flows</u> On-going multi-year study to: evaluate barge exit improvements and the use of hydraulic dynamics as a behavior modifier to reduce holding and improve fish passage during raceway, truck, and barge releases; develop separator design criteria; develop criteria to reduce delays in areas of accelerating flows.

Category	Agency Code	Project
Fish; Water Quality	MPE-96-1	<u>Temperature Control Measures/Fish Ladders - Evaluation of Facility Modifications to the Adult Fishway, Snake River Projects and Evaluation of Water Temperature in Fish Ladders and Forebays, Lower Granite and Ice Harbor Projects</u> On-going multi-year study to: evaluate fishway use; evaluate closure of floating orifice gates or other recommended modifications based on final report of 1991-1994 study; monitor/collect water temperature data in fish ladders and forebays.
Fish	LSRF-94-1	<u>Lower Snake River Fall Chinook Spawning - Identification of Spawning Sites Near Lower Snake River Hydroelectric Projects</u> On-going multi-year study to: collect additional data on extent of spawning by Fall Chinook salmon in the Lower Snake River.

Note: Turbine projects TUR-97(3)-1, TUR-97(2)-2, and TUR-97(1)-3 included in this report and Appendix A as projects 14, 15, and 16, respectively.

APPENDIX D

Columbia River Fish Mitigation Program Turbine Passage Survival Program Project Study Plan

Draft

February 7, 1997

Note: The information contained in this Draft is
not entirely included in the main Report

EXECUTIVE SUMMARY

The Portland and Walla Walla Districts have developed a program to investigate improving juvenile fish passage through the turbine environment for the Corps projects located on the Snake and Lower Columbia Rivers. This document outlines the activities to conduct the investigation of short term and possible long term solutions. This investigation will consist of biological and engineering studies of existing conditions to determine baseline conditions on a dedicated turbine unit, operational and possible physical modifications to the existing turbine environment to enhance fish passage, studies to quantify the biological benefits from the modifications, and engineering testing to determine the impacts of the modifications on turbine performance and system operations. Cost effectiveness will also be addressed. The program will conclude with findings and recommendations for potential incorporation of the modifications into existing projects and future Powerhouse Major Rehabilitation efforts.

The basis for this study is reported in the Columbia River Salmon Mitigation Analysis System Configuration Study Phase I, Appendix F, dated April, 1994. This report was prepared in response to the Northwest Power Planning Council's, Columbia Fish and Wildlife Program. Section 6, titled "Turbine Passage Survival", describes the mechanisms that are the possible causes of fish damage and mortality through turbine passage. The report identifies that further investigation is necessary to quantify the parameters. The report indicated an increasing trend in fish survival through the hydrosystem with increased turbine survival for many of the stocks.

The current level of understanding of fish passage through Kaplan Turbines on the large run of river projects on the Snake and Columbia River is more qualitative than quantitative. The routing through the unit, the mechanisms that cause fish injury, and the effects of turbine modifications or operational changes need additional evaluations.

The primary focus of this study is to gather information that will allow accurate estimates of turbine passage impacts caused by turbine operational changes, changes in the intake such as installation of fish screens and surface collection structures, and changes resulting from the incorporation of improved fish passage turbine design concepts.

A decision will be made at the end of this study to determine if turbine studies will continue. The region is currently evaluating a wide range of significantly different strategies for restoring the anadromous fish runs on the Snake and Columbia Rivers to acceptable levels. This Turbine Passage Survival Program is one of the strategies that will be compared. A better estimate of turbine passage impacts caused by changes in turbine operation, addition of screens and surface collectors, and improvements inside the turbine is necessary in order to realistically compare these alternatives with other proposed strategies and to be able to make recommendations on which strategies or combinations of strategies should be implemented.

Current estimates are that direct fish survival through turbines is 89-94% for present conditions. With improvements it is estimated that turbine survival can be improved by as much as 4%. Even with other fisheries mitigation programs which are underway, such as Screened Bypass Systems, Surface Collection, and Gas Abatement, new turbine designs have the potential to complement the screened bypass systems and surface collection systems by minimizing turbine effects on the fish that are not guided by the screens or surface collectors. If new turbine designs are biologically favorable and cost effective, powerhouse discharge may be increased and spill may be reduced, aiding in reducing gas supersaturation problems for fish.

Also, since there are a large number of turbines that will likely be rehabilitated in the near future, the development of new turbine designs that increase fish survival over existing conditions should occur as soon as possible to ensure the new designs can be incorporated into scheduled turbine rehabilitation programs.

This study will focus on biological and engineering testing to determine biological design criteria, operational and physical modifications as short and long term solutions, and a study of cost effective alternatives. The findings would be applied to turbine operations and incorporated into rehabilitation programs as soon as possible. Prototype biological and engineering testing of existing conditions and operational modifications on a base case turbine will be conducted. Hydraulic and numerical model testing will be performed for existing and operational modifications to understand the hydraulics within the turbine environment and to correlate it with fish distribution data collected from the prototype. Alternative physical modifications will be studied by modeling. Modeling will be heavily relied upon to gain a better understanding of fish passage through turbines which will aid in determining the direction of future actions. Prototype testing on the new Bonneville Minimum Gap Runner design will be performed to quantify fish passage improvements due to the new runner design. Results of this study will also provide direction for future studies. Current expectations are that an improved turbine design can be developed which should be carefully evaluated in future studies. A report will document the work performed and make recommendations for continued efforts.

A Decision Matrix will be developed to show how implementation plans may be scheduled. The matrix will show how operational modifications can be incorporated into existing projects, and how turbine physical modifications may be incorporated into assumed rehabilitation schedules. The matrix will show when and if decision points will be made to delay rehabilitation programs to include provisions for improved fish passage turbine design elements.

If it is determined that the turbine studies should continue, the follow up work would consist of refining the best alternative and verifying through prototype testing that it meets criteria. A brief outline of the follow up work that may be required is provided in this PSP.

This program will occur over a 3 year period at an estimated cost of \$7.56 million. It is anticipated that as more detailed testing and information is developed, the scope will be more clearly defined and the cost estimates will be reevaluated.

It is recommended that the work as described in this Project Study Plan be carried forward to investigate biological impacts of operational and physical modifications of the turbine environment, to determine if those modifications provide enough benefit to fish survival, to determine the effects of the modifications on system operations, and to determine cost effectiveness. The investigation will conclude with implementation recommendations.

