U.S. Army Corps of Engineers
Walla Walla District

Lower Snake River Programmatic Sediment Management Plan

Draft Environmental Impact Statement

December 2012

LOWER SNAKE RIVER
PROGRAMMATIC SEDIMENT MANAGEMENT PLAN
DRAFT ENVIRONMENTAL IMPACT STATEMENT

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Lead Agency. U.S. Army Corps of Engineers, Walla Walla District
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Abstract. This draft Programmatic Sediment Management Plan (PSMP) and Environmental Impact Statement (EIS) presents the U.S. Army Corps of Engineers' (Corps) plan for managing sediment within the lower Snake River system to meet the authorized project purposes that are affected by sediment deposition. The Corps is preparing this EIS to evaluate a long-term plan for management of sediment accumulation that affects authorized purposes of the four lower Snake River lock and dam projects in southeastern Washington and north central Idaho. This EIS also addresses an immediate need action, consistent with the plan, to reestablish the navigation channel in four locations.

The purpose of the proposed action is to establish a programmatic framework to evaluate and implement potential sediment management measures to address problem sediment accumulation. The PSMP provides a long term plan to manage, and prevent if possible, the accumulation of sediment that interferes with authorized project purposes. The immediate need action to reestablish the navigation channel to the Congressionally-authorized dimensions will be consistent with the PSMP.

The Corps formulated a range of alternatives by identifying and evaluating sediment management measures, then assembling the feasible and effective measures into groupings based on how measures could be implemented and what agencies could implement them. The alternatives are programmatic and describe broad categories of actions that could be implemented to meet the purpose and need. The Corps identified Alternative 7 – Comprehensive (Full System and Sediment Management Measures) as the preferred alternative. The alternative includes dredging and dredged material management along with other sediment and system management measures, and provides the Corps with a complete toolbox for addressing sediment that interferes with the authorized purposes of the four projects.

Draft Copy. The draft copy of this report was officially filed with the Director, Office of Federal Activities, U.S. Environmental Protection Agency on December 14, 2012.

Comments. Comments on the draft report are due on February 8, 2013, 55 days from December 21. 2012, the expected the date of U.S. Environmental Protection Agency's publication of Notice of Availability in the Federal Register. Comments are to be directed to the following:

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Further Information. Additional information on the Draft Environmental Impact Statement and related documents also may be obtained from the above. The documents are also available on the Corps web site at www.nww.usace.army.mil/Missions/Projects/ProgrammaticSedimentManagementPlan.aspx .

Environmental Operating Principles

The U.S. Army Corps of Engineers has reaffirmed its commitment to the environment by formalizing a set of “Environmental Operating Principles” applicable to all its decision-making and programs. These principles foster unity of purpose on environmental issues, reflect a new tone and direction for dialogue on environmental matters, and ensure that employees consider conservation, environmental preservation and restoration in all Corps activities.

Sustainability can only be achieved by the combined efforts of federal agencies, tribal, state and local governments, and the private sector, each doing its part, backed by the citizens of the world. These principles help the Corps define its role in that endeavor.

By implementing these principles, the Corps will continue its efforts to develop the scientific, economic and sociological measures to judge the effects of its projects on the environment and to seek better ways of achieving environmentally sustainable solutions. The principles are being integrated into all project management process throughout the Corps.

The principles are consistent with the National Environmental Policy Act, the Army Strategy for the Environment with its emphasis on sustainability and the triple bottom line of mission, environment and community, other environmental statutes, and the Water Resources Development Acts that govern Corps activities.

The Principles

- Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
- Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
- Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
- Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.
- Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
- Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

TABLE OF CONTENTS

Table of Contents i
Executive Summary xi
Acronyms and Abbreviations xvii
Section 1.0 Introduction 1-1
1.1 Introduction to the PSMP EIS 1-1
1.1.1 Proposed Action 1-2
1.1.2 Purpose and Need 1-2
1.1.3 Programmatic EIS 1-4
1.2 Corps Authorities, Directives, and Obligations 1-4
1.3 Sediment and the Authorized Purposes of the LSRP 1-6
1.3.1 Sediment Interference with Authorized Project Purposes 1-6
1.3.2 Corps Sediment Management Guidance 1-7
1.4 Corps Management of Sediment in LSRP 1-8
1.4.1 Sediment Accumulation Areas 1-8
1.4.2 Corps Sediment Management Activities 1-9
1.5 Other Agencies' Management of Erosion and Sediment 1-11
1.6 A Watershed Approach to Sediment Management Planning 1-12
1.6.1 Watershed Sediment Study Area 1-13
1.6.2 Sediment and the Lower Snake River Watershed 1-15
1.7 Environmental Review Process 1-25
1.7.1 Steps in the EIS Process 1-25
1.7.2 Scoping 1-25
1.7.3 Commenting on the EIS 1-26
1.8 Next Steps 1-27
1.9 Organization of this EIS 1-27
Section 2.0 Alternatives 2-1
2.1 Introduction 2-1
2.2 Alternatives Development and Evaluation 2-1
2.2.1 Problem Identification 2-2
2.2.2 Development of Management Measures 2-3
2.2.3 Criteria Development and Measure Screening 2-7
2.2.4 Measures Retained 2-9
2.2.5 Range of Alternatives 2-21
2.2.6 Alternatives Screening 2-31
2.2.7 Alternatives Removed from Further Consideration 2-32
2.2.8 Plan Alternatives Evaluated in Detail 2-34

2.3 Environmental Effects of Alternatives 2-35
2.4 Corps' Preferred Alternative 2-38
Section 3.0 Affected Environment 3-1
3.1 Aquatic Resources 3-1
3.1.1 Plankton 3-1
3.1.2 Benthic Invertebrates 3-2
3.1.3 Aquatic Plants 3-3
3.1.4 Fish 3-3
3.1.5 Threatened and Endangered Species 3-22
3.2 Terrestrial Resources 3-23
3.2.1 Vegetation 3-23
3.2.2 Terrestrial Wildlife 3-24
3.2.3 Threatened and Endangered Species 3-28
3.3 Recreation 3-31
3.4 Cultural Resources 3-33
3.4.1 Cultural Resources Property Types 3-33
3.4.2 Cultural Resources in the Study Area 3-34
3.5 Socioeconomics 3-39
3.5.1 Population and Demographics 3-39
3.5.2 Environmental Justice Communities 3-41
3.5.3 Transportation 3-41
3.5.4 Rail 3-49
3.5.5 Roads and Highways 3-50
3.6 Water Quality and Sediment Quality 3-51
3.6.1 Water Quality 3-51
3.6.2 Sediment Quality 3-52
3.7 Hydrology and Sediment 3-55
3.7.1 Geomorphology and Sediment Transport in the Snake River Basin 3-57
3.7.2 Watershed Sediment Production 3-60
3.7.3 Lower Snake River System and Sediment Transport 3-71
3.8 Hazardous, Toxic, and Radioactive Waste 3-85
3.9 Air Quality 3-87
3.9.1 Regional Climate Conditions 3-87
3.9.2 Regional Air Quality Conditions 3-87
3.9.3 Regional Greenhouse Gas Conditions 3-88
3.10 Aesthetics 3-91

Section 4.0 Environmental Effects of Alternatives 4-1
4.1 Aquatic Resources 4-1
4.1.1 Alternative 1: No Action (Continue Current Practices) 4-1
4.1.2 Alternative 5 (Dredging-Based Sediment Management) 4-2
4.1.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-11
4.2 Terrestrial Resources 4-19
4.2.1 Alternative 1: No Action (Continue Current Practice) 4-19
4.2.2 Alternative 5: Dredging-Based Sediment Management 4-19
4.2.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-21
4.3 Recreation 4-23
4.3.1 Alternative 1: No Action (Continue Current Practices) 4-23
4.3.2 Alternative 5: Dredging-Based Sediment Management 4-23
4.3.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-24
4.4 Cultural Resources 4-27
4.4.1 Alternative 1: No Action (Continue Current Practices) 4-27
4.4.2 Alternative 5: Dredging Based Sediment Management 4-27
4.4.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-29
4.5 Socioeconomics 4-31
4.5.1 Alternative 1: No Action (Continue Current Practices) 4-31
4.5.2 Alternative 5: Dredging-Based Sediment Management 4-31
4.5.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-33
4.6 Water Quality and Sediment Quality 4-35
4.6.1 Alternative 1: No Action (Continue Current Practices) 4-35
4.6.2 Alternative 5: Dredging-Based Sediment Management 4-35
4.6.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-37
4.7 Hydrology and Sediment 4-39
4.7.1 Alternative 1: No Action (Continue Current Practices) 4-39
4.7.2 Alternative 5: Dredging-Based Sediment Management 4-39
4.7.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-40
4.8 Hazardous, Toxic, and Radioactive Waste 4-43
4.8.1 Alternative 1: No Action (Continue Current Practices) 4-43
4.8.2 Alternative 5: Dredging-Based Sediment Management 4-43

