PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Characterize Historic Channel Morphology Of The Columbia River: Mcnary Pool

BPA project number: 20100
Contract renewal date (mm/yyyy): ☐ **Multiple actions?**

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

Business acronym (if appropriate) PNNL

Proposal contact person or principal investigator:

Name	Tim P. Hanrahan
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NPPC Program Measure Number(s) which this project addresses
7.6A.2, 7.6D, 1995 Ammendment 4.1A

FWS/NMFS Biological Opinion Number(s) which this project addresses
1998 Supplement to 1995 RPA Measure 10 (drawdown)

Other planning document references
ISG (1996) Return to the River (pages 164 & 269).
ISRP (1998) Review of the Fish and Wildlife Program, Report 98-1, Recommendation V-B.2.b.2

Short description
Characterize pre-dam channel morphology of the Columbia River between the mouths of the Yakima and Walla Walla rivers, focusing on the physical features controlling the development of salmonid spawning and rearing habitat.

Target species
fall chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (O. mykiss)

Section 2. Sorting and evaluation

Subbasin
Lower Mid-Columbia Mainstem, Walla Walla, Yakima, Lower Snake Mainstem

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☐ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☐ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Quantify the pre-impoundment physical characteristics of the channel and riparian/floodplain areas in the Columbia River between the confluence of the Yakima River downstream to the confluence of the Walla Walla River, including lower reaches of tribs.	a	Acquire existing historic spatial data and compile it into GIS databases.
		b	Characterize and quantify historic channel

			morphology.
2	Describe typical alluvial characteristics of large rivers based on reference reaches (e.g., Hanford Reach of the Columbia River, Hells Canyon Reach of the Snake River) and the fluvial geomorphology literature.	a	Acquire existing data and knowledge describing alluvial characteristics in reference reaches.
3	Describe the pre-impoundment historic flow conditions in the proposed study reach and reference reaches.	a	Acquire, compile and analyze historical flow records.
4	Compare the results from objectives (1) and (2) to determine the presence and extent of similar characteristics.	a	Compile results from Objective 1.
		b	Compare results from Objective 2 with results from Objective 4, Task a.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	10/1999	9/2000		Task completion report	40.00%
2	10/1999	9/2000		Task completion report	15.00%
3	10/1999	9/2000		Task completion report	15.00%
4	3/2000	9/2000		Project completion report	30.00%
				Total	100.00%

Schedule constraints

Completion date
FY2000

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel		%51	61,245
Fringe benefits		%9	11,072
Supplies, materials, non-expendable property		%5	6,103
Operations & maintenance		%0	
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		%0	

NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel		%6	7,721
Indirect costs		%18	21,762
Subcontractor	Central Washington University	%10	11,848
Other		%0	
		TOTAL BPA FY2000 BUDGET REQUEST	$119,751

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
		%0	
		%0	
		%0	
		%0	
		Total project cost (including BPA portion)	$119,751

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget				

Section 6. References

Watershed?	Reference
☐	Berggren, T.J. and M.J. Filardo 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13:48-63.
☐	Hanrahan, T. P., D. A. Neitzel, M. C. Richmond, and K. A. Hoover. 1998. Assessment of drawdown from a geomorphic perspective using geographic information systems: Lower Snake River, Washington. Final Report to Walla Walla District, U.S. Army Corps of E
☐	Imhof, J. G., J. Fitzgibbon, and W. K. Annable. 1996. A hierarchical evaluation system for characterizing watershed ecosystems for fish habitat. Can. J. Fish. Aquat. Sci. 53(Suppl. 1): 312-326.
☐	Independent Scientific Group (ISG). 1996. Return to the river, restoration of salmonid fishes in the Columbia River ecosystem. Pre-publication copy dated September 10, 1996. Northwest Power Planning Council, Portland, OR.
☐	Independent Science Review Panel (ISRP). 1998. Review of the Columbia River Basin Fish and Wildlife Program for Fiscal Year 1999 as Directed by the 1996 Amendment to the NW Power Act. Northwest Power Planning Council, Portland, OR.
☐	Kellerhals, R., and M. Church. 1989. The morphology of large rivers: Characterization and management. In D. P. Dodge (ed.), Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106: 31-48.
☐	Knighton, D. 1984. Fluvial forms and processes. Edward Arnold, NY, NY, 218 pp.
☐	Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial Processes in Geomorphology. W.H. Freeman and Co., San Francisco, 522 pp.
☐	Lichatowich, J.A., L. Mobrand, L. Lestelle, and T.Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in Pacific Northwest watersheds. Fisheries. 20:10-18.