**COLUMBIA RIVER FISH MITIGATION PROGRAM
SYSTEMS CONFIGURATION SYSTEM PHASE II
TURBINE FISH PASSAGE SURVIVAL PROGRAM
PROJECT STUDY PLAN**

TABLE OF CONTENTS

<u>SECTION</u>	<u>Page</u>
Executive Summary	i
Table of Contents	iii
 SECTION 1 -PROJECT PURPOSE	
1.1 GENERAL	1-1
1.2 OPERATIONAL MODIFICATIONS	1-1
1.3 IDENTIFY BIOLOGICAL CRITERIA	1-1
1.4 EVALUATE IMPROVED TURBINE DESIGNS	1-1
1.5 SYSTEMS CONFIGURATION STUDIES 1999 DECISION	1-2
 SECTION 2 - PROJECT STUDY PLAN PURPOSE	
2.1 GENERAL	2-1
 SECTION 3 - BIOLOGICAL JUSTIFICATION	
3.1 GENERAL	3-1
 SECTION 4 - ENGINEERING JUSTIFICATION	
4.1 GENERAL	4-1
4.2 TURBINE ENVIRONMENT	4-1
4.3 TURBINE OPERATIONAL CHANGES	4-1
4.4 TURBINE DESIGN	4-2
 SECTION 5 - REGIONAL PERSPECTIVE	
5.1 GENERAL	5-1
 SECTION 6 - SCS PHASE I RESULTS	
6.1 GENERAL	6-1
6.2 TURBINE SURVIVAL WORKSHOP	6-1
6.3 BASE CASE REPORT	6-2
 SECTION 7 - TURBINE PASSAGE SURVIVAL PROGRAM SCOPE	
7.1 GENERAL	7-1

<u>SECTION</u>	<u>Page</u>
7.2 ENGINEERING AND BIOLOGICAL TESTING	7-1
7.3 INCORPORATION INTO EXISTING PROJECTS	7-6
7.4 SCHEDULES	7-7
7.5 COST ESTIMATES	7-7
7.6 RELATED ACTIVITIES	7-7
7.7 POTENTIAL FUTURE STUDIES	7-7
7.8 INCORPORATION INTO FUTURE TURBINE REHABILITATION PROGRAMS	7-11
7.9 DESIGN QUALITY CONTROL PLAN	7-11

SECTION 8 - RECOMMENDED PROGRAM

8.1 SUMMARY	8-1
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FIGURES

FIGURE 7-1 WORK FLOW CHART	7-2
FIGURE 7-2 SCHEDULE	7-8

TABLES

TABLE 7-1 COST ESTIMATE	7-9
TABLE 7-2 ORGANIZATIONAL COST ESTIMATE	7-10

APPENDICES

APPENDIX A RELATED ACTIVITIES
APPENDIX B COST ESTIMATES BACKUP

SECTION 1

PROJECT PURPOSE

1.1 GENERAL

The purpose of the Turbine Fish Survival Program is to:

- a. Develop operational modifications as short term solutions to improve fish passage survivability and condition as they pass through the existing turbines and to recommend applying these modifications as soon as possible.
- b. Identify biological design criteria to provide the basis for design of new turbine modifications to existing designs.
- c. Investigate improved fish passage turbine designs or modifications to existing designs as a potential long term solution. Improved designs would be applied to Corp's turbines to be rehabilitated.
- d. Provide information for the evaluation in the Systems Configurations Studies 1999 decisions.

1.2 OPERATIONAL MODIFICATIONS

Operational modifications (tuning a turbine) can be made without large expenses and can be implemented in a relatively short time period. Operational issues require immediate attention to benefit fish runs and current system operations. Operational changes should be investigated for turbine units with and without screens or other obstructions in place. In addition to testing the "on cam" position of the turbines without obstructions, other operational points will be tested to determine the best operating position for fish passage. Adjusting wicket gate and blade openings to minimize their effect on fish will be investigated along with estimates of the impact on turbine performance.

1.3 IDENTIFY BIOLOGICAL CRITERIA.

To quantify biological criteria, investigations of direct and indirect effects on fish are required. To study direct effects, hydraulic modeling, imaging, and fish condition and Survival tests will be performed. These tests will determine fish routes through the turbine environment and identify critical areas for improvement. Turbine environment includes the turbine intake, wheel case, runner, discharge ring, draft tube, and draft tube exit. Laboratory pressure tests (to be performed by others) will be coordinated with NPP and will be used to determine thresholds for fish condition and survivability.

1.4 EVALUATE IMPROVED TURBINE DESIGNS

Development of improved turbine fish passage designs address the long term needs of the region. Designs specifically developed to pass fish safely have a great potential to benefit all species of fish over continued operation of the existing turbine designs. Known turbine design

improvements should be incorporated into ongoing Powerhouse Major Rehabilitation programs when economical. The development of environmentally benign turbine designs is critical in improving the survival of stocks listed for protection under the Endangered Species Act. Designs developed from this program would be incorporated into future powerhouse rehabilitation programs for the Corp's Snake and Lower Columbia River Projects, complementing existing bypass systems. The cost of studying mitigating measures on improved turbine design performance will be covered by other programs.

1.5 SYSTEMS CONFIGURATION STUDIES 1999 DECISION

a. The Biological Opinion for operation of the Snake and Columbia hydropower system includes a decision date in 1999 for the Operation of the Snake River projects. This decision will help chart the future direction of fish passage in the Snake River. Currently, the options for fish passage in the Snake River that are being studied include drawdown, surface bypass, best use of the existing system, or combinations of alternatives. The 1999 decision is intended to choose a path for implementation.

b. In the Biological Opinion there is not a similar requirement or date for a decision for the lower Columbia River projects. However, to be consistent with the Snake River, a similar "directional" decision is expected in 1999. Similar to the Snake River decision this will assist in determining which path to take for future fish passage. In the lower Columbia actions being considered include surface collection, turbine improvements, extended length screens, and combinations of alternatives. Information resulting from this study will provide input for comparison of the alternatives for the 1999 decisions.

c. Estimates will be made on the effects of fish passage through turbines with surface collectors in place. If drawdown were implemented, the results of this program would be used differently. Drawdown pools will produce flow lines that are drastically different from that which the turbines are designed for and that are being evaluated under this program. For intermittent drawdowns, that period of time when pools were full would benefit from the fish passage improvement design changes. Recommendations to revise existing operation limitations of turbines may effect spill quantities, gas abatement and project fish passage route ratios. Results of this study will have no negative effect on the Juvenile Fish Transportation Program, except that more or less fish may be collected by the bypass system, should flowrates be revised.

SECTION 2

PROJECT STUDY PLAN PURPOSE

2.1 GENERAL

The purpose of this Project Study Plan (PSP) is to explain the study plan elements for the Turbine Fish Survival Program and to provide a discussion of the Systems Configuration Studies, Phase I activities. This PSP will also provide the background of activities and their approximate schedules related to fish passage through turbines (Appendix A) that is not a part of this program but will provide information for the direction of the studies. Also included in this PSP is a flow chart showing the relationship between the study plan elements and known existing powerhouse major rehabilitation's, schedule of activities, and cost estimates to perform the work. This program was cooperatively developed by the Portland and Walla Walla Districts of North Pacific Division.

SECTION 3

BIOLOGICAL JUSTIFICATION

3.1 GENERAL

Hydropower is a major source of energy in the Pacific Northwest, turbines will continue to be operated. The concerns and uncertainties of the juvenile bypass programs, and the fact that the turbines will be here in the long term future, make it prudent and timely to implement a program to study and develop turbine biological design criteria. Even if other bypass systems prove successful, there will still be a portion of juveniles entering the turbine, and fish survival benefits due to improvements in turbine passage will still be realized.

Numerous programs are being studied to bypass juvenile fish past the dams. Some of the programs being studied are the screened bypass systems, surface collection systems, and the gas abatement programs.

Although there has been some successes with the screened bypass systems, there will always be a number of juvenile salmon that will pass through the turbines. This is particularly true for summer migrants. These stocks, which have lower bypass efficiencies than spring migrants, would benefit by improved passage conditions in the turbines. Any improvements to the turbine environment will be complimentary to bypass systems and will contribute to higher survival of fish passing the project.

Surface collection is still in its infancy and has not yet been successfully developed for the Corps projects. If powerhouse surface collectors are successful, migration delay may be reduced and fish condition through the system may be improved over existing systems. However, turbine passage of fish will still occur at some level.