4.8.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-44

4.9 Air Quality 4-47

4.9.1 Alternative 1: No Action (Continue Current Practices) 4-47

4.9.2 Alternative 5: Dredging-Based Sediment Management 4-47

4.9.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-48

4.10 Aesthetics 4-51

4.10.1 Alternative 1: No Action (Continue Current Practices) 4-51

4.10.2 Alternative 5: Dredging-Based Sediment Management 4-51

4.10.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures) 4-52

4.11 Cumulative Effects 4-55

4.11.1 Geographic and Temporal Scope of Cumulative Effects Analysis 4-55

4.11.2 Past, Present, and Reasonably Foreseeable Future Actions and Implications for Resources 4-56

4.11.3 Cumulative Effects of Alternatives 4-63

Section 5.0 Compliance with Applicable Environmental Laws and Regulations 5-1

5.1 Federal Statutes 5-1

5.1.1 American Indian Religious Freedom Act (AIRFA) 5-1

5.1.2 Archeological Resources Protection Act 5-1

5.1.3 Clean Air Act 5-1

5.1.4 Endangered Species Act 5-2

5.1.5 Federal Water Pollution Control Act (Clean Water Act) 5-2

5.1.6 Federal Water Project Recreation Act 5-3

5.1.7 Fish and Wildlife Coordination Act (FWCA) 5-3

5.1.8 Fishery Conservation and Management Act of 1976 5-4

5.1.9 Migratory Bird Treaty Act 5-4

5.1.10 National Environmental Policy Act 5-5

5.1.11 Native American Graves Protection and Repatriation Act (NAGPRA) 5-5

5.1.12 The National Historic Preservation Act (NHPA) 5-5

5.1.13 Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act) 5-6

5.1.14 Pollution Control at Federal Facilities 5-7

5.1.15 Rivers and Harbors Act of 1899 5-7

5.2 Executive Orders 5-8

5.2.1 Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 13, 1971 5-8

5.2.2 Executive Order 11988, Floodplain Management Guidelines, May 24, 1977 5-8

5.2.3 Executive Order 11990, Protection of Wetlands 5-8
5.2.4 Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994 5-8
5.2.5 Executive Order 13007, Native American Sacred Sites, May 24, 1996 5-9
5.3 Executive Memoranda 5-9
5.3.1 Council on Environmental Quality Memorandum, August 11, 1990, Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA 5-9
5.4 State Statutes 5-9
Section 6.0 Notice of Intent Coordination, Consultation, and Public Involvement 6-1
6.1 Scoping 6-1
6.1.1 Local Sediment Management Group 6-1
6.1.2 Agency Scoping Workshops 6-2
6.1.3 Public Scoping 6-2
6.2 Tribal Consultation 6-2
6.3 Agency Coordination 6-4
6.4 Public Outreach and Comment on the DEIS 6-4
Section 7.0 List of Preparers 7-1
Section 8.0 Distribution 8-1
Section 9.0 References 9-1
Section 10.0 Glossary 10-1
Section 11.0 Index 11-1

LIST OF TABLES

Table ES 1: Range of Alternatives Screening xvii
Table ES 2. Environmental Effects Summary Table xxiii
Table 1 1. Lower Snake River Projects 1-1
Table 1 2. Corps-identified Sediment Problem Areas in the Lower Snake River System 1-8
Table 1 3: Partial History of Federal/Port Dredging in the Lower Snake River 1-10
Table 1 4. Studies Conducted in the Snake River System 1-17
Table 2 1. Management Measures 2-3
Table 2 2. Measure Screening Criteria 2-7
Table 2 3: Measures Dismissed 2-8
Table 2 4. Management Measures Retained 2-9
Table 2 5: Range of Alternatives Screening 2-32
Table 2 6. Alternatives and Associated Measures 2-34
Table 2 7. Environmental Effects Summary Table 2-35
Table 3 1. Anadromous and Resident Fish Collected in the Study Area1 3-4

Table 3 2. Anadromous Populations Present in the Study Area 3-22
Table 3 3. Number of Terrestrial Wildlife Species known to Occur in the Study Area 3-24
Table 3 4. Lower Snake River ESA-listed Species (Threatened, Endangered, Proposed, Candidate) 3-28
Table 3 5. Total Recreation Visits and Visitor Hours at Lower Snake River Recreation Facilities 3-31
Table 3 6. Study Area Population Projections by County (2010-2030) 3-40
Table 3 7. Race and Hispanic Ethnicity of Population within Study Area (2000) 3-40
Table 3 8. Study Area Income per Capita by County 2000-2009 3-41
Table 3 9. Lower Snake Pool Levels 3-42
Table 3 10. Lower Snake River Barge Facilities – Lower Granite Reservoir 3-43
Table 3 11. Lower Snake River Barge Facilities – Little Goose, Lower Monumental and Ice Harbor Pools 3-44
Table 3 12. Lower Snake River Barge Facilities – McNary Pool (includes facilities on the Columbia River) 3-45
Table 3 13. Lower Snake River Navigation Lock Detail (million tons) 3-46
Table 3 14. Origin of Grain Shipped on the Lower Snake River, by State 3-48
Table 3 15. Watershed Subbasins 3-60
Table 3 16. Sediment Accumulation in Lower Granite Reservoir, 1974 – 2010 3-74
Table 3 17. Relative Contributions of Subbasins to Sediment and Sand Load at Lower Granite Reservoir, 2009 – 2010 3-74
Table 3 18. Historic Dredging Activities in the Lower Granite Reservoir 3-77
Table 3 19. Corps Identified Potential Sediment Problem Areas in the Lower Granite Reservoir and Adjacent Areas 3-78
Table 3 20. Historic Dredging Activities in Little Goose Reservoir 3-79
Table 3 21. Corps-Identified Potential Sediment Problem Areas in Little Goose Reservoir 3-79
Table 3 22. Corps Identified Potential Sediment Problem Areas in the Lower Monumental Reservoir 3-80
Table 3 23. Historic Dredging Activities in Ice Harbor Reservoir 3-81
Table 3 24. Corps-Identified Sediment Problem Areas in Ice Harbor Reservoir 3-82
Table 3 25. Historic Dredging Activities in McNary Reservoir (Snake River Portion) 3-83
Table 3 26. Corps Identified Potential Sediment Problem Areas in McNary Reservoir (Snake River Portion) 3-83
Table 3 27. Typical Range of Average Regional Climate Data Representative of the Study Area 3-87
Table 4 1. Alternatives and Associated Measures 4-2
Table 4 2. Reasonably Foreseeable Future Actions 4-62

LIST OF FIGURES

Figure 1 1. Lower Snake River Projects 1-1
Figure 1 2. PSMP Study Area 1-13
Figure 1 3. Watershed Land Ownership 1-14
Figure 1 4. Sediment Types 1-15
Figure 1 5. Watershed Schematic of Subbasins 1-16
Figure 1 6. Wildfire-Affected Areas in Lower Granite Reservoir Watershed 1-20
Figure 1 7. Wildfire Area in the Lower Granite Sediment Yield Watershed 1-20
Figure 1 8. Percentage of Total Annual Suspended Sediment Load October 2008-October 2011 1-22
Figure 1 9. Percentage of Total Annual Suspended Sand Load October 2008-October 2011 1-22
Figure 2 1. Dredging Operation on the Columbia River 2-10
Figure 2 2. Schematic of In-water Sediment Placement 2-11
Figure 2 3. Joso HMU Upland Disposal Site 2-13
Figure 2 4. Schematic of Bendway Weirs 2-14
Figure 2 5. Dike Construction 2-14
Figure 2 6. Dike on the Mississippi River 2-15
Figure 2 7. Vegetation Filter Strip Surrounding Agricultural Area 2-18
Figure 2 8. Gabion Baskets Installed for Slope Stabilization Along a Stream 2-18
Figure 3 1. Typical Migration Timing of Anadromous Salmonid Stocks at McNary and Lower Granite Dams 3-7
Figure 3 2. Snake River Grain Volume Originating by Reservoir (excluding McNary Pool) 3-47
Figure 3 3. Snake River Grain Volume Originating by Pool (including McNary Reservoir) 3-48
Figure 3 4. Sediment Encroachment in 2009 at the Confluence 3-56
Figure 3 5. Lower Snake River System Sediment Issues – Conceptual Diagram 3-59
Figure 3 6. Annual Average Streamflow, Salmon River at White Bird, Idaho 3-61
Figure 3 7. Annual Average and Annual Peak Streamflow, Snake River near Anatone, Washington 3-64
Figure 3 8. Annual Average and Annual Peak Streamflow, Grande Ronde River at Troy, Oregon 3-66
Figure 3 9. Annual Average Streamflow, Clearwater River at Spalding, Idaho 3-68
Figure 3 10. Lower Granite Dam 3-72
Figure 3 11. Comparison of 1974 and 2009 Sediment Ranges at Snake River Mile 137.69 3-73
Figure 3 12. Comparison of 1974 and 2009 Sediment Ranges at Snake River Mile 123.30 3-73
Figure 3 13. Little Goose Dam 3-78
Figure 3 14. Lower Monumental Dam 3-80
Figure 3 15. Ice Harbor Dam 3-81

APPENDICES

Appendix A: Draft Programmatic Sediment Management Plan (USACE 2012a)

Appendix B: Investigation of Sediment Source and Yield, Management, and Restoration Opportunities within the Lower Snake River Basin (Tetra Tech 2006)

Appendix C: Upland Erosion Processes in Northern Idaho Forests (Draft Report), USFS (Elliott et al. 2010)

Appendix D: Enhanced Sediment Delivery in a Changing Climate in Semi-arid Mountain Basins: Implications for Water Resource Management and Aquatic Habitat in the Northern Rocky Mountains, USFS (Goode et al. 2011)

Appendix E: Evaluation of Sediment Yield Reduction Potential in Agricultural and Mixed-Use Watersheds of the Lower Snake River Basin (University of Idaho and Washington State University 2010)

Appendix F: Lower Granite Reservoir – Hydrologic and Hydraulic Investigations.