☐	MacArthur, R.H. and E.O.Wilson. 1967. The theory of island biogeography. Monographs in Population Biology I. Princton University Press. Princeton, New Jersey
☐	National Marine Fisheries Service (NMFS). 1998. A Supplemental Biological Opinion to the March 2, 1995, Biological Opinion on Operation of the Federal Columbia River Power System.
☐	Northwest Power Planning Council (NPPC). 1994. 1994 Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, Oregon.
☐	Richards, K. 1982. Rivers: Forms and process in alluvial channels. Methuen, NY. 361 pp.
☐	Rieman, B.E., and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124: 285-296.
☐	Rosgen, D. L. 1994. A classification of natural rivers. Catena 22: 169-199.
☐	Schumm, S. A. 1977. The Fluvial System. Wiley, NY, 338 pp.
☐	Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers: Research & Management, 12:391-413.
☐	Townsend, C. R. 1980. The ecology of streams and rivers. Studies in Biology No. 122. Edward Arnold, London. 68 pp.
☐	Wilcox, B.A. 1980. Insular ecology and conservation, p. 95-117. In M.E. Sourle and B.A. Wilcox (eds). Conservation Biology: an evolutionary-ecological perspective. Sinauer, Sunderland, Massachusetts.
☐	
☐	

PART II - NARRATIVE

Section 7. Abstract

The ISG (1996) and ISRP (1998) have identified the need to protect and enhance mainstem spawning and rearing habitat for salmonids. Both groups also recommended evaluation of additional spawning and rearing habitat that may be made available in the event of operational modification or removal of lower Snake River dams, John Day Dam, and McNary Dam. The ISRP (1998) specifically indicated that such actions could prove most beneficial to spawning and rearing habitat of mainstem populations, and that, “Scientific information on this issue may be critical in supporting whatever decisions are made regarding modification of dams or their operations.” The research conducted under this proposal will result in the scientific information necessary for evaluating historic habitat conditions, as well as for reducing uncertainty regarding the predictions of future mainstem habitat conditions following flow modifications. The most informative outcome of this research will be the analysis of the historic presence and extent of alluvial characteristics in the McNary pool and associated study reaches. The project will be based on sound methods in applied fluvial geomorphology, and coupled with geographic information system analyses. Results from this work will include reports, peer-reviewed papers, professional society and agency presentations, GIS databases, digital elevation models of river channels and floodplains, electronic and hardcopy maps.

Section 8. Project description

a. Technical and/or scientific background

Historically, salmon existed as a series of local populations that comprised a larger regional population. Metapopulation theory suggests that these regional populations formed core areas that supplied colonists to remote satellite populations (Rieman and McIntyre 1995). The assumption is that these metapopulations overcame extinction risks by incorporating local populations having diverse life history strategies that use more and different habitats. Construction of mainstem dams fragmented these populations by blocking the flow of colonists between the regional and local populations (Lichatowich et al. 1995). One concern is that elimination of both upstream and downstream source populations has increased the distance of the source pool of potential colonists (after MacArthur and Wilson 1967, Wilcox 1980). The ISG (1996) and ISRP (1998) have suggested that fall chinook spawning in the Hanford Reach are a core population that could serve to seed nearby mainstem habitats (i.e., McNary reservoir) and tributaries (i.e., lower Snake and lower Yakima rivers). Small satellite populations of fall chinook currently in the lower Yakima and Snake rivers could also expand into nearby mainstem habitats.