Improvements to the spillways, such as adding flow deflectors, will reduce the dissolved gas problem but still may not reduce gas to the recommended levels. If the turbine passage route can be improved to address biological concerns, spill volumes for fish passage may be reduced, thus, lessening the potential for gas bubble disease.

Currently, the estimates of direct fish survival through turbines that is used in modeling efforts is 89 to 94%. The 89% survival is based on several studies in the 1970's on the Columbia and Willamette River systems. There have been some recent studies to suggest that survival may be higher than that (recent studies at Lower Granite and Rocky Reach Dams), however, the 89% survival is used since there has not been regional agreement on a higher survival value. It is expected that project modifications to the turbine environment (either structural and/or operational) could improve direct survival as much as 4 percent. This increase in survival through turbines will assist in improving fish survival past a project to the goal of 95 percent as recommended in the Biological Opinion for system operations and the Northwest Power Planning Council (NPPC) fish and wildlife program. Also, this is a key time to look at improvements to turbine passage since turbine rehabilitation is ongoing, or planned for several projects on the Snake and Columbia rivers.

SECTION 4

ENGINEERING JUSTIFICATION

4.1 GENERAL

Existing technology and engineering science is satisfactory to improve fish passage through Kaplan turbines given the required biological design requirements. Since there are a large number of turbines that will likely be rehabilitated in the near future, the development of a turbine design that increases fish survival and improves fish condition over existing conditions should occur as soon as possible to insure the new designs can be incorporated into scheduled turbine rehabilitation programs.

4.2 TURBINE ENVIRONMENT

For many years the turbine environment is and has remained biologically undefined. The necessary biological information, biological restrictions, the inaccessibility of the turbine environment and the costs associated with replacement of turbine-generating equipment have precluded investigations for improved fish survival. However, technical advances, additional biological and engineering research, and the need to replace old and unreliable turbine generating sets have come together to indicate that improving fish passage through turbines has a high probability of success.

Historically, it has been desired to preclude fish entrance into the turbine environment. However, a substantial number of fish avoid diversion from the turbine and are passed down stream. Given that the powerhouses and turbines on the Snake and Columbia rivers will be rehabilitated or replaced, it is likely that the application of existing engineering science to future biological design criteria would result in improvement in both turbine performance and fish passage survival.

4.3 TURBINE OPERATIONAL CHANGES

The existing turbines on the Snake and Columbia rivers are being operated under the basic assumption that identically designed machines operate identically. This assumption is generally valid for units recently installed. However, deviations in wear and tear result in deviations in optimum operation between machines. These deviations are infrequently corrected by index testing. The installation of fish diversion devices in a turbine intake effects the flow distribution and optimum operating conditions. Conventional index testing has only been marginally successful in maintaining optimum turbine operation with diversion devices in place. Ongoing studies are investigating methods to improve turbine operation with fish diversion devices installed. Implementation of recommendations resulting from ongoing studies would be verified at the base case prototype test site (McNary). This will "tune" a turbine for optimum operation with and without fish diversion devices in place. Another system benefit resulting from this project study plan will be a quantifiable turbine survival rate for the McNary site. Biological turbine survival testing with a fully instrumented turbine may establish fish survival rates better or worse than currently assumed. This may by itself substantially alter the spill, bypass and turbine flow quantity relationship to achieve project survival rates of 95% or greater.

4.4 TURBINE DESIGN

The state of the art in turbine design has taken significant steps forward with better measurement, manufacturing, and control technology to allow serious consideration of environmental design parameters in developing a turbine design.

Technical advances in computer analysis, fish monitoring, sound and laser technology, hydraulic modeling and simulation, turbine design, material science, flow visualization, and remote imaging provide the opportunity to investigate, predict, measure, and evaluate the turbine environment, fish passage and define biological unknowns in quantifiable engineering terms.

There is sufficient technical justification to expect turbine performance increases of 2 to 6 percent in efficiency over existing conditions with turbine rehabilitation or replacement while improving fish survival through the turbine environment. However, given that biological criteria for turbine fish passage is undefined, there are possibilities that optimum fish passage may alter existing generation and operating ranges.

SECTION 5

REGIONAL PERSPECTIVE

5.1 GENERAL

The Turbine Fish Passage Survival Program has been coordinated with other Federal and State and tribes agencies through the Anadromous Fish Evaluation Program (AFEP), Fish Facility Design Review Work Group, and the Turbine Working Group.

This program is supported by National Marine and Fisheries Service (NMFS) in the Biological Opinion for system operations as reasonable and prudent alternative No. 6 (Operation of turbines within 1 percent peak efficiency), reasonable and prudent alternative No. 15 (improving fish passage with a goal of 95 percent survival through each project), and conservation measure No. 5 (develop a program to study/improve fish passage through turbines).

This program is also supported by the NPPC's fish and wildlife program. The program item 5.6A.14 calls for studies to improve the understanding of the mechanisms of fish mortality in turbines, and item 5.6D.1 calls for operation of turbines within 1 percent of peak efficiency. The North Pacific Division's Turbine Fish Passage Survival Program is consistent with these items.

SECTION 6

SCS PHASE I RESULTS

6.1 GENERAL

In response to the NPPC's request to enhance the survival of migrating adult and juvenile salmonids in passing the lower Columbia projects, studies for various improvements to these projects were undertaken and are presented in the "System Configuration Studies (SCS) report Phase I, Appendix F". The purpose of the studies was to identify alternative implementation methods for each improvement, perform preliminary engineering and design evaluations, estimate the potential biological benefits, provide preliminary cost estimates for implementation and operation, estimate implementation schedules, and develop the requirements for further evaluations, including engineering and biological hydraulic model and field studies for the next phase of work. One of these studies was to improve turbine fish passage survival. The two major items resulting from the SCS study of turbine passage survival are the Turbine Passage Survival Workshop, and the Turbine Basecase Report. This Project Study Plan for SCS Phase II uses the information from SCS Phase I as a guide and provides a detailed description of the proposed studies.

6.2 TURBINE SURVIVAL WORKSHOP

A Turbine Passage Survival Workshop was held in Portland, Oregon, on May 31-June 1, 1995. The workshop was comprised of a 20-member panel of engineering and biological experts from government, industry, and universities, along with over 50 non-panel participants. The major goals of this workshop were: 1) Determine how to deliver fish from the turbine to the tailrace environment that are ready to cope with the river environment, 2) Focus on those uncertainties that prevent closure on developing biological criteria, 3) Identify and prioritize the causal agents of turbine mortality. The general conclusion from the workshop was that there are physical and operational modifications to the turbines that have been identified that could possibly increase the survival of fish passing through the turbine environment as well as some studies that could be investigated immediately to improve our knowledge base. Conclusions and recommendations from the workshop are as follows:

- a. Optimize Existing Operation. Investigate engineering options currently available to modify the turbine environment and operations with fish survival as the goal. Use existing or additional programs, studies, and modeling to ensure the optimal operation of existing turbine units with and without fish screens installed.
- b. Study Injury Mechanisms. The direct injury mechanisms in need of study were prioritized as follows a) mechanical injury, b) cavitation and shear, and c) pressure. These injury mechanisms may be studied immediately. Also, determine if there are "sweet spots" in the turbine environment. The indirect mechanisms (water quality and stress) were prioritized lower due to uncertainties about their influence on fish survival.
- c. Determine Fish Distribution. Determine fish distribution and passage route within the turbine environment using imaging or tracking techniques, strive to learn fish location, orientation, and reactions (passive and active) of fish relative to the turbine environment.
- d. Establish Criteria. Establish base case engineering and biological criteria required to select a turbine that will be used for base case testing. Consider the possibility of using more than one unit for base case testing.

e. Transfer Information. Pursue the question of technology transfer to other applications, such as FERC licensed plants.