Appendix G: Scoping Summary: Lower Snake River Programmatic Sediment Management Plan and Environmental Impact Statement

Appendix H: Summary of Proposed 2013/2014 Dredging

Appendix I: Lower Snake and Clearwater Rivers Sediment Evaluation Report for Proposed 2013/2014 Channel Maintenance

Appendix J: Lower Snake River Programmatic Sediment Management Plan, 2013/2014 Navigation Maintenance Monitoring Plan

Appendix K: Snake River Channel Maintenance 2013-2014, Lower Snake River, PM-EC-2007-0001, Biological Assessment

Appendix L: Clean Water Act Section 404(b)(1) Evaluation

ACRONYMS AND ABBREVIATIONS

AIRFA	American Indian Religious Freedom Act
APA	Administrative Procedures Act
BEA	business economic area
BLM	Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
BOR	Bureau of Reclamation
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CH_4	methane
CO_2	carbon dioxide
Corps	U.S. Army Corps of Engineers
CRBG	Columbia River Basalt Group
CWA	Clean Water Act
cy/yr	cubic yards per year
dB	decibel
dBA	adjusted decibel
DEQ	Department of Environmental Quality
DMMP	Dredged Material Management Plan
DO	dissolved oxygen
DPS	distinct population segment
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
EIA	Energy Information Administration
EIS	Environmental Impact Statement
ER	Engineer Regulation
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
fps	feet per second
ft^2	square feet
FTA	Federal Transit Administration
FWCA	Fish and Wildlife Coordination Act
FY	fiscal year
GCRP	Global Climate Research Program
GHG	greenhouse gases
HMU	Habitat Management Unit
HTRW	hazardous, toxic, and radioactive waste
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IPCC	Intergovernmental Panel on Climate Change
L_{dn}	day-night noise level
L_{eq}	hourly equivalent sound pressure levels
LSMG	Local Sediment Management Group
LSRP	Lower Snake River Projects
M^3	cubic meters
mcy	million cubic yards
mi^2	square miles
$MM+CO_{2e}$	million metric tons of carbon dioxide equivalent
MOP	minimum operating pool
msl	mean sea level
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act
NGO	nongovernment organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent

NPPC	Northwest Power Planning Council
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Registry of Historic Places
NTU	nephalometric turbidity unit
NWI	National Wetland Inventory
ODEQ	Oregon Department of Environmental Quality
ortho-P	orthophosphorus
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PIT	passive integrated transponder
PL	Public Law
PM	particulate matter
ppm	parts per million
PSMP	Programmatic Sediment Management Plan
RCRA	Resource Conservation and Recovery Act
RM	river mile
SEF	Sediment Evaluation Framework
SO_2	sulfur dioxide
SPCC	spill prevention, control, and countermeasure
SPF	standard project flood
TCP	traditional cultural property
TMDL	total maximum daily load
TP	total phosphorus
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UPRR	Union Pacific Railroad
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
USWCD	Union Soil and Water Conservation District
Water Center	University Water Resources Center
WCTED	Washington Department of Community, Trade, and Economic Development
WRCC	Western Regional Climate Center
WSU	Washington State University

SECTION 1.0 INTRODUCTION

1.1 Introduction to the PSMP EIS

The Walla Walla District of the U.S. Army Corps of Engineers (Corps) is identifying and evaluating sediment management strategies for the lower Snake River. Based on the analysis presented in this Environmental Impact Statement (EIS) and stakeholder and public comments, the Corps will adopt and implement a Programmatic Sediment Management Plan (PSMP) (see Appendix A) for management of sediment within the lower Snake River system to meet authorized project purposes.

As a part of its Congressional authorization, the Corps operates and maintains the navigation system on the lower Snake River, which is part of an inland navigation system from Lewiston, Idaho to the Pacific Ocean and includes the Columbia River.

The Corps constructed four dams on the Snake River in Washington State (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) between 1961 and 1975 (Table 1-1). The Corps' sediment management area includes the lower Snake River from the confluence with the Columbia River to the upstream limits of Lower Granite Reservoir. For the purposes of this EIS, the sediment management area, including the four dams and their associated locks and reservoirs, is referred to as the Corps' Lower Snake River Projects (LSRP) (Figure 1-1).

Table 1-1. Lower Snake River Projects

Dam	Year Completed
Ice Harbor	1961
Lower Monumental	1969
Little Goose	1970
Lower Granite	1973

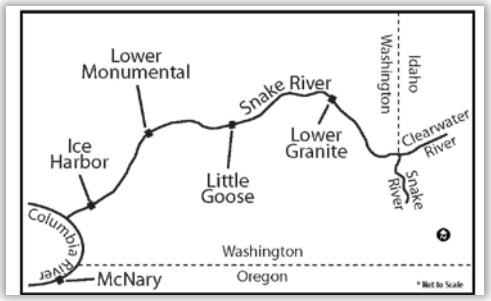


Figure 1-1. Lower Snake River Projects

The authorized purposes of the LSRP include commercial navigation, hydroelectric power generation, recreation, and fish and wildlife conservation. Sediment accumulation in the lower Snake River can interfere with these authorized project purposes of the LSRP.

The Corps has historically used dredging as its primary method of removing accumulated sediment that interferes with the authorized purposes of the LSRP. Dredged sediments were moved to and placed in areas where they would no longer interfere with the authorized purposes, either in-water within the reservoirs or on upland sites.

Between 1999 and 2002 the Corps prepared a Dredged Material Management Plan (DMMP)/ EIS, which evaluated alternatives for managing dredged sediments in the LSRP. Following publication of the Record of Decision for the DMMP/EIS in September 2002, a group of environmental and fishing interests (collectively referred to as the "plaintiffs") filed a lawsuit in

November 2002, alleging compliance failures by the National Marine Fisheries Service (NMFS) with respect to the Endangered Species Act (ESA) and by the Corps with respect to the National Environmental Policy Act (NEPA). The U.S. District Court, Western District of Washington, granted a preliminary injunction, halting further action by the Corps. The Corps withdrew the Record of Decision and in 2005 prepared an EIS for a one-time navigation channel maintenance action (dredging). The litigation was ended in 2005 through a settlement agreement between the plaintiffs and the Corps. In the settlement agreement the Corps was allowed to perform a one-time dredging of the Federal navigation channel and related port berthing areas in the winter of 2005/2006. The Corps also agreed to "…initiate and complete a NEPA analysis on a long-term plan for the management of sediment in the lower Snake River, to be designated the Programmatic Sediment Management Plan…." The plan is designed to evaluate actions for sediment management to meet authorized project purposes. This document presents the NEPA analysis of the immediate and long-term plan for sediment management directed by the settlement agreement.

This section presents background information on the LSRP, the purpose and need for the proposed action, Corps authorizations that identify project purposes, sediment sources in the lower Snake River watershed, and the historic and ongoing efforts to manage sediments in the lower Snake River watershed to meet authorized project purposes.

1.1.1 Proposed Action

The Corps proposes to adopt and implement a PSMP for managing sediment within the lower Snake River system to meet the authorized project purposes that are affected by sediment deposition. These purposes are commercial navigation, recreation, and fish and wildlife conservation and mitigation. The Corps is preparing this EIS to evaluate a long term plan for management of sediment accumulation that affects authorized purposes of the LSRP and an immediate need action consistent with the plan to reestablish the navigation channel.

1.1.2 Purpose and Need

The purpose of the proposed action is to adopt and implement a PSMP, which includes actions for long-term, immediate need, and emergencies for managing sediment that interferes with the authorized purposes of the LSRP. The PSMP provides a programmatic framework to evaluate and implement potential sediment management measures. The PSMP must provide a long term plan to manage, and prevent if possible, the accumulation of sediment that interferes with authorized project purposes. The immediate need action to re-establish the navigation channel to the Congressionally-authorized dimensions will be consistent with the PSMP.

The need for the PSMP is to manage, reduce and prevent if possible, sediment accumulation in areas of the lower Snake River reservoirs that interfere with federally authorized purposes. Sediment accumulation interferes with the following authorized purposes of the LSRP:

- *Commercial navigation* by reducing the depth of the Federal navigation channel to less than the authorized depth (14 feet) when operating at minimum operating pool, or MOP, thereby

impairing access to port berthing areas, access to navigation locks, and safe movement of tug and multibarge tows;

- *Recreation* by limiting water depth at boat basins to less than original design dimensions;
- *Fish and wildlife conservation* by sediment accumulation interfering with irrigation water intakes at Habitat Management Units (HMUs), juvenile ESA-listed fish barge access to loading facilities, and fish barge passage through the reservoirs and locks within the LSRP.

Sediment accumulation at the confluence of the Snake and Clearwater Rivers can interfere with the intended design and function of the Lower Granite Project levees to provide adequate flood risk protection at Lewiston-Clarkston. Continued sediment management at the confluence of the Snake and Clearwater Rivers may be needed in the long-term to ensure adequate flow conveyance through the Lewiston levee system to support Lower Granite project purposes and manage the risk of flooding consistent with applicable Corps policies. For the PSMP and EIS the need to manage sediment for flow conveyance is considered to be equivalent to an authorized project purpose.