The creation of a reservoir system where a riverine system once existed has reduced habitat diversity and life history strategies, and resulted in synchronized life histories subject to the same stochastic and deterministic risks. The overall effect of these processes is a reduction in production capacity of the Columbia River Basin and an increase in risk that salmon populations will continue to decline unless restorative actions are taken to diversify mainstem habitats. The ISG (1996) and NMFS (1998) have suggested that operational modification (i.e., drawdown) of lower Snake River dams and McNary Dam could enhance mainstem salmonid habitats. Such enhancement may be particularly beneficial immediately downriver of the Hanford Reach by extending the expression of alluvial river attributes from the Hanford Reach downstream to the Yakima River confluence and lower reach, as well as to the Snake River confluence and it's lower reaches. However, the productive capacity in these reaches will continue to be influenced by regulated flows from upstream hydropower facilities, as well as by the backwater effects of McNary Dam. Thus, the predevelopment alluvial river ecosystem is not expected to be fully restored in these reaches through operational modification of dams. Nevertheless, the rehabilitation and enhancment of predam biotic and abiotic components depends on the extent to which alluvial characteristics can be restored. Characterizing and quantifying the predam channel morphology in these reaches provides a starting point for determining future channel characteristics and habitats, while also reducing the uncertainty of future management decisions and analyses.

Many in the region believe that McNary Dam on the Columbia River and the four Lower Snake River dams have inundated important alluvial reaches of these large rivers. Restoration of such inundated reaches towards becoming a functional river system entails more than merely increased flow rates that would result from dam modification. The climate, geology, and landcover of a catchment basin combine to form the hydrological, physical, chemical and biotic properties that result in alluvial river *ecosystems*. Alluvial rivers are those that are capable of shaping their own bed and bank – they are self-formed (Richards 1982). Their channel morphology results from the entrainment, transportation, and deposition of unconsolidated sediments throughout the channel course (Richards 1982). This morphology is maintained in "dynamic quasi-equilibrium" – where sediment is transported through or stored within the channel (dynamic), but the channel morphology remains relatively stable over time (quasi-equilibrium) even though the channel may not be static (Knighton 1984, Richards 1982). In ideal alluvial rivers, this morphological relationship is maintained when the rates of sediment supply and sediment transport are roughly equal (Kellerhals and Church 1989). Physicochemical factors (e.g., temperature, light intensity, oxygen concentrations) vary longitudinally and horizontally as a result of channel heterogeneity from headwaters to mouth (Townsend 1980). The primary variables driving the distribution and abundance of biota are usually abiotic (e.g., discharge, channel/floodplain geometry, temperature, substrate, nutrients) and mostly determined by the geologic and climatic setting of the catchment basin (Stanford et al. 1996). In combination, all of these factors (e.g., hydrology, morphology, physicochemical, etc.) interact to determine the productive capacity of an alluvial river ecosystem. Our proposed work will address two primary controlling factors of alluvial river ecosystems: hydrology and channel morphology.

The U. S. Army Corps of Engineers (Corps) is currently considering several options for modifying the operation of the Lower Snake River hydropower system in order to protect and enhance existing salmon and steelhead populations. For all the drawdown scenarios considered, only the permanent natural river option (NRO) has been recommended for further evaluation. It is not known to what extent the NRO can restore alluvial characteristics and other normative biotic and abiotic functions of alluvial rivers. Hanrahan et al. (1998) have conducted research and continue to work in the Lower Snake River to address the uncertainties of restoring alluvial river characteristics. Much of this work is based on historical analyses of channel morphology coupled with hydrodynamic flow modeling. One premise of this work is that it is not possible to restore salmon populations without restoring those conditions that supported their life history requirements. The research is conducted within a framework that maintains the links between formative processes (cause) and physical channel characteristics (response) (Imhof et al. 1996) -- incorporating controlling factors and desired attributes of unregulated alluvial rivers.