6.3 BASE CASE REPORT

The purpose of the report is to gather data on physical attributes of turbines and the ability to perform prototype tests for eight prospective base case sites. Data from the report has aided in selecting a site to perform engineering and biological prototype tests. Information presented in the report include dimensional and operational data on: blade shape, wicket gates, draft tube shape, runner submergence, head, speed, operational flow range, number of blades, and scroll case shape. Also included in the report is a summary of biological tests performed to date related to turbine passage. The following Corps projects were investigated in the report: Bonneville First and Second Powerhouses, The Dalles Dam, John Day Dam, McNary Dam, Ice Harbor Dam and Big Cliff Dam. Additionally, Priest Rapids Dam, a Grant County PUD project, is included in the report. McNary Unit 5 has been selected by the Corps as the base case prototype test site.

SECTION 7

TURBINE PASSAGE SURVIVAL PROGRAM SCOPE

7.1 GENERAL

The Turbine Passage Survival Program Scope of work consists of using a basecase turbine and site dedicated for engineering and biological prototype testing. Engineering and biological prototype tests will be performed on the selected unit for existing conditions and modifications to existing operations to obtain baseline information. Hydraulic modeling of existing conditions and operational modifications will be made to provide additional information that cannot be collected from the prototype studies. Numerical analysis on existing turbines will be made to supplement data that are difficult to collect on the hydraulic model. Biological testing in a lab will be conducted to aid in determining biological criteria for design. A summary report will document the work performed and provide recommendations. A flow chart showing the program elements and their relationship to each other is shown on figure 7-1.

All prototype testing will be coordinated with the NMFS to ensure that all ESA requirements are met.

7.2 ENGINEERING AND BIOLOGICAL TESTING

a. Select Base Case Turbine Unit. The Corps selected a representative base case turbine site to be dedicated for prototype testing. The selection was based on the ability to perform biological testing, engineering testing, powerhouse capacity, and the ability to use that unit or set of units without largely interfering with the hydrosystems operations. The McNary site has been selected, however, testing may also be performed at other sites currently being rehabilitated. The test unit will be available for normal operation during non test times. The unit will be unavailable for normal operation during test times and during installation of monitoring equipment. The selection of McNary Unit 5 was made with the advice of the Turbine Working Group and will be coordinated with the fisheries agencies, tribes, the BPA, and the appropriate Corps entities.

b. Prototype Testing. Prototype testing consists of biological and engineering testing. Biological testing consists of fish survival and condition studies and fish route/distribution studies. Engineering studies will consist of index testing, flow testing, imaging investigations, and pressure distribution testing.

Initial prototype testing will "tune" the turbine for optimal performance with and without fish diversion devices. Operational modifications testing will consist of testing the base case unit under various operating points to investigate the wicket gate/blade angle combination that optimizes fish passage conditions. The current operating criteria based on fish passage is that the turbines should be operated within 1% of its best operating efficiency. Theoretically, this would provide the least turbulent flow conditions providing for the best fish passage conditions. Other theories suggest that operating the units at points beyond the 1% limitation can provide better conditions for fish by opening the wicket gates to reduce the chance of mechanical injury. This theory will be investigated.

Work Flow Chart

Figure 7 - 1

(1) Biological Testing. Biological prototype testing consists of fish condition and survival tests and fish route/distribution studies. The testing will satisfy the NMFS Biological Opinion conservation recommendation No. 4, to "determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action....". The first two years of the prototype testing program will be used to investigate the technologies and methods to study fish distribution, and will focus on determining mechanical and pressure mechanisms of fish injury/mortality within the turbine environment. The second and third years will consist of biological testing of the existing unit and operational modifications to that unit with and without fish screens.

(a) Fish Survival and Condition Testing. The purpose of this testing is to determine the differential direct and indirect mortality rates (and injury) due to turbine passage under current conditions and operations using both PIT tag and balloon tag methodologies.

The base case testing will include testing of one existing turbine unit to help define design criteria for prototype turbine improvements as well as some baseline data for evaluation of the prototype. During prototype testing, this will include comparisons of the existing unit operations and other operating points of the turbine.

This study will be coordinated with the DOE Advanced Hydro-Turbine work group as well as regional resource agencies to ensure study design and methods that will adequately evaluate fish condition and survival of fish passing through turbines.

(b) Fish Distribution Studies. One need that has arisen based on information presented at the turbine workshop was the need for information regarding fish distribution within the turbine environment. Currently there is not an established methodology that will allow this study to be conducted, however, there are technologies that may be applicable, such as sound and visual equipment, light emitting tags and infra-red video. It is the intent of this study to apply these technologies to assist in determining fish distribution within the turbine environment. This study is important to help us understand the physical conditions the fish are experiencing as they pass through the turbine environment. The work will include comparing fish trajectories to physical modeling to verify the reliability of models for future evaluations of various designs.

The objectives of the study will be to coordinate and develop a methodology (and associated equipment) for use within the turbine environment to assist in determining fish distribution, prototype test a methodology (and associated equipment) within a main-stem turbine, and develop test protocol and methodologies to determine fish distribution within the turbine environment, determine/map fish distribution within the turbine environment under a range of operations (1999), and to compare fish trajectories to physical modeling to determine if we can rely on these models in the future to evaluate various designs. Grant Co. Public Utility District is currently scheduled to begin initial investigations of imaging methodology. Coordination will be performed to eliminate duplication of efforts.

(c) Laboratory Pressure Studies. Currently, there is some information on the pressure changes within the turbine environment. However, there is no clear connection between the pressure changes and what the fish actually experience when they pass through a turbine. Information relating fish distribution in the water column and pressure changes are needed to evaluate potential changes to operations and/or runner design. At the Turbine Workshop, pressure was not considered to be a major concern, however, effects have not been quantified. Pressure drops on the suction side of the blade is one of the main aspects of the turbine design that manufacturers can modify. The effects on fish are quantifiable using existing methods and equipment. The DOE has plans to study the pressure effects on fish and is coordinating the effort with the Corps. The goals of the study are to cycle various sizes and species of fish through turbine pressure regimes and verify that pressure is not a design concern, or establish that it is a

concern above certain absolute levels. Turbine designs can then be developed to stay above these absolute levels.

The objectives of the study are to determine pressure changes at specific locations within the turbine under various operations and cycles, subjecting various sizes and species of fish to pressure regimes that match the levels found, and relating fish trajectories from the fish distribution studies to these results.

(d) Bonneville Minimum Gap Runner Evaluations. Minimum gap runners are being installed in the turbines at Bonneville First Powerhouse beginning in 1998. The Turbine Survival Program will conduct biological testing of the MGR under both high and low flow conditions. The purpose of this study will be to evaluate the MGR at low and high turbine loads. These data, combined with data from post construction studies (described below) conducted at peak efficiency will provide an overall assessment of MGR performance.