Additionally, sediment deposition is currently interfering with the Corps' ability to comply with requirements of the Federal Columbia River Power System (FCRPS) 2008/2010 biological opinion (2008/2010 BiOp)[1], which was prepared by the National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA). The 2008/2010 BiOp addresses operation of the Columbia River system projects including the Lower Snake River Projects. Reasonable and Prudent Alternative (RPA) Action 5 of the 2008/2010 BiOp states that the lower Snake River reservoirs will be operated within one foot of MOP from April through August each year to help move juvenile threatened and endangered salmon through the river system to the ocean. Operating the reservoirs at MOP versus full pool (a drop in elevation of 3 to 5 feet) is thought to decrease the amount of time downstream migrating juvenile fish spend in the reservoirs, thereby increasing their overall survival rates. Over time, sediment deposition in the navigation channel reduces the water depth to less than 14 feet deep at MOP, which interferes with navigation. RPA Action 5 allows the reservoir level to be adjusted (i.e., raised) to meet authorized project purposes, primarily navigation, but this deviation from operation at MOP is not considered desirable by the Corps or the regional partners. Regional fish managers and the Corps view operation above MOP only as a temporary measure for addressing sediment deposition in the navigation channel until channel maintenance can be performed. The Corps has been operating the Lower Granite Project above MOP (1 to 2 feet) for navigation purposes during the juvenile outmigration season since 2010 in response to accumulation of sediment at the confluence of the Snake and Clearwater Rivers.

[1] The 2010 FCRPS Biological Opinion incorporated by reference the 2008 FCRPS Biological Opinion.

In the past, the Corps has approached sediment management by identifying areas where sediment interfered with authorized LSRP purposes and then taking action to remove the sediment, usually by dredging. Development of the PSMP would establish a decision-making process to manage and, if possible, prevent sediment accumulation that interferes with authorized project purposes.

Historically, the Corps has routinely maintained the navigation channel at its authorized dimension through dredging actions, typically every 3 to 5 years. The Corps has not performed maintenance dredging in the channel since the winter of 2005-2006 when the Lower Monumental and Lower Granite downstream navigation lock approaches, the federal channel at the Snake and Clearwater Rivers confluence, and the berthing areas of the Ports of Lewiston and Clarkston were dredged. Sediment has been accumulating in the navigation channel and over the past 2 to 3 years, and the accumulation has reached a level where channel dimensions at some locations are not at authorized dimensions, even when the reservoir is operated above MOP. Currently, sediment accumulation has reduced the navigation channel depth to as shallow as seven to nine feet at MOP and is impairing navigation. Therefore, immediate action is needed to reestablish the navigation channel to its authorized dimensions at the following locations:

- Ice Harbor Navigation Lock downstream approach
- Federal navigation channel at confluence of Snake and Clearwater Rivers
- Port of Clarkston berthing area
- Port of Lewiston berthing area

Finally, the Corps agreed to complete a PSMP as part of the 2005 settlement agreement referenced in Section 1.1 above. The Corps has developed this PSMP EIS to fulfill this requirement.

1.1.3 Programmatic EIS

A federal agency may enact a programmatic approach versus project-specific approach for a broad program of management activities under their authority (40 CFR 1502.4(b)). The purpose of programmatic management is to provide consistency in and a roadmap for future project-specific decision-making. The associated programmatic management plan developed by a federal agency requires preparation of a programmatic EIS. The PSMP programmatic EIS includes alternatives that define broad programs for managing sediments through implementation of future and immediate actions as they relate to maintaining the authorized project purposes of the LSRP. Actions taken to address the immediate need to reestablish the navigation channel are covered in this EIS. Future actions may require project-specific environmental reviews, including preparation of National Environmental Policy Act (NEPA) documents (Environmental Assessment [EA], EIS, or supplemental EIS) tiered off of this programmatic EIS.

1.2 Corps Authorities, Directives, and Obligations

In response to Congressional authorization, the Corps has constructed and operates and maintains the navigation system on the lower Snake River, which is part of an inland navigation system from Lewiston, Idaho to the Pacific Ocean and includes a portion of the Columbia River. Congress authorized the reservoir system and the navigation channel that runs through the reservoirs by the River and Harbor Act of 1945 (Public Law [PL] 79-14), Section 2. This Act included authorization for the construction of the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite lock and dams for the purposes of inland navigation, power generation, and incidental irrigation water supply. The Flood Control Act of 1944 (PL 78-534) authorized the Chief of Engineers to construct, maintain, and operate recreational facilities in reservoir areas under Corps management. Compliance with the Fish and Wildlife Coordination Act of 1958 (PL 85-624) resulted in certain modifications to the LSRP during and after construction for fish and wildlife conservation/mitigation and added the same as an authorized project purpose.

The Flood Control Act of 1962 (PL 87-874) mandated the establishment of the navigation channel within the LSRP at 14 feet deep by 250 feet wide at the minimum operating pool level, and provides the Corps with authority to maintain the channel at those dimensions. Based on the authorizing documents and subsequent related Congressional documents, the Corps interprets that Congress intended for the Corps to maintain the channel to provide year-round navigation. In 1991, Congress reiterated its intent to provide for navigation in the Columbia and Snake River system (102 Senate Report 80). The designated Federal navigation channel dimensions are increased beyond typical dimensions in the turning basins in front of port berthing areas in accordance with navigation practice as authorized in the United States Code (U.S.C.) at 33 U.S.C. § 562: “Channel dimensions specified shall be understood to admit of such increase at the entrances, bends, sidings, and turning places as may be necessary to allow of the free movement of boats.”

The LSRP provide aquatic and shoreline recreational opportunities. There are 51 designated recreation sites located on the shores and adjacent areas of the Snake River between the confluence with the Columbia River and the upstream end of the Lower Granite Reservoir on the Snake River. These facilities include local and state parks, and marinas, which are managed and operated by the Corps and local and state recreation agencies.

The original enabling legislation for the Lower Granite Lock and Dam project included construction and maintenance of levees as ***appurtenant*** facilities of the project. This means that the levees provide for normal operating reservoir water levels from 733 to 738 feet above mean sea level in Lewiston – permitting commercial navigation without inundating portions of Lewiston. The levees were originally designed to have a 5-foot ***freeboard*** during the “***standard project flood***,” or SPF. This means that the top of the levee would be 5 feet higher than the water level during the SPF. The SPF is a *very* high stream flow resulting from severe meteorological events, specifically a flow of 420,000 cubic feet of water per second in the Snake River downstream of the confluence with the Clearwater River, which is substantially higher than any flows previously recorded. Freeboard was added to the levees to reduce the likelihood of

flooding in Lewiston either by very high stream flow or by variable operation of the dam. Since the dam and levees were constructed, the Corps has adopted risk-based methodology to assess the level of flood risk reduction provided by its facilities. The SPF and original design freeboard is no longer the only criterion used to evaluate the risk of flooding.

Design of the levees was consistent with applicable required standards at the time of the construction of the Lower Granite Project. Subsequently Engineer Regulation (ER) 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies* (January 2006) provides guidance on analyzing risks of potential flooding associated with facilities like the Lewiston levee system. ER 1105-2-101 provides a revision to the design standard that required 5 feet of freeboard when passing the SPF, and directs the Corps to use risk analysis to determine the appropriate project approach.

The 2008/2010 BiOp RPA Action 5 requires Action Agencies to operate the run-of-river mainstem Columbia and Snake River projects (Bonneville, The Dalles, John Day, McNary on the Columbia, and Ice Harbor, Lower Monumental, Little Goose and Lower Granite projects on the Snake) to minimize water travel time through the lower Columbia and Snake Rivers to aid in juvenile fish passage as defined below. These projects are operated for multiple purposes including fish and wildlife, irrigation, navigation, power, recreation, and limited flood control.

1.3 Sediment and the Authorized Purposes of the LSRP

1.3.1 Sediment Interference with Authorized Project Purposes

The watershed, or the area that drains and contributes sediment to the lower Snake River, is more than 32,000 square miles and made up of diverse landscapes. The watershed includes the following major tributary rivers: the Salmon, Grande Ronde, the Clearwater, and the Snake River upstream of the Clearwater. Other rivers, such as the Tucannon and Palouse, drain to the lower Snake River downstream of the Clearwater/Snake confluence.

Dams affect the movement and behavior of sediment within river systems. Upstream of the LSRP, Dworshak Dam on the Clearwater River and the Hells Canyon complex of dams on the Snake River trap substantial amounts of sediment that originate upstream. The lower Snake River dams slow the velocity of the river, allowing the heavier sediments to settle out and deposit within the reservoir while the lighter sediments pass through the dams. The Lower Granite Reservoir, which is the farthest upriver reservoir in the lower Snake River system, receives the majority of the sediment entering the system from the watershed and experiences the greatest accumulation of heavier sediments.

The accumulation of sediment in some locations in the lower Snake River adversely affects the authorized purposes of the Corps' projects, including commercial navigation, fish and wildlife conservation, and recreation. The Corps manages those sediments pursuant to the authorities described in Section 1.2 above, and has historically managed sediments to maintain:

- The federal navigation channel at the authorized depth of 14 feet deep and 250 feet wide.

- The port approaches at 14 feet deep.
- Access and use of recreation facilities.
- Functioning irrigation water intakes for irrigated habitat management units (HMUs).
- Flow conveyance through the Lewiston levee system consistent with ER 1105-2-101.

1.3.2 Corps Sediment Management Guidance

The Corps' ER 1105-2-100, *Planning Guidance Notebook* provides policies and guidelines for sediment management planning. ER 1105-2-100 directs the Corps to perform dredged material management planning for all federal harbor projects. The purpose of the planning is to "ensure that maintenance dredging activities are performed in an environmentally acceptable manner, use sound engineering techniques, [and] are economically warranted…." Further, the ER directs incorporation of a "watershed perspective" in conducting civil works planning, which includes accounting for "…the interconnectedness of water and land resources…." The general guidance contained in the ER was applied in the development of this PSMP and this EIS; however, it should be noted that the PSMP EIS was developed to fulfill the requirement of a settlement agreement and to provide a long-term plan for operations and maintenance, and therefore is different from typical Corps planning processes.