The research to be conducted under this proposal will address the question, “What were the morphological characteristics of the Columbia River between the confluence of the Yakima River downstream to the confluence of the Walla Walla River prior to hydroelectric development?” Results from this work will provide useful information in resolving uncertainty surrounding the physical habitat and biotic components that may develop in this area following operational modifications of lower Snake River dams and McNary Dam. That is, any uncertainties may be tempered by bounding the predicted changes between known pre-dam channel morphology and present day conditions.

b. Rationale and significance to Regional Programs

The ISG (1996) and ISRP (1998) have identified the need to protect and enhance mainstem spawning and rearing habitat for salmonids. Both groups also recommended evaluation of additional spawning and rearing habitat that may be made available in the event of operational modification or removal of lower Snake River dams, John Day Dam, and McNary Dam. The ISRP (1998) specifically indicated that such actions could prove most beneficial to spawning and rearing habitat of mainstem populations, and that, “Scientific information on this issue may be critical in supporting whatever decisions are made regarding modification of dams or their operations.” The research conducted under this proposal will result in the scientific information necessary for evaluating historic habitat conditions, as well as for reducing uncertainty regarding the predictions of future mainstem habitat conditions following flow modifications. At the spatial and temporal scales considered in this proposal, it is the physical channel characteristics that control habitat development, and ultimately the structure of biotic communities.

The objectives of the Fish and Wildlife Program (NPPC 1994, 1995) and recommendations by the ISG (1996) and ISRP (1998) contain several common themes relative to mainstem spawning and rearing habitat for fall chinook salmon and steelhead. FWP objectives 7.1A.1, 7.1C.3, 7.6A.2, 7.6D and 1995 Amendment 4.1A all target evaluations of mainstem habitat, limiting factors, and uncertainty reduction. This study will provide a quantitative description of historic channel characteristics, which are controlling factors for habitat conditions. The results will provide the baseline information for necessary for determing what were alluvial reaches and what were not, as well as guideposts for identifying and evaluating mainstem habitat restoration options.

c. Relationships to other projects

This proposed project is based on a similar framework and methodology as ongoing work by PNNL in the Lower Snake River being conducted for the Corps titled, "Assessment of Drawdown from a Geomorphic Perspective." Both projects will benefit from data and knowledge sharing, as well as knowledge of the river systems. The BPA has funded PNNL and USGS to complete a mainstem project titled, "Assessment of the Impacts of Development and Operation of the Columbia River Hydroelectric System on Mainstem Riverine Processes and Salmon Habitats." This is a coarse scale assessment, as the geographic extent of the project ranges from Bonneville Dam to Grand Coulee Dam on the Columbia River, and from the mouth of the Snake River up to Twin Falls, ID. Nevertheless, that project and the proposed project will share data, knowledge, and experience in evaluating riverine processes.

d. Project history (for ongoing projects)

e. Proposal objectives

Hypothesis: Prior to impoundment the McNary pool reach of the Columbia River and the lower reaches of its main tributaries exhibited physical characteristics typical of alluvial reaches in large rivers.

Objective 1. Quantify the pre-impoundment physical characteristics of the channel and riparian/floodplain areas in the Columbia River between the confluence of the Yakima River downstream to the confluence of the Walla Walla River, including lower reaches of main tributaries (i.e. Yakima, Snake, Walla Walla).

> Assumption. Pre-impoundment data sources (hardcopy maps, charts, reports) are available for use and can be compiled into a geographic information system (GIS) database.
>
> Assumption. Pre-impoundment data sources contain information describing physical channel and floodplain characteristics.

Objective 2. Describe typical alluvial characteristics of large rivers based on reference reaches (e.g., Hanford Reach of the Columbia River, Hells Canyon Reach of the Snake River) and the fluvial geomorphology literature.