The objective of this study (under the Turbine Survival Program) will be to evaluate the effectiveness of the MGR with respect to fish mortality and injury. The data from this study (1998 and 1999) will be used to not only evaluate the MGR at Bonneville First Powerhouse, but to collect data that can be used to help in designs of turbines (and estimate potential improvements) at other Projects on the Snake and Columbia Rivers.

This study will be coordinated closely with the Bonneville First Powerhouse Rehabilitation Program to ensure that data collected will meet the needs of both groups and will not be duplication of efforts. The Rehab Program will be conducting studies (in 1998 and 2000) designed to be a post construction evaluation of the new turbine runner as compared to the existing turbines (at Bonneville 1) at peak efficiency. These two programs (MGR test and Post construction evaluation testing) will be used together to determine fish condition and survival information of the MGR for use in the Turbine Survival Program.

(2) Baseline Engineering Testing. Initial index testing will be performed to assure turbine operating conditions are consistent with the design and present operating parameters. After establishment of "on cam" performance with and without fish screens, abbreviated field testing will be performed to assure "on cam" operation of the prototype. In the second and third year of the program, operational modifications will be made and biological tests will evaluate biological benefits of the operational modifications.

Long term installation of instrumentation and data acquisition equipment for monitoring turbine operation will be required to maintain definable turbine operating conditions during subsequent biological and turbine modification field testing. It is expected that an index test would be performed annually for the next three years to confirm correct operation of the turbine and would be incorporated with other engineering and biological testing. Biological and engineering field testing will be coordinated to reduce the number of required tests (estimate up to 4 additional annual tests) and maintain reasonable unit availability for meeting site generating or ESA fish passage requirements.

(a) Index Testing. Index measurement equipment will consist of a set of transducers (pressure, differential pressure, linear, rotational, water level, and power measurement), data acquisition and recording equipment and computer monitoring, reporting and data reduction equipment. This equipment will be dedicated for field testing on the baseline unit.

(b) Flow Testing. The turbine intake will be instrumented with sonic measurement equipment suitable for estimation of the quantity of flow and water velocity profiles.

(c) Turbine Environment Imaging. Investigate the engineering requirements of imaging equipment and the selection of a methodology (and associated equipment) for use within the turbine environment to assist in biological fish passage route/distribution studies. The selection of a method will be coordinated with the associated biological studies and other groups. Prototype field tests of the selected methodology (and associated equipment) within the baseline turbine will be conducted to determine reliability and applicability of the methodology for use in fish distribution studies and evaluation of operational modifications to the baseline turbine.

(d) Pressure Distribution Testing. Pressure taps will be installed at selected points within the prototype turbine. The measurement points will be selected in coordination with biological pressure studies, hydraulic model studies, and turbine imaging. The measurements will indicate the pressure and will aid in verifying the pressure cycles that fish are subjected to. The data will be collected by the data acquisition equipment. An iterative process of laboratory model investigations and prototype measurements will allow the determination of the pressure distributions and cycles within the turbine environment to which a fish is subjected. This work will be coordinated with others.

c. Modeling. Modeling will consist of turbine hydraulic modeling at the Waterways Experiment Station (WES) and numerical modeling. Turbine hydraulic modeling is required to examine in detail the complete passage route of water through the turbine environment. The hydraulic model will be relied upon to better understand fish passage through turbines which will help determine direction and set priorities of future actions. Numerical modeling will aid in providing estimated turbine performance data and will provide data that can not be collected on the hydraulic model. Turbine performance modeling is out of the scope of this work, but would likely be required if future follow up turbine studies occur. Turbine performance modeling would be performed in a turbine manufacturer's laboratory. Modeling would be capable of determining absolute pressures and pressure cycles under prototype head conditions and ranges, and to determine expected turbine performance in response to design and operational modifications.

(1) Turbine Hydraulic Modeling.

(a) Description. The 1:25 McNary turbine model located at the WES will be used for hydraulic modeling. The model water passageways are made of clear plastic and will accurately represent the entire turbine passageway from the forebay and intakes through the draft tube to the tailrace. The use of clear plastic allows for easy visibility and data collection. The test heads will be scaled to the model scale. A non-intrusive laser Doppler velocimeter, neutrally buoyant beads, dye, videotape, and photography will be used to collect data and visualize flow patterns and fish passage routes.

(b) Testing Baseline Conditions. Initial testing of baseline conditions on the McNary and Lower Granite models will be performed. Testing will be performed for existing conditions and operational modifications. The McNary and Lower Granite configurations will aid in identifying possible problem areas within the turbine environment.

Areas to be studied are flow patterns in the intake, entering and exiting the turbine runner, throughout the draft tube, and draft tube discharge. Flow patterns include water velocity, flow direction, formation of vortices, rapid decelerations and accelerations, and turbulence. Pressure measurements and pressure fluctuations can also be measured. Flow patterns will be examined in these areas to identify possible critical areas on which to focus. Information from this testing will provide input to key locations for instrumentation of prototype engineering and biological testing. Information gained from those models will be used to define and prioritize future turbine related work.

(c) Alternatives Testing. Hydraulic modeling and numerical modeling must be used together in an iterative process to optimize the expected prototype performance. Hydraulic modeling will be used to qualitatively evaluate alternatives to the baseline testing. The following modifications to the turbine water passage will be investigated: trash racks, intake water passage, turbine scroll case, and draft tube. These areas will be examined in the hydraulic models and, if flow patterns appear promising, the modifications will be evaluated in the numerical model.

(2) Numerical Modeling.

(a) General. One, two, and 3-dimensional computer modeling is under development by other entities. Under the DOE's AHT program, the DOE has contracted with Georgia Tech and Alden Research Laboratories to develop the numerical codes to compute flow parameters through the turbines. In previous studies, numerical modeling of flow past fish screens and in the draft tube area have been unsuccessful. There has been some success in modeling and simulating conditions at the turbine runner. The runner area is the most difficult area to visualize flow patterns and collect data on in the WES model, so this is an area where the numerical models will compliment the physical modeling.

(b) Testing. The numerical modeling part of this program will be contracted to a private firm or an organization that has expertise in the field. Numerical modeling of the turbine environment of the selected unit will be calibrated based on results of the baseline prototype and physical modeling. Results from numerical modeling will be compared to data collected on the prototype and the success of the numerical models to predict parameters will be evaluated. If results are successful, future turbine rehabilitation designs may be made based on numerical analysis. A satisfactory numerical modeling routine will reduce physical modeling requirements.

d. Cost Effectiveness Analysis. Cost effectiveness analysis will facilitate comparisons amongst alternative turbine environment improvement measures. The cost effectiveness analysis will be used to identify the least cost means of improving turbine fish passage survival. The costs for the analysis will be National Economic Development (NED) costs including project implementation, operation and maintenance and hydropower costs. Turbine efficiency gains (or losses) as the result of turbine fish passage improvements will result in changes to hydropower production. These changes will be modeled to quantify the economic costs. Any other known economic costs will also be identified.

e. Decision Matrix. A decision matrix will be developed to show how implementation plans may be scheduled. The matrix will show how operational modifications can be incorporated into existing projects, and how turbine physical modifications may be incorporated into assumed rehabilitation schedules. The matrix will show when and if decision points will be made to delay rehabilitation programs to include provisions for improved fish passage turbine designs.

f. Evaluations and Recommendations Report. A report will present the prototype and modeling test results obtained through the studies performed on the selected base case turbine. Biological criteria developed will be presented. Fish benefits from operational modifications will be evaluated. Alternatives for physical modifications will be presented and evaluated. A selection and recommendation of alternatives to be considered in follow up turbine studies (turbine modification studies) will be made based on the ability of the alternatives to meet the biological criteria in a cost effective manner. Information gained through the related activities as described in this report will be summarized. The direction of the turbine modification studies will be better established at the end of this study and with new information gained from the related activities.