The Corps' Policy Guidance Letter #61 – *Application of Watershed Perspective to Corps of Engineers Civil Works Programs and Activities* (USACE 1999a) provides policy direction to integrate a watershed perspective, including soliciting participation from the spectrum of agencies, tribes, and stakeholders with interests in the Corps' Civil Works programs and involving diverse technical experts. This policy is embodied in the principles of Regional Sediment Management, which stresses a "system based approach" to solve sediment-related problems (EPA 2011, USACE 2011b).

The Sediment Evaluation Framework for the Pacific Northwest (SEF) (USACE 2009) provides guidance for the assessing and characterizing sediments associated with dredging in Idaho, Oregon, and Washington. It was developed collaboratively by agencies with responsibility for sediment evaluation and management. The SEF describes the methods available for sediment characterizations related to management activities. While the SEF is geared toward determining the suitability of sediments for open water disposal, it also provides consistency for testing and evaluation procedures for sediment management projects in the LSRP.

The Corps' Environmental Operating Principles (included inside the front cover of this document) provide guidance for Corps activities. By following these principles, the Corps aims to develop the scientific, economic, and sociological measures to judge the effects of its projects on the environment and to seek better ways of achieving environmentally sustainable solutions.

1.4 Corps Management of Sediment in LSRP

1.4.1 Sediment Accumulation Areas

The Corps has evaluated locations where sediment accumulation could interfere with the LSRP authorized purposes. The Corps has identified 43 locations in the LSRP where sediment accumulation historically has affected authorized purposes or sediment accumulation may potentially be a problem in the future[2]. Table 1-2 lists these areas, their authorized use, and their approximate river mile location. Of the locations identified, 21 sites are used for recreation, 16 are navigation sites[3], and 5 sites are related to water intakes. Flow conveyance (as it relates to flood risk management through the Lewiston levee system) and navigation are affected uses at the Snake/Clearwater confluence.

Table 1-2. Corps-identified Sediment Problem Areas in the Lower Snake River System

Reservoir	River	Approx. River Mile[1]	Site Name	Purpose
Lower Granite	Clearwater	1.0-2.0	Port of Lewiston	Navigation2
		3.0	Clearwater Boat Ramp	Recreation
	Snake/ Clearwater	131.5-139.5/ 0.0-2.0	Snake River at Mouth of Clearwater River	Navigation, conveyance
	Snake	128-130	Silcot Island	Navigation
		137.0	Hells Canyon Resort	Recreation
		139.0	Port of Clarkston	Navigation
		139.5	Greenbelt Boat Basin	Recreation
		140.5	Southway Boat Ramp	Recreation
		141.5	Swallows Park Boat Basin and Swim Beach	Recreation
		142.5	Hells Gate State Park	Recreation
		146.0	Chief Looking Glass Park	Recreation
Little Goose	Snake	82.5	Central Ferry Park	Recreation
		83.0	Port of Garfield Access	Navigation
		83.5	Port of Central Ferry	Navigation
		88.0	Willow Landing HMU	Fish and wildlife
		100.0-102.0	Navigation Channel at Schultz Bar	Navigation
		103.5	Port of Almota	Navigation
		103.5	Illia Landing	Recreation
		105.5	Boyer Park and Marina	Recreation
		107.0	Lower Granite Lock Approach	Navigation

[2] It should be noted that, to date, dredging has occurred at relatively few of the sites identified; however, the Corps has attempted to identify all areas where sediment accumulation could potentially affect authorized purposes in the future.

[3] Several of these sites are port facilities. While the Corps is not specifically authorized to maintain theses sites, the Corps has, at the request of ports, dredged accumulated sediments at these locations to coincide with dredging to maintain the federal channel. The ports pay the Corps for the dredging and a portion of the administrative costs.

Table 1-2. Corps-identified Sediment Problem Areas in the Lower Snake River System

Reservoir	River	Approx. River Mile[1]	Site Name	Purpose
Lower Monumental	Snake	48.0	Skookum HMU	Fish and wildlife
		51.0	Ayer	Recreation
		55.0	55-Mile HMU	Fish and wildlife
		56.5	Joso HMU	Navigation
		59.5	Lyons Ferry Park	Recreation
		66.0	Texas Rapids Boat Basin	Recreation
		70.0	Little Goose Lock Approach	Navigation
Ice Harbor	Snake	10.0	North Shore Boat Ramp	Recreation
		11.5	Charbonneau Park	Recreation
		13.5	Levey Park	Recreation
		15.0	Big Flat Habitat Management Unit (HMU)	Fish and wildlife
		18.0	Fishhook Park	Recreation
		23.0	Lost Island HMU	Fish and wildlife
		24.5	Hollebeke HMU	Fish and wildlife
		29.0–33.3	Walker's Elevator	Navigation
		39.0	Windust Boat Ramp	Recreation
		41.0	Lower Monumental Lock Approach	Navigation
McNary	Snake	0.0	Sacajawea State Park	Recreation
		1.5	Hood Park Boat Ramp	Recreation
		9.2	Ice Harbor Lock Approach/Nav Coffer Cells	Navigation
		0.0–1.5	Snake River Entrance	Navigation
		2.0–10.0	Nav Channel Below Ice Harbor	Navigation
		2.0–10.0	Nav Channel Below Ice Harbor	Navigation

1.4.2 Corps Sediment Management Activities

The Corps' past project maintenance program has been to monitor sediment accumulation through periodic surveys of the river bottom, coordinate with river users (e.g., navigators, recreation managers) regarding river conditions, and to dredge accumulated sediment that interferes with the authorized purposes of the lower Snake River. Table 1-3 details the Corps' past dredging actions, most of which were conducted to maintain navigation or flow conveyance. The Corps has dredged problem sediment areas every 3 to 5 years on average, scheduling this dredging when river survey data or user reports indicated the sediment deposition was interfering with navigation or other uses of the reservoirs. Disposal methods for dredged materials are indentified in accordance of Corps regulations (33 CFR 335-338). The "federal standard" for disposal of dredged material is defined as "[T]he least costly alternatives consistent with sound engineering practices and meeting the environmental standards established by the 404(b)(1) evaluation process. . . ." (33 CFR 335.7). 33 CFR 336.1(c)(1) states, "[I]t is the Corps' policy to regulate the discharge of dredged material from its projects to assure that dredged material

disposal occurs in the least costly, environmentally acceptable manner, consistent with engineering requirements . . . .” Historically, the Corps dredged the accumulated sediment from problem areas and disposed of the material either upland or in the reservoirs (called “in-water disposal”). The Corps ceased in-water disposal in the 1980’s as several Snake River salmonid stocks were proposed for listing as threatened or endangered under ESA and regional fisheries managers opposed continued use of this disposal method. The concern was that in-water disposal had an adverse effect on salmonids and provided potential salmonid predator habitat. In the late 1980’s and early 1990’s, the Corps funded a series of studies that evaluated these effects of in-water disposal. The studies indicated in-water disposal could be beneficial to juvenile salmonids if certain design criteria were used to guide sediment disposal methods. Since 1997, the regional fisheries managers have provided qualified support for shallow water disposal as long as the Corps performs the disposal using design criteria from the most recent research. For its most recent disposal actions (1997/98, 1998/99 and 2005/06), the Corps has disposed of dredged material in-water to create shallow water habitat for juvenile salmonids.

Table 1-3: Partial History of Federal/Port Dredging in the Lower Snake River

Dredging Location	Year	Purpose	Amount Dredged (cubic yards)	Disposal Method
Navigation Channel Ice Harbor, Part I and II, Channel Construction	1961	Navigation	3,309,500	Upland and in-water
Navigation Channel, Ice Harbor Part III, Channel Construction	1962	Navigation	120,000	Upland and in-water
Downstream Navigation Channel, Ice Harbor	1972	Navigation	80,000	Upland and in-water
Downstream Approach, Navigation Channel, Lower Monumental	1972	Navigation	25,000	Upland
Navigation Channel Downstream of Ice Harbor	1973	Navigation	185,000	Upland and in-water
Downstream Approach Channel Const., Lower Monumental Lock	1973	Navigation	10,000	Upland
Downstream Approach Channel Construction, Ice Harbor Lock	1978	Navigation	110,000	Upland and in-water
Downstream Approach Channel Construction, Ice Harbor Lock	1978 1981/82	Navigation	816,814	Upland and in-water
Various Boat Basins, Swallows Swim Beach, Lower Granite Reservoir (Corps)	1975-1998	Recreation	20,000	Upland sites
Port of Lewiston – Lower Granite Reservoir (Corps)	1982	Navigation/Maintain Flow Conveyance Capacity	256,175	Upland sites
Port of Clarkston – Lower Granite Reservoir (Corps)	1982	Navigation	5,000	Upland sites
Downstream Approach Channel Construction, Ice Harbor Lock	1985	Navigation	98,826	In-water
Confluence of Clearwater and Snake Rivers (Corps)	1985	Maintain Flow Conveyance Capacity	771,002	Upland site