> Assumption. Alluvial characteristics of large rivers can be described and quantified in common terms (i.e., nomenclature).

Objective 3. Describe the pre-impoundment historic flow conditions in the proposed study reach and reference reaches.

> Assumption. Pre-impoundment historic flow records for these reaches are available.

Assumption. Pre-impoundment historic flow conditions maintained the alluvial characteristics of the subject reaches.

Objective 4. Compare the results from objectives (1) and (2) to determine the presence and extent of similar characteristics.

Assumption. Alluvial characteristics of all reaches will be expressed in terms that are comparable.

Products from this work are expected to include reports, peer-reviewed papers, professional society and agency presentations, GIS databases, digital elevation models of river channels and floodplains, electronic and hardcopy maps, and hydrologic analyses results (e.g., time-series and flow-duration curves).

In addition to the products identified above, the most informative outcome of this research will be the analysis of the historic presence and extent of alluvial characteristics in the McNary pool and associated study reaches. If alluvial characteristics were present in this area decision-makers in the region will want to know the ability and uncertainty of altered flow conditions to restore those alluvial river attributes. In this case we can prepare a follow-on proposal, similar to previous (Hanrahan et al. 1998) and ongoing work in the Lower Snake River, to answer these questions. For example, in 1997 we addressed the ability of altered flow regimes in the Lower Snake River to erode and transport accumulated fine sediments out of Lower Granite Reservoir. The results indicated that most of the sediment would be transported out of the reservoir within five years (Hanrahan et al. 1998). Our current work in the Lower Snake River includes assessing the ability of altered flow regimes to mobilize the channelbed surface that's been compressed and cemented by reservoir water volumes and fine sediment storage.

Contrarily, if our research proposed here indicates that the McNary pool and associated study reaches did not contain an appreciable amount of alluvial characteristics, then it's unlikely that decision-makers in the region would find a need to continue analysis of spawning and rearing habitat restoration in this area.

f. Methods

Objective 1. Quantify the pre-impoundment physical characteristics of the channel and riparian/floodplain areas in the Columbia River between the confluence of the Yakima River downstream to the confluence of the Walla Walla River, including lower reaches of main tributaries (i.e. Yakima, Snake, Walla Walla).

Task a. Acquire existing historic spatial data and compile it into GIS databases.

For some areas of the Columbia Basin, historic spatial data exists in the form of hardcopy maps, electronic data files, and hardcopy reports. These spatial data will be compiled into GIS data layers, edited, error-checked, and georeferenced. All GIS data layers will be accompanied by metadata complying with the Content Standards for Digital Geospatial Metadata created by the Federal Geographic Data Committee (FGDC).

Task b. Characterize and quantify historic channel morphology.

Using the data layers resulting from Task a, elevational data will be extracted and used for the construction of 3D surface models of bathymetry and near-channel topography. The GIS data layers will be used to quantify channel morphology, including hydraulic geometry, channelbed slope (longitudinal and lateral), planform geometry, channel confinement, bar and island features, hydraulic features (rapids, pools, riffles), channel and floodplain substrates, and geologic composition.

Objective 2. Describe typical alluvial characteristics of large rivers based on reference reaches (e.g., Hanford Reach of the Columbia River, Hells Canyon Reach of the Snake River) and the fluvial geomorphology literature.

Task a. Acquire existing data and knowledge describing alluvial characteristics in reference reaches.

This task is focused on obtaining existing spatial data and descriptions of alluvial river characteristics for the reference reaches. This includes consultation with and acquiring of data sets from PNNL, USFWS, USGS, Idaho Power Co., and other scientists knowledgeable of the fluvial geomorphology of these river systems. We will also complete a review of the fluvial geomorphology literature pertaining to alluvial characteristics of large rivers. This information will be compiled into a report describing typical alluvial characteristics of these reaches. The description of alluvial characteristics will conform with accepted fluvial geomorphology nomenclature, based on such works as Leopold et al. (1964), Schumm (1977), Richards (1982), Rosgen (1994), and others.