7.3 INCORPORATION INTO EXISTING PROJECTS

Information gained through this study may be incorporated into existing turbine systems. If operational modifications are determined to be beneficial for fish, operationally acceptable, and cost effective, the operational modification concepts can be tested and implemented on all Corps lower Columbia and Snake River projects immediately. Implementation of such operational modifications are not included in the scope of this PSP.

7.4 SCHEDULES

a. The schedule to accomplish the work for this study is shown in figure 7-2. The work will occur over a 3 year period. Pertinent information from this study will be available for the 1999 Systems Configuration Study decision. The schedule was prepared based on the assumptions that funding is provided, and the region supports the program.

b. A schedule showing the time lines for the related activities relative the CENPD Turbine Passage Survival program is provided in Appendix A.

7.5 COST ESTIMATES

The summary cost estimates per fiscal year and work item are shown on table 7-1 and shows a total cost estimate of \$7.56 million. Table 7-2 summarizes the labor and contract costs for the Portland and Walla Walla Districts, and Hydroelectric Design Center. Back up information for the estimates are provided in Appendix B. Cost estimates are preliminary and will change based on further refinements to the scope of work.

7.6 RELATED ACTIVITIES

A summary of each known activity related to fish passage through turbines is provided in Appendix A. Information developed from these programs will provide input to the direction of this study. Extensive coordination will occur between the Corps and other entities conducting studies.

This Corps study is intended to provide a comprehensive evaluation of the effects of the turbine environment on fish survival by physical and numerical modeling, and prototype testing on a base case unit. The difference between this program and the other related activities is that by conducting all tests on a single unit configuration, definite conclusions can be drawn regarding the tracing of the route of fish through the turbine, collection of data on the pressures and velocities along that route, and the effect of those conditions on the fish. None of the related activities have a comprehensive plan.

7.7 POTENTIAL FUTURE STUDIES

Follow up work to the Turbine Passage Survival Program could implement the recommendations for turbine modifications testing as described in the Turbine Passage Survival Report. Two options for implementation are considered. The first option consists of conducting prototype tests on a modified turbine at the base case site, McNary Dam. The second option consists of incorporating results directly into an ongoing turbine rehabilitation, pending that the Major Turbine Rehabilitation Program for that project will provide support. Turbine Modification Studies will consist of refining the design of the selected alternative by modeling, constructing and installing the new turbine design, post construction biological and engineering verification, numerical modeling verification, and a report.

Project: TURBINE
 Time Now: 02Oct95
 Start: 02Oct95
 Finish: 29Sep99
 Run: 07Feb97
 Page: 1 of 1

Turbine Passage Survival Program

Schedule in Fiscal Years

Figure 7-2

Planned
 Milestones
 Subprojects
 Subprojects

**TURBINE PASSAGE SURVIVAL PROGRAM
COST ESTIMATE**

TASK	Lead/Org.	FY 97		FY 98		FY 99	
		Contract	Labor	Contract	Labor	Contract	Labor
Scoping/ Finish PSP/ Management			\$241,200				
Prototype/Basecase Testing							
Biological Testing	NPP-PE-E						
Bonneville MGR Tests				\$840,000	\$130,600	\$840,000	\$130,600
Fish Condition/ Survival				\$600,000	\$79,200	\$600,000	\$64,200
Fish Dist. Studies	PE-E	\$200,000	\$57,400	\$240,000	\$65,400		\$33,100
Engineering Testing							
Initial Instrumentation Procure & Install	HDC	\$495,000	\$75,100				
Index testing/Operational Optimization			\$109,600	\$0	\$109,800	\$0	\$142,700
Investigate Imaging Equipment			\$20,600	\$0	\$15,500		
Imaging and Monitoring Instrumt Procure and Install	HDC		\$36,500	\$600,000	\$154,500		
Field testing & Evaluation			\$48,400	\$0	\$111,300		\$111,300
Engineering Baseline Testing report						\$0	\$154,500
Modeling- Operational Mods and Alternatives Testing							
McNary WES Modeling	NPW/NPP	\$235,000	\$88,300	\$223,200	\$70,000	\$120,000	\$74,600
Lower Granite WES Modeling	NPW/NPP			\$144,000	\$69,300		
Numerical Modeling	HDC	\$55,700	\$37,200	\$66,900	\$44,600	\$35,300	\$20,800
Report	NPP					\$0	\$191,100
Subtotals		\$985,700	\$714,300	\$2,714,100	\$850,200	\$1,595,300	\$922,900
Fiscal Year Total		\$1,700,000		\$3,564,300		\$2,518,200	

Project Total = \$7,561,400

Table 7 - 1

TURBINE PASSAGE SURVIVAL PROJECT STUDY PLAN

ORGANIZATIONAL COST ESTIMATE

Table 7 - 2

FY 97					
NPP		NPW		HDC	
CT/MIPR	Labor	CT/MIPR	Labor	CT/MIPR	Labor
\$200,000	\$410,000	\$235,000	\$168,300	\$550,700	\$135,900
Total per district		\$610,000		\$403,300	
				\$686,600	

FY 98					
NPP		NPW		HDC	
CT/MIPR	Labor	CT/MIPR	Labor	CT/MIPR	Labor
\$840,000	\$198,100	\$223,200	\$360,700	\$810,900	\$164,100
Total per district		\$1,038,100		\$583,900	
				\$975,000	

FY 99					
NPP		NPW		HDC	
CT/MIPR	Labor	CT/MIPR	Labor	CT/MIPR	Labor
\$35,300	\$248,100	\$120,000	\$349,900	\$600,000	\$194,100
Total per district		\$283,400		\$469,900	
				\$794,100	

7.8 INCORPORATION INTO FUTURE TURBINE REHABILITATION PROGRAMS

Information gained through this program should be incorporated into upcoming rehabilitation programs as soon as the information becomes available. Biological criteria should be established and can be incorporated into rehabilitation programs ongoing at that time.

7.9 DESIGN QUALITY CONTROL PLAN (DQCP)

A DQCP will be developed that addresses the technical management approach, design team coordination, preparation of reports, and independent technical review of the reports. The DQCP will include the process to track design quality progress. Adherence to costs and schedules will be tracked and measured. A Technical Review Plan (TRP) will be prepared which will be a part of the DQCP. The DQCP will be prepared upon approval of this Project Study Plan.

SECTION 8

RECOMMENDED PROGRAM

8.1 SUMMARY

The program recommended in this PSP has been developed to improve survival and condition of fish passing through turbines. As the program progresses and more detailed testing and information is developed, the scope will be more clearly defined and the estimates and schedules will be adjusted as needed. It is recommended that the work as described in this PSP be carried forward to investigate turbine biological design requirements, biological impacts of operational modifications of the turbine environment, to determine if those modifications provide a cost effective benefit to fish survival, and to determine the effects of the modifications on system operations. Investigations to study potential physical modifications for fish passage improvements should be performed. If the initial investigations imply that modifications can significantly benefit fish and there is no significant impact to system operations, it will be recommended that future studies to verify the benefits be carried forward, either as an extension of this program or as a part of a future turbine rehabilitation program.