Dredging Location	Year	Purpose	Amount Dredged (cubic yards)	Disposal Method
Port of Lewiston – Lower Granite Reservoir (Corps)	1986	Navigation/Maintain Flow Conveyance Capacity	378,000	Upland sites
Confluence of Clearwater and Snake Rivers (Corps)	1988	Maintain Flow Conveyance Capacity	915,970	In-water
Confluence of Clearwater and Snake Rivers (Corps)	1989	Maintain Flow Conveyance Capacity	993,445	In-water
Schultz Bar – Little Goose (Corps)	1991	Navigation	27,335	Upland site
Confluence of Clearwater and Snake Rivers (Corps)	1992	Maintain Flow Conveyance Capacity	520,695	In-water
Barge Approach Lane, Juvenile Fish Facilities, Lower Monumental	1992	Navigation	10,800	Upland site
Ports of Lewiston (Lower Granite Reservoir), Almota and Walla Walla	1991/92	Navigation	90,741	Upland and in-water
Schultz Bar – Little Goose (Corps)	1995	Navigation	14,100	In-water
Confluence of Clearwater and Snake Rivers (Corps)	1996/97	Navigation	68,701	In-water
Confluence of Clearwater and Snake Rivers (Corps)	1997/98	Navigation	215,205	In-water
Greenbelt Boat Basin, Clarkston – Lower Granite Reservoir	1997/98	Recreation	5,601	In-water
Port of Lewiston – Lower Granite Reservoir (Port)	1997/98	Navigation	3,687	In-water
Port of Clarkston – Lower Granite Reservoir (Port)	1997/98	Navigation	12,154	In-water
Lower Granite Lock Approach	1997/98	Navigation	2,805	In-water
Lower Monumental Lock Approach	1998/99	Navigation	5,483	In-water
Lower Monumental Lock Approach (Ice Harbor Reservoir) Lower Granite Lock Approach (Little Goose Reservoir) Clearwater/Snake Confluence and Ports of Clarkston and Lewiston (Lower Granite Reservoir)	2005/2006	Navigation	335,898	In-water

1.5 Other Agencies' Management of Erosion and Sediment

As noted in Section 1.3.1, a 32,000 square mile watershed drains to the lower Snake River. The watershed includes several major tributary rivers (the Salmon, Grande Ronde, the Clearwater, and the Snake River upstream of the Clearwater) and diverse land forms and uses. Erosion from land within the watershed, transport of eroded materials by streams, and sediment deposition are natural processes. The amount and type of eroded sediments varies widely across the watershed based on many factors including soil types, slopes, and climate conditions. Natural events like forest fires and landslides can greatly increase the amount of sediments reaching streams and rivers. Additionally, erosion and sediment loading to streams and rivers is often increased by human activities such as logging, agriculture, and urban development.

The Corps owns and manages very little land within the watershed – only about 42 square miles of land adjacent to the LSRP. Other agencies are involved in the management of sediment through land use management practices that limit erosion and sedimentation. The U.S. Forest Service (USFS) owns and manages approximately 56 percent of the land within the watershed; the Bureau of Land Management manages another 6 percent. Soil erosion on federal lands results from disturbances, especially from post-wildfire conditions, landslides, and roads in forest areas. Land management agencies implement various structural and conservation measures to limit soil erosion, including road maintenance and removal, post-fire land treatments, streambank stabilization, and protecting and restoring riparian areas.

In agricultural areas, which make up approximately 23 percent of the watershed (Tetra Tech 2006), landowners along with Conservation Districts and other agencies are involved in managing soil resources. Conservation Districts work directly with agricultural users to implement soil conservation practices that limit soil erosion caused by agricultural practices.

In addition, the Idaho Department of Environmental Quality (IDEQ), Oregon Department of Environmental Quality (ODEQ), and the Washington State Department of Ecology (Ecology) address water-borne sediments primarily through their TMDL (total maximum daily load) water quality management plans. All three agencies have implemented a TMDL planning process as required by the Clean Water Act (CWA) to develop strategies to reduce pollutants in waterbodies that do not meet water quality standards. Sediment reduction is often targeted as a means to reduce other pollutants from entering streams. Some plans may also directly address sediment.

1.6 A Watershed Approach to Sediment Management Planning

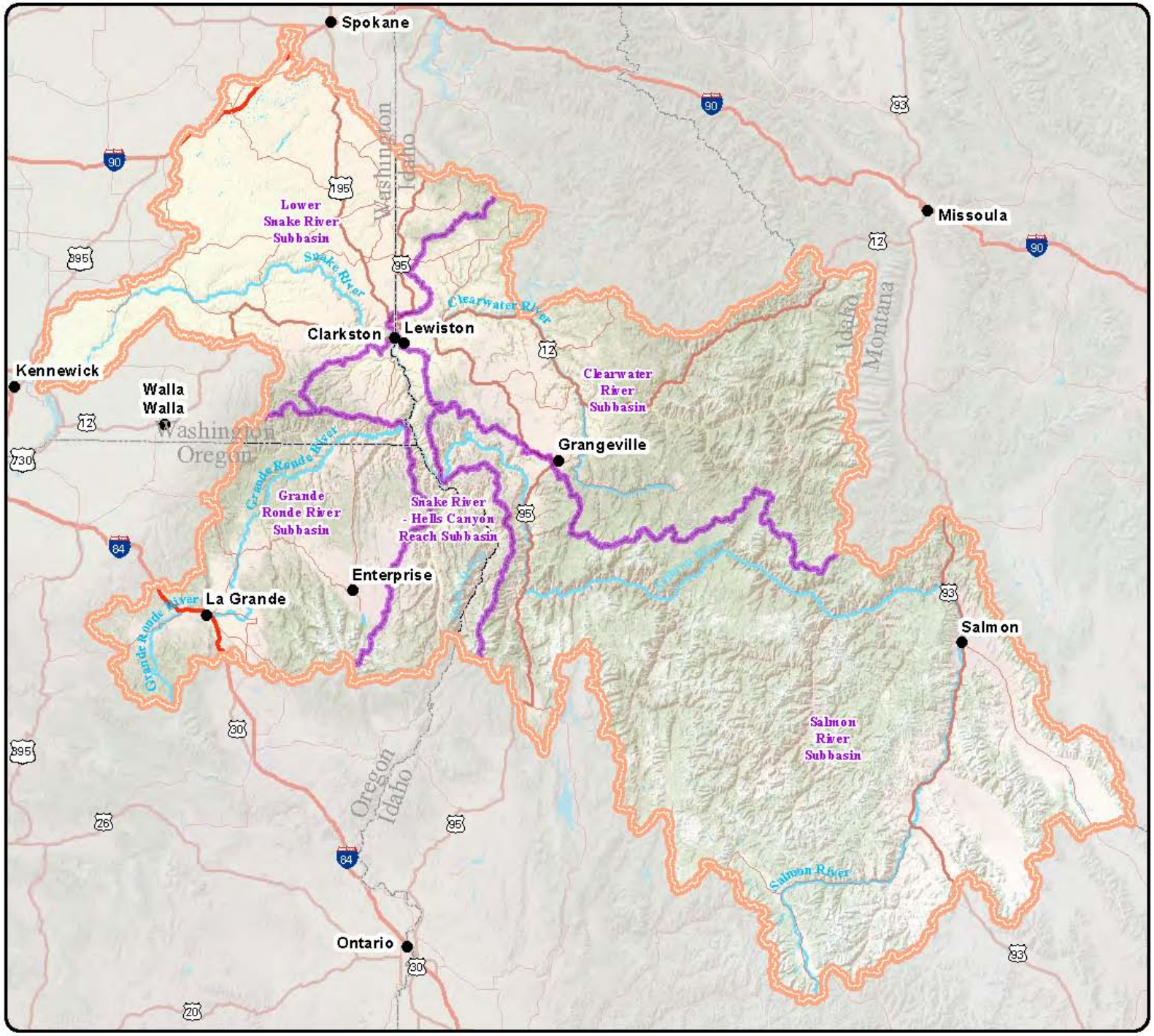
As noted in Section 1.4 above, the Corps has historically managed sediments through a program based primarily on dredging. Dredging is a cost effective, proven technology of sediment management and provides immediate benefit, although the effect does not last long. However, dredging also involves disturbing the river bottom, which has the potential to adversely affect water quality, cultural resources, aquatic habitat, and aquatic organisms. Dredging addresses the immediate need to remove sediment deposits to meet project purposes but does not address sediment sources or future sediment deposition.

Through the PSMP EIS process, the Corps has undertaken a comprehensive watershed-based approach that investigates and analyzes sources of sediment from within the sediment-contributing area, how sediment moves through the tributaries, and how sediment moves and is deposited within the lower Snake River reservoirs. This approach was based on public and stakeholder input gathered during scoping (in 2006 and 2007) and through extensive coordination and partnerships with the resource agencies and technical experts with the knowledge and tools to aid in the understanding of sediment yield and transport in the lower Snake River watershed. The purposes of the study included: gaining a better understand sediment sources and their relative contributions to sediment in the LSRP; and assessing opportunities for controlling sediment sources, sediment transport, and sediment deposition as alternative methods to dredging for meeting project purposes. Understanding the sources of sediment and how it is transported allows the Corps to identify where to focus its efforts to manage the sediment. As part of this effort the Corps has conducted or sponsored intensive data collection and analysis of sediment yields and transport throughout the Snake River basin

(discussed in detail in Section 1.6.2 below). This PSMP EIS incorporates the findings of this data collection and analysis along with the stakeholder input to identify a range of alternatives for meeting the stated purpose and need.