Objective 3. Describe the pre-impoundment historic flow conditions in the proposed study reach and reference reaches.

Task a. Acquire, compile and analyze historical flow records.

This task will assist in quantifying the formative processes that shaped historical physical channel characteristics. Under this task we will quantify the magnitude, timing and duration of baseflows, bankfull flows (1:1 – 1:2 yr.), riparian flows (1:2 – 1:20 yr.), and floodplain flows (1:20 – 1:100 yr.). The results will be presented as time-series and flow-duration curves, and compiled into a report.

Objective 4. Compare the results from objectives (1) and (2) to determine the presence and extent of similar characteristics.

Task a. Compile results from Objective 1.

The results from Objective 1 will include GIS databases, digital elevation models of river channels and floodplains, electronic and hardcopy maps, and narrative reports describing historical channel morphology. The narrative reports will include descriptions of alluvial characteristics that conform with accepted fluvial geomorphology nomenclature.

Task b. Compare results from Objective 2 with results from Objective 4, Task a.

This task will result in a report containing quantitative and qualitative analyses of the historic presence and extent of alluvial characteristics in the McNary pool and associated study reaches. The report will be available in harcopy and electronic format, and will include final maps of the study reach.

g. Facilities and equipment

PNNL has specialized facilities that support this evaluation effort. We utilize commercial and PNNL-developed GIS software applications including ARC/INFO, ArcView, GRASS, IDRISI, EPPL7, and the PNNL-developed hydrodynamic models MASS(1/2). Configured in central GIS platforms, these systems support analysis of vast data sets, spatial analysis of complex ecosystems, and multi-dimensional modeling and imaging.

h. Budget

The total cost to complete this work in FY2000 is estimated at approximately $120,000. Approximately 60% of this amount is for personnel and fringe benefits. Contained within these two categories are direct labor and direct overheads including program development and management (business development, planning and monitoring), PNNL procurement and subcontract support, general and administrative expenses (e.g., accounting, legal, contracting, and personnel departments), and service assessment fees (costs paid to the Department of Energy for plant-wide support services such as patrol, fire, library, mail and roads). Five percent of the total is for supplies and materials. These include software, software updates, electronic and hardcopy GIS data layers and maps, reference material and other miscellaneous expenses. Approximately 6% of the budget is for travel to and from the work sites of collaborating scientists and agencies, as well as travel to various locations to present research findings at regional and national meetings. The percentage of the budget allocated to indirect costs is approximately 18%. Indirect costs include primarily organizational overheads which include costs for management, supervision, and administration of technical departments as well as costs for buildings and utilities, maintenance and operation of research equipment. Finally, approximately 10% of the budget is for subcontractors, specifically to assist with converting hardcopy spatial data sources to electronic GIS data layers (e.g., digitizing).

Section 9. Key personnel

TIMOTHY P. HANRAHAN, Research Scientist
Pacific Northwest National Laboratory (PNNL)

Project Role: Principal Investigator and Project Manager (0.6 FTE)

Education

B.S., General Sciences, University of Wisconsin, 1989
M.S., Natural Resource Science, Washington State University, 1993

Experience

Mr. Hanrahan's professional interests and research focus on large river processes, including biotic and abiotic interactions. He is a technical contributor to public- and private-sector projects, including ecological characterization and monitoring, ecological risk assessment, ecological resource compliance, and regulatory analysis (e.g., NEPA, ESA, CWA). He has worked on all phases of these projects including study design, field data gathering, data analysis, habitat evaluation, development and evaluation of GIS-based habitat models, application of risk assessment tools, and technical writing. Mr. Hanrahan's current work focuses on assessing aquatic ecosystem effects resulting from fluctuating large river flow regimes. Through this research, other projects, and training he has developed a strong background in methods for assessing flow/geomorphology relationships, assessment and modeling of aquatic habitats, and stream temperature modeling.