APPENDIX A

Related Activities

RELATED ACTIVITIES

GENERAL. There are various efforts underway studying the turbine environment related to fish passage. Results of these studies will be considered, and if appropriate, incorporated into this program. The ongoing efforts are: Bonneville Rehabilitation Project, Department of Energy (DOE) Advanced Hydro Turbine (AHT) Investigations, McNary Turbine Modeling, Lower Granite Turbine Modeling, Bonneville Power Administration's (BPA) 2406 program, the BPA's Generation beyond 1% Limitation Investigations, Dardanelle, Sault Ste. Marie, Rocky Reach, and Wanapum projects. Due to the magnitude of activities, a Turbine Working Group was formed as a regional advisory group. The following are goals and summaries of each effort.

TURBINE WORKING GROUP. Because of the diverse nature of the Corps and regional turbine study activities, a Turbine Working Group (TWG) comprised of representatives from HDC, North Pacific Division, NPP and NPW convened in 1994 to coordinate and exchange information on the various efforts. To coordinate efforts outside the Corps, the TWG invited representatives from the BPA, Public Utility Districts (PUD) of Chelan, Grant and Franklin Counties, the Electric Power Research Institute (EPRI), Department of Energy (DOE) and the Idaho National Engineering Laboratory (INEL), and the NMFS. The working group is to exchange information, provide guidance to the Corps' Turbine Fish Passage Survival Program, and to see that duplication of effort within the region is minimized so funding available is prudently expended.

BONNEVILLE REHABILITATION PROGRAM. A major rehabilitation program by Portland District is currently underway to restore the reliability and performance of the turbines, generators, and switchyards at the Bonneville Dam First Powerhouse. As part of this effort, all 10 of the Kaplan turbine runners will be replaced. Alternative designs for the new runners have been model tested by the turbine manufacturer, a design has been selected, and the manufacturer has been instructed to proceed with the fabrication, delivery, and installation of the new runners. The runner design selected for Bonneville has incorporated the latest information available regarding improved unit performance and fish passage conditions. This includes increasing unit efficiency and potentially reducing injuries to juvenile fish from mechanical sources by closing runner gaps. The new runner has been designed to achieve a high level of peak efficiency, the leading and trailing edge gaps at the hub have been reduced by redesigning the hub, and the gap at the blade tips has been reduced through the modification of the discharge ring.

Installation of the new Bonneville runners will start in 1997 and continue through 2002. The first runner installation will be completed in 1998, at which time the new design will be evaluated for its effect on fish condition and survival. The design has been or will be incorporated into this proposed program as an initial step in improving turbine fish passage survival.

DEPARTMENT OF ENERGY ADVANCED HYDRO TURBINE SYSTEM PROGRAM. The DOE and INEL in Idaho Falls have been conducting a program to bring forward to the hydropower industry new turbine designs that are more environmentally friendly. The program is currently in the first phase, the conceptual design phase. The program has the goal of developing new turbine designs that address low dissolved oxygen, instream flow, powerhouse pollutant, and most importantly for the Pacific Northwest, the fish passage conditions within the turbine environment. If promising concepts are developed during Phase I, the program will proceed into Phase II, where the concepts from Phase I will be

modeled, and finally Phase III, where new turbine designs will be constructed and evaluated for biological and engineering performance.

The Corps has provided technical expertise to DOE and this program in the areas of turbine design (CENPD-ET-HDC) and fish passage through turbines (CENPP-PE-E). Representatives from these offices have participated as members of the AHT technical review committee to provide technical expertise to the AHT program. Their participation will also ensure coordination between the Corps turbine fish passage survival program and the DOE AHT, and eliminate any duplication. The Corps representatives will continue to integrate the two programs, bring knowledge gained from the DOE AHT program into the turbine fish passage survival program, and look for ways to reduce the cost, scope, and schedule of the Corps turbine fish passage survival program.

The DOE AHT program is currently in Phase I. A contract has been issued to Voith Hydro of York, Pennsylvania, to develop concepts for designs that improve fish passage through Kaplan and Francis turbines, low dissolved oxygen, and minimum flow applications. Another contract has been issued to Alden Research Laboratory to develop a concept where a hydrostol pump is turned into a turbine to take advantage of the more benign hydraulic characteristics of the Hydrostol design. The DOE is in the planning stages of Phase II, and will proceed in FY97 if funded.

Confirming that the Corps turbine fish passage survival program is right on track, in April, 1995, the DOE AHT technical review team persuaded the DOE of the need to redirect their Phase II efforts. The DOE AHT will now investigate fish distributions through turbines to gain the necessary information that will allow any new runner design to proceed beyond the stage we are at today. Without additional biological design information, any fish passage concepts for Kaplan turbines developed in Phase I can not be advanced into Phase II. While it is too soon to tell whether the DOE Phase II will be funded and whether useful information will be provided to our program in a timely manner, the study team will look for ways to use the DOE AHT program to reduce our costs and schedules.

MCNARY TURBINE MODELING. In early 1993 a contract was awarded to a turbine manufacturer, to construct and test a model of an existing turbine at the McNary Project. The objective of this study was twofold. First, to evaluate the effect of fish screen devices on overall turbine efficiency and recommend improved operational guidelines where appropriate. Second, to study the hydraulic aspects of flows through the turbine and downstream areas in regard to potential impacts on fish passage.

The study is being accomplished using two separate modeling efforts. The first includes a 1:25 scale turbine model and is being conducted by Voest Alpine M.C.E. in Austria. The primary emphasis of this phase of the testing is to evaluate the effect of fish screen installation on turbine performance. This includes both standard and extended length screens. These tests will be compared to on site field test of the prototype unit. The second effort will utilize the existing McNary 3-bay Fish Guidance Efficiency (FGE) intake model at the Waterways Experiment Station (WES) which include operating wicket gates, adjustable turbine blades, and the downstream draft tube and boil area. The purpose of this effort is to examine flow conditions in regards to fish passage through the turbine and draft tube areas.

The above described modeling effort is unique in that it includes the fish screens during the performance testing. In order to model the fish screens correctly, the turbine modeler is required to use a different similitude relationship. Since this method has not been used

before in testing turbines, it is necessary to compare the model results to prototype conditions to verify that the modeling method is feasible.

The low head (Froude) testing of the model was complete in August 1995, a high head verification test was completed in July, 1996 and results are currently being evaluated. This high head verification testing which is funded by BPA is necessary to ensure that the low head model test method is reasonable. HDC will use the model study results(if successful) to develop new cam curves for the with extended screen condition for McNary and to then extrapolate this information for the other Corps Projects. It is anticipated that this change may gain approximately 1.4 percent in operating efficiency.

In addition to the screen studies, improvement measures as identified by the Bonneville Rehabilitation Program, such as reduced gaps, and modified hub and discharge rings, will be investigated in the McNary Turbine Model under separate funding provided by BPA.

LOWER GRANITE TURBINE EVALUATION STUDY. The Lower Granite Turbine Evaluation Study was initiated in March 1994. A contract for construction of a model turbine was awarded to Voest Alpine in January 1995. The model is being used to evaluate hydraulic conditions which are occurring within the existing turbine unit at Lower Granite Dam.