1.6.1 Watershed Sediment Study Area

As noted above, the sediment-contributing watershed for the LSRP encompasses approximately 32,000 square miles. The watershed sediment study area (Figure 1-2) consists of the lower Snake River's sediment-contributing drainage area and includes the four main river systems flowing into Lower Granite Reservoir (the most upstream of the lower Snake River reservoirs): the Hells Canyon Reach of the Snake, and the Clearwater, Salmon, and Grande Ronde watersheds. The watershed also includes the area draining directly to the lower Snake River. Areas above the Hells Canyon dam complex and Dworshak Dam are not included, as these facilities are high dams that effectively prevent most sediment generated upstream of these dams from reaching the lower Snake River system.



PSMP Study Area

With 5 Subbasins

Legend

- PSMP Study Area
- Subbasin Boundaries
- State Boundary
- Cities

Transportation

- Interstate
- Major/US Highway
- State Highway
- Major Rivers

0 5 10 20 Miles

US Army Corps of Engineers
Walla Walla District

The Corps manages only a very small part of the more than 32,000 square miles in the watershed – approximately 42 square miles of land around the LSRP. Other branches of the federal government manage most of the study area, with 27 percent in federal wilderness area and another 35 percent as national forest (nonwilderness). Thirty-four percent of the study area is in private ownership (Figure 1-3).

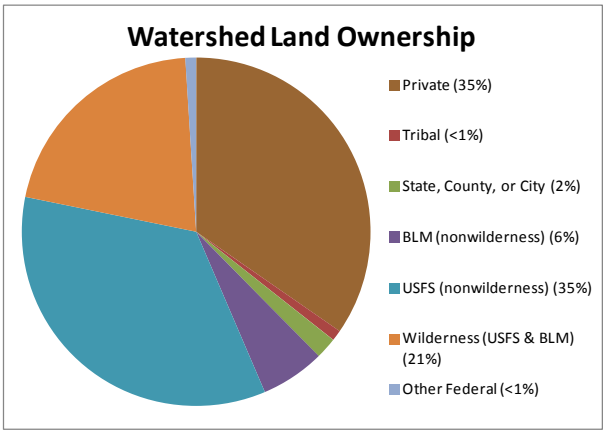


Figure 1-3. Watershed Land Ownership

1.6.2 Sediment and the Lower Snake River Watershed

Sediment is both a resource and a problem in river and reservoir systems. Erosion, sediment loading to and transport by streams, and sediment deposition are natural processes, but erosion and sediment loading can be increased by human activities, sometimes worsening problems associated with sediment. The following sections provide: a brief overview of watersheds and sediment; the extensive sediment studies undertaken in support of evaluating sediment management measures to be included in the programmatic sediment management plan; and the key findings of those studies.

1.6.2.1 Watersheds and Sediment – An Overview

The Corps' historical sediment management approach generally addresses sediment in the locations where it accumulates within the reservoirs and interferes with the authorized uses of the lower Snake River. In contrast, other agencies sediment management activities are aimed at reducing sediment delivered to local streams. A watershed approach involves assessing the large sediment-contributing area to better understand sources of sediment, how sediment moves through the watershed and river systems, and how sediment in the lower Snake River interferes with the Corps authorized purposes. As part of development of a long-term plan for managing sediment in the lower Snake River to meet authorized project purposes, the Corps and other agencies have conducted extensive literature reviews, data collection, and analysis to assess sediment sources and transport within the sediment-contributing watershed and the lower Snake River. This section describes the general characteristics of sediment, its transport within river systems, and why and where it accumulates in the lower Snake River.

Sediment is a mixture of soil particles and other material carried by a river. Sediment originates from the surrounding lands, as well as from the bed and banks of streams, and is carried into rivers and their tributaries by stormwater runoff, bank erosion, or is blown in by wind. Landslides and unstable slopes can also directly contribute sediment into the river system. Land-disturbing activities and events such as road building, urban development, logging, and agriculture can increase the sediment load entering the tributary streams and reservoirs. These chronic sources generally contribute sediment to streams over long periods of time. Wildfires

alter vegetation and affect physical properties of soil, frequently leading to slope instability and large-scale erosion and sediment loading (Goode et al. 2010; Elliot et al. 2010). Research has shown that these large-scale infrequent events are responsible for most sediment delivered to rivers and streams (Goode et al. 2010; Elliot et al. 2010). Complicating the management of sediment is the fact that sediment in large watersheds can be stored for years or even decades within the channel system before it is transported downstream.

Sediment in rivers can be classified into two general types (Figure 1-4):

- ***Suspended sediment*** is typically fine-grained material such as clay, silt and fine sand, which moves downriver suspended within the water column.
- ***Bed load*** is coarse-grained material such as coarse sand, gravels, and cobbles, which move along the river bottom.

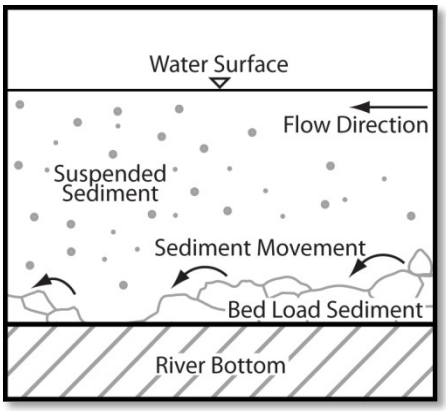


Figure 1-4. Sediment Types

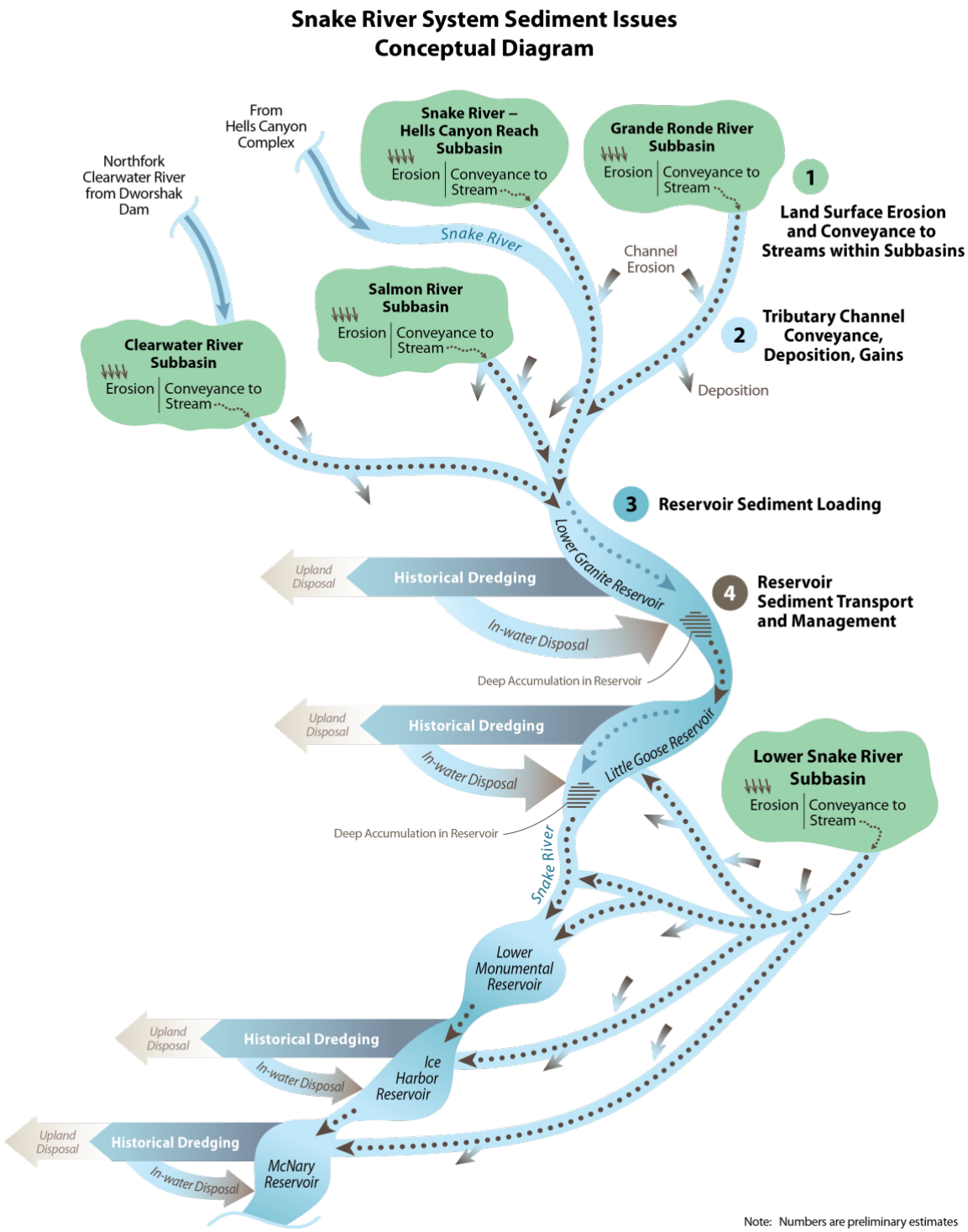
Suspended sediment in relatively steep, swiftly flowing headwater streams often becomes bed load as it moves downstream and into areas where the stream channel deepens and water velocities slow. Figure 1-5 provides a schematic illustrating: land surface erosion and conveyance to streams; channel conveyance and deposition; reservoir sediment loading; and reservoir sediment transport and management. Sediment yield and transport through the study area are discussed in detail in Section 3.10.