Ongoing and Recent Projects

Assessment of Drawdown from a Geomorphic Perspective (lower Snake River), *Ongoing*: Co-principal investigator of a study assessing the geomorphological changes resulting from natural river drawdown, and the subsequent effects on anadromous salmonids.
Snake River Hyporheic Study (Hells Canyon), *Ongoing*: Co-principal investigator of a study investigating the interactions between ground water and surface water, and the associated relationship with fall chinook salmon spawning habitat.
Assessment of Columbia River Hydroelectric System on Mainstem Riverine Processes and Salmon Habitats, *Ongoing*: Co-principal investigator of a systematic assessment of the extent and types of habitat modifications that have occurred to the mainstem Columbia and Snake rivers.
Fisheries Technical Assessment, Central Valley EIS (California), *Recent*: Technical lead on a project to conduct an independent scientific assessment of the methods and results contained in the fisheries and aquatic impacts assessment of the Central Valley Project Improvement Act EIS.

Columbia River Comprehensive Impact Assessment, *Recent*: Technical contributor to the assessment of ecological risk from organic and inorganic contaminants from the Hanford Site on almost 100 miles of the Columbia River.

Relevant Publications

Hanrahan, T. P., D. A. Neitzel, M. C. Richmond, and K. A. Hoover. 1998. Assessment of drawdown from a geomorphic perspective using geographic information systems: Lower Snake River, Washington. Final report submitted to U.S. Army Corps of Engineers, Walla Walla District.

Blatner, K. A., T. P. Hanrahan, and M. S. Carroll. 1994. Evaluating alternative development strategies. USDA Forest Service PNW Technical Bulletin, Blue Mountains Natural Resources Institute. 10 pp.

Frazier, B. E., B. C. Moore, and T. P. Hanrahan. 1992. Remote sensing of *Lythrum salicaria*, purple loosestrife, in wetland environments of Washington. State of Washington Water Research Center, Washington State University.

David R. Geist
Senior Research Scientist

Project Role: Co-Investigator (0.2 FTE)

EDUCATION

B.S., Biology, Eastern Washington University, 1984
M.S., Biology, Eastern Washington University, 1987
Ph.D., Fisheries Science, Oregon State University, 1998

EMPLOYER AND EXPERIENCE

Dr. Geist is a Senior Research Scientist in the Ecology Group at Battelle, Pacific Northwest National Laboratory. He has been with Battelle since 1991 and has extensive experience and expertise in the ecology of Pacific Northwest fishes, especially fall chinook salmon in the Hanford Reach. Dr. Geist is developing and testing a conceptual spawning habitat model that describes the importance of landscape processes in determining utilization of spawning areas by fall chinook salmon. Dr. Geist has served on several technical panels related to future management of the Hanford Reach, including invited expert testimony at Congressional hearings. He is a member of the American Fisheries Society and American Institute of Fishery Research Biologists. Recent research activities include:

- Lead scientist and project manager for several projects addressing environmental monitoring and technology applications, including investigating habitat utilization, bioenergetics, and migration behavior of fall chinook salmon in the Columbia River.
- Studying ground-water/surface-water interactions and contaminant movement in salmon spawning areas in the Hanford Reach.
- Modeling impacts of hydropower system operations on resident fish in the Upper Columbia River, including Lake Roosevelt; and participating in planning and evaluation activities of salmon supplementation in the Yakima and Klickitat rivers.

SELECTED PUBLICATIONS

Geist, D.R. 1995. "The Hanford Reach: What Do We Stand to Lose?" Illahee 11:130-141.

Geist, D.R., M.C. Joy, D.R. Lee, and T. Gonser. 1998. "A Method for Installing Piezometers in Large Cobble Bed Rivers". Ground Water Monitoring and Remediation 18:78-82.

Geist, D.R., and D.D. Dauble. 1998. "Redd Site Selection and Spawning Habitat Use by Fall Chinook Salmon: the Importance of Geomorphic Features in Large Rivers." Environmental Management 22:655-669.