A turbine fish survival test was completed in the spring 1995. During this testing the turbine was monitored very closely. This information combined with detailed testing of the turbine model should provide a better understanding of juvenile fish mortality or condition vs. turbine operation and associated hydraulic conditions. Once existing conditions are understood then research into turbine improvements will be undertaken via the turbine model. A special turbine model is also part of this contract and will be shipped to WES for incorporation into the existing 1:25 Lower Granite 3-Bay Intake Model. This will allow head to head comparison of fish passage conditions between the McNary and Lower Granite Units to determine effects of different water passage configurations. The Lower Granite Turbine Model will also be used to evaluate the impacts of drawdown on turbine operation. The development of improved performance curves for the operating condition with fish screens will improve the ability of HDC to accurately extrapolate the new cam curves to other projects.

In 1995 the Corps of Engineers, Walla Walla District contracted with Normandeau Associates to conduct turbine survival studies at Lower Granite Dam using balloon tag methodology. Survival probabilities were estimated for fish released at mid/upper elevations within the turbine intake with turbines operating within 1% operating limit at high and low discharge. Fish were also released at the mid-intake elevation with the unit operating in "cavitation" mode. Estimated survival probabilities were approximately 95 percent for all releases. Although the estimated survival was similar for all test scenarios, there was some difference in the type of injury to the fish. Fish released in the upper-intake area appeared to suffer a greater rate of mechanical injury than fish released in the mid-intake releases.

THE 2406 PROGRAM. This program has been developed by the North Pacific Division and the BPA to improve power generation efficiency through funding specifically allocated from BPA to NPD for this purpose. This work consist of updating the 3-D cam operating systems of several existing Snake and Columbia River Corps of Engineers powerhouses. The updating consists of modification to the existing control system and programming to allow use of switch selectable turbine operating data for optimizing turbine performance with and without specific fish diversion devices in place in the turbine intake.

The work includes field Index testing at Bonneville, modification of the McNary control system to include hydraulic head input, model test verification testing and reprogramming control systems at other selected plants. This effort has expanded to include other priority operations and maintenance work effecting system generating capabilities.

BONNEVILLE POWER ADMINISTRATION'S GENERATION BEYOND 1 PERCENT ISSUE. The Turbine Survival Program will investigate a hypothesis presented at the turbine workshop that turbines operated at a higher gate setting may provide improved survival conditions within the turbine environment. Turbine engineers suggested that when a turbine is operated beyond the 1 percent of peak efficiency range at the upper end, the efficiency loss is primarily due to frictional losses, and that in this range the overall fish passage conditions and survival may be improved. This would result from increased spacing between the mechanical components and a reduced probability of mechanical injury. Verification of the hypothesis would greatly increase system operational flexibility with the ability to operate at a more open blade angle and higher power setting, thereby reducing involuntary spill, gas production, and possibly gas related impacts to fish stocks. The benefits also include elimination of operational constraints that impact current Columbia River hydropower system operations.

The 1 percent turbine operating limit is in the NMFS 1995 Biological Opinion listed as item number 6 in the "Reasonable and Prudent Alternative to the Proposed Action" Section. Several meetings have been held to discuss operating beyond the 1 percent turbine operating limit. These meetings were initiated by the Turbine Technical Working Group. This discussion was based upon the hypothesis that the 1 percent turbine operational criteria may need to be reconsidered. It was determined that this concept should be discussed in a larger forum. Follow-up working meetings are planned to strategically present this issue at other forums

Current operation of turbine units during the fish passage season is limited to within 1 percent of the best operating point of the unit. Currently this allows for a reasonable range of operation since the efficiency curves for the existing units are fairly flat, with turbine efficiency around 86 to 91 percent. The new units being designed for Bonneville rehabilitation project have much higher efficiencies (94 percent), however, they have a steeper efficiency curve with a reduced band of operation near the best operating efficiency. It is possible that operation outside of 1 percent efficiency for replacement units may still be better for fish than operation of the existing units since, even outside of the 1 percent, actual efficiency of the unit is significantly higher with the new design.

SAULT STE. MARIE. The Detroit District is currently replacing a station service Kaplan turbine at the St. Mary's powerhouse as part of a modernization. The replacement turbine runner is required to be designed using computer numerical analysis, CFD and other computer design tools. This is the Corp's first Kaplan design which is based upon numerical modeling techniques. The numerical modeling is complete and the turbine is being fabricated and is scheduled for commissioning in late 1996.

The turbine will be field tested to determine the accuracy of the numerical modeling. Numerical modeling has the potential to assist in the design of turbines considering environmental design criteria. The data and test information on velocity profiles and the turbine environment resulting from current and future efforts can be used to calibrate and refine numerical models sufficiently to make them usable within the turbine water passage for other than turbine performance.

ROCKY REACH TURBINE REPLACEMENT. Chelan County PUD is in the process of replacing all 11 of its turbine runners at Rocky Reach Dam on the Columbia River for

rehabilitation purposes. Design of the new runners will increase generating efficiency, reduce cavitation, and improve fish passage. Installation of the new runners has begun and is scheduled for completion in the year 2001.

An important part of Chelan's turbine runner design efforts include environmental enhancements intended to improve fish passage survival for those anadromous fish not successfully guided into fish bypass systems. Beginning in 1993, Chelan performed tests which estimated the fish passage survival of its existing turbine runners. Test results pointed to certain features of the older runner design which could be improved. Two of the alternatives showed promising results including high generating efficiency and low cavitation. The two most promising alternatives were then tested in a 1:30 scale turbine performance model, with the use of carefully scaled, buoyancy-controlled fish-simulating particles. The interaction between the fish-simulating particles and the runner were observed with the use of specialized high speed, low light digital imaging cameras. An alternative was chosen and is being installed at Rocky Reach. The new prototype turbine has been tested with live juvenile salmonids to estimate fish passage survival.

Results from previous tests of the old design at this project showed an estimated fish survival of approximately 93 percent (1995 study). In 1996 fish were released near the top of the intake and at a mid-depth in the intake. The results of the testing in 1996 which tested both an old and new turbine, showed a combined survival (upper and lower releases) for the old and new units were greater than 95 percent. The survival estimates for the new runner design were not statistically different from the old unit overall. These results indicate (preliminary) that even though the overall survivals did not vary, injury types may vary between the new and old unit. One conclusion of this study is the multiple fish release points (more than two) are needed for a comparison of new and old turbine designs. This study also indicated possible differences in identifying "pinching" types of injury that are suspected to occur at the gaps in the turbine runners.

WANAPUM DAM TURBINE REPLACEMENT. Grant County PUD has conducted fish survival studies at Wanapum Dam on existing Turbine Unit 9 in the spring of 1996. The PUD is using this information to develop new turbines which would improve fish passage. Model tests are being conducted to improve turbine performance in areas of improving efficiency and flattening the efficiency curve. This approach is being done on the basis of the current theory that operating within 1 percent of the best operating efficiency is best for fish passage. Preliminary results show that the best survival occurs not at the peak of the efficiency curve, but at a lower efficiency point corresponding with higher generation. The PUD is a participant in the Advanced Hydroturbine (AHT) Project sponsored by the DOE which is using the Wanapum turbine for their project. The PUD is also integrating the work from the AHT Project to Wanapum. A proposal is being developed to visualize fish passing through the turbine.

Schedule of Related Activities

Fiscal Years