Sediment is a natural part of the lower Snake River and all other river systems. It can be a valuable resource or a problem, depending on the amount of sediment, whether the sediment contains pollutants, and where, when, and how sediment deposition occurs within the river and reservoir systems. Sediment can carry food and nutrients to nourish downstream plant and animal life and can create new riparian and aquatic habitats. However, too much sediment can smother some aquatic habitats, degrade water quality, and reduce visibility and light in the water column.

Sediment particle size, flow velocity, and other factors affect sediment movement. ***Sedimentation*** is sediment settling, or depositing, along the river bottom and floodplains, which typically occurs when water flow velocity decreases and sediment particles stop moving and settle or stay on the bottom. Sediment primarily enters each of the lower Snake River reservoirs from tributary streams and the upstream Snake and Clearwater Rivers.

Sediment deposition can also limit human uses of the reservoirs, such as commercial navigation and recreational boating. Further, large quantities of deposited sediment can reduce the volume of water that can be conveyed within the channel, thereby increasing the risk of flooding during

high flows. Sediment deposition can also clog water intakes used for Corps-managed irrigated



HMUs.

Figure 1-5. Watershed Schematic of Subbasins

1.6.2.2 Watershed Sediment Studies

To better understand the sources and movement of sediments entering the lower Snake River, the Corps has coordinated an extensive program of research and analysis with the following objectives:

- Identify and characterize the sources of sediment in the study area.
- Evaluate sediment transport and deposition in the study area.
- Understand long-term patterns and trends of sediment deposition in Lower Granite Reservoir, particularly at the confluence of the Snake and Clearwater Rivers.
- Understand long-term patterns and trends of sediment deposition from major tributaries downstream of Lower Granite Reservoir.
- Evaluate the impact of sediment on the risk of flooding in the Lewiston levee system.
- Characterize the effectiveness of potential measures to reduce sediment loads to Lower Granite Reservoir.

The analysis conducted by the Corps and other agencies provides information to support decision making about short- and long-term strategies for managing sediment deposition that interferes with authorized purposes of the lower Snake River. This research and analysis represents the most comprehensive assessment of sediment sources, loading, transport, and deposition conducted for the Snake River system, and forms the foundation of the Corps' analysis of measures that could potentially address the deposition of sediment in areas that interferes with the authorized purposes of the lower Snake River.

Studies conducted are summarized in Table 1-4 and reports documenting the studies are included in appendices to this EIS.

Table 1-4. Studies Conducted in the Snake River System

Studies	Agency	Appendix
Sediment sources and yield (basin wide)	Corps	B
Erosion and sediment yield from forest and rangeland	USFS	C and D
Erosion and sediment yield and reduction potential from agricultural and mixed-use watersheds	University of Idaho/ Washington State University	E
Hydraulics and hydrology investigations of the lower Snake River: Flood frequency analysis Hydraulic modeling and flood risk analysis Lower Granite Reservoir sediment loading analysis Lower Granite Reservoir sedimentation analysis Lower Granite Reservoir bed material characterization Sediment transport analysis Sediment quality analysis Water quality analysis	Corps	F

Table 1-4. Studies Conducted in the Snake River System

Studies	Agency	Appendix
Sediment load (suspended sediment and bed load) measurements on the Snake and Clearwater Rivers and tributaries Sediment coring Bathymetric survey Lower Granite bed sediment video mapping	United States Geological Survey (USGS)	—
Fingerprinting sediment sources using neutron activation analysis, ICP-MS, and isotope analysis in the lower Snake River basin	University of Idaho/ Washington State University	—

As a starting point, in 2005-2006 the Corps conducted a watershed assessment of land cover, land ownership, and existing sediment management practices (Tetra Tech 2006). This study, along with scoping input (see Section 1.7), helped frame the subsequent and more detailed sediment yield assessment. The objectives of the sediment yield assessment included:

- Assessing and modeling the sediment yield of the study area using scientifically credible methods;
- Forecasting sediment delivery to the lower Snake River reservoirs;
- Identifying the primary sources of and trends in sediment delivery to the lower Snake River reservoirs; and
- Assessing whether sediment reduction measures would be effective in reducing sediment delivery to Lower Granite Reservoir that interferes with the authorized purposes of the LSRP.

The objectives recognized the need to evaluate both the amount and sources of historic, current, and future sediment loads to the lower Snake River reservoirs, and that sediment yield monitoring and estimation should be a continuing and adaptive process that is refined and updated over time.

Methods to assess and predict sediment yield for large areas like the study area include: sediment range surveys, sediment load measurements, and expert opinion (Ayyub 2001). These methods best quantify and characterize ***sediment yield*** and delivery at the scale relevant to management of sediment in the lower Snake River reservoirs. Based on scoping input and coordination with resource agencies with expertise in hydrology and sediment yield, the Corps developed and performed the sediment yield assessment to characterize sediment yield in the study area. The basin-scale assessment is complimented by a tributary assessment that quantified sediment yield from the main tributary watersheds. In combination these allow assessment of relative contributions of sediment to Lower Granite Reservoir from the main tributaries and allow sediment loads to be generally associated with land cover and conditions. Appendices B through F are the reports presenting the detailed methods and findings from the major studies conducted by the Corps, USFS, and Washington State University and University of Idaho.

1.6.2.3 Summary of Sediment Studies Findings

The watershed assessment began with an examination of land cover and conditions that influence sediment yield. The Corps used the National Land Cover Dataset 2006 (NLCD 2006), a land cover classification scheme that uses the most recent available data and has been applied consistently across the conterminous United States. Assessment of the NLCD2006 data, and comparison with NLCD2001 data, demonstrated the following characteristics of the study area:

- The majority of the study area draining to Lower Granite Reservoir[4] is forested (55 percent in 2006); shrub communities (21 percent) and grassland (16 percent) categories are the next most common cover types.
- In contrast the portion of the study area draining to the lower Snake River below Lower Granite Reservoir is dominated by cultivated agriculture (79 percent).
- The total amount of forest land in the portion of the study area draining to Lower Granite Reservoir decreased between 2001 and 2006.

Data on wildfire from the Geospatial Multi-Agency Coordination Group shows that the study area has experienced a trend of increasing fire over the last 40 years. Wildfire has affected 22 percent of the Lower Granite Reservoir watershed between 1971 and 2010, including substantial portions of the Salmon, Clearwater, and Snake River-Hells Canyon Reach Subbasins. Figure 1-6 illustrates the area affected by wildfire over the past four decades, and Figure 1-7 presents the cumulative increase in the area affected by fire between 1971 and 2010.

[4] The sediment yield watershed for Lower Granite Reservoir is composed of the tributary subbasins that drain to the areas upstream of the head, or most upstream part, of Lower Granite Reservoir near the confluence of the Snake and Clearwater Rivers. This is an approximately 27,000 square mile subset of the approximately 32,000 square mile study area. The remainder of the study area drains to the lower Snake River reservoirs downstream of the confluence of the Snake and Clearwater Rivers.

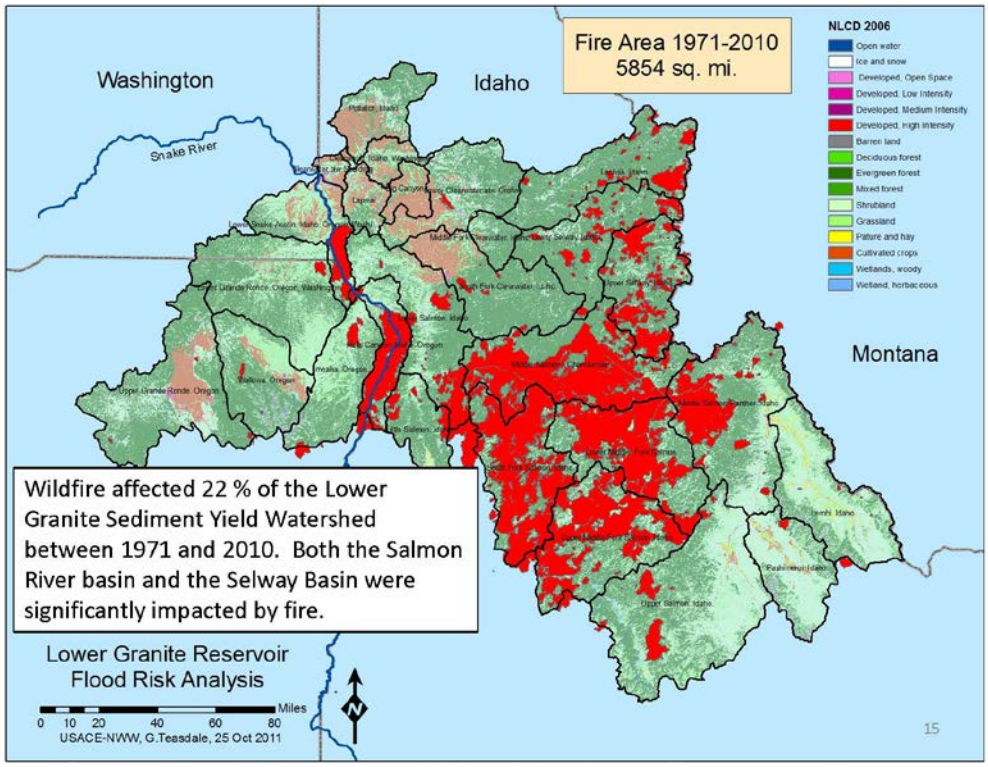


Figure 1-6. Wildfire-Affected Areas in Lower Granite Reservoir Watershed