Geist, D.R., D.D. Dauble, and R.H. Visser. 1997. The development of a spawning habitat model to aid in recovery plans for Snake River fall chinook salmon." Fiscal Year 1995 and 1996 Progress Report to the Bonneville Power Administration, Portland, Oregon.

Geist, D.R., L.W. Vail, and D.J. Epstein. 1996. "Analysis of Potential Impacts to Resident Fish from Columbia River System Operation Alternatives". Environmental Management 20:275-288.

Dennis D. Dauble
Technical Group Manager

Project Role: Co-Investigator (0.2 FTE)

EDUCATION

B.S., Fisheries, Oregon State University, 1972
M.S., Biology, Washington State University, 1978
Ph.D., Fisheries, Oregon State University, 1988

EMPLOYER AND EXPERIENCE

Dr. Dauble has been a staff member at Battelle, Pacific Northwest National Laboratory since 1973. He is currently a Staff Scientist and Technical Group Leader for the Ecology Group. Dr. Dauble regularly interacts with state and federal regulatory and management agencies in issues relating to regional impacts of power plants, hydroelectric facilities, and other energy-development activities on anadromous and resident fishes.

Dr. Dauble has considerable expertise in activities related to impacts from hydropower generation and flow regulation on anadromous salmonids. For example, he served on regional committees and directed studies to evaluate potential impacts of drawdown and other operational scenarios on anadromous fish survival. He also provided assistance to the Snake River Recovery team on the passage and survival of Endangered Species Act salmon stocks. Dr. Dauble was involved in salmonid enhancement efforts in the Yakima River Basin, including coordination of environmental review activities among the science and policy teams for the project. On-going studies focus on characterizing habitat requirements of fall chinook salmon in the mid-Columbia and lower Snake rivers which involve the use of aerial photography, stream mapping, and geographic information system (GIS) techniques. He recently synthesized 45 yrs of data on factors influencing the abundance of fall chinook salmon populations in the Hanford Reach.

Dr. Dauble is a member of the American Fisheries Society, the Ecological Society of America, the Northwest Scientific Association, the Pacific Fishery Biologists, and is a Fellow in the

American Institute of Fishery Research Biologists. He is also an adjunct professor at Washington State, Oregon State, and Central Washington State universities.

SELECTED PUBLICATIONS

Dauble, D.D. and D.G. Watson. 1997. “Status of fall chinook salmon populations in the mid-Columbia River, 1948-1992.” North American Journal of Fisheries Management 17:283-300.

Dauble, D.D., R.L. Johnson, R.P. Mueller, C.S. Abernethy, B.J. Evans, and D.R. Geist. 1994. Identification of fall chinook salmon spawning sites near lower Snake River hydroelectric projects. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Dauble, D.D., J.R. Skalski, A.E. Giorgi, and A. Hoffman. 1993. Evaluation and application of statistical methods for estimating smolt survival. DOD/BP-62611-1. Prepared for Bonneville Power Administration, Portland, Oregon.

Dauble, D.D. and R.P. Mueller. 1993. Factors affecting the survival of upstream migrant adult salmonids in the Columbia River basin. Recovery issues for threatened and endangered Snake River Salmon. Technical Report 9 of 11. Prepared for Bonneville Power Administration, Portland, Oregon.

Dauble, D. D., T. L. Page, and R. W. Hanf, Jr. 1989. “Spatial distribution of juvenile salmonids in the Hanford Reach, Columbia River”. Fishery Bulletin 87(4):775-790.

Section 10. Information/technology transfer

Products will consist of scientific reports that will be made available through BPA’s report distribution system. In addition, we anticipate papers (rather than or in addition to reports) will be published in peer reviewed journals. GIS data layers and maps will be made available electronically and hardcopy. All GIS data layers will be accompanied by metadata complying with the Content Standards for Digital Geospatial Metadata created by the Federal Geographic Data Committee (FGDC).

Congratulations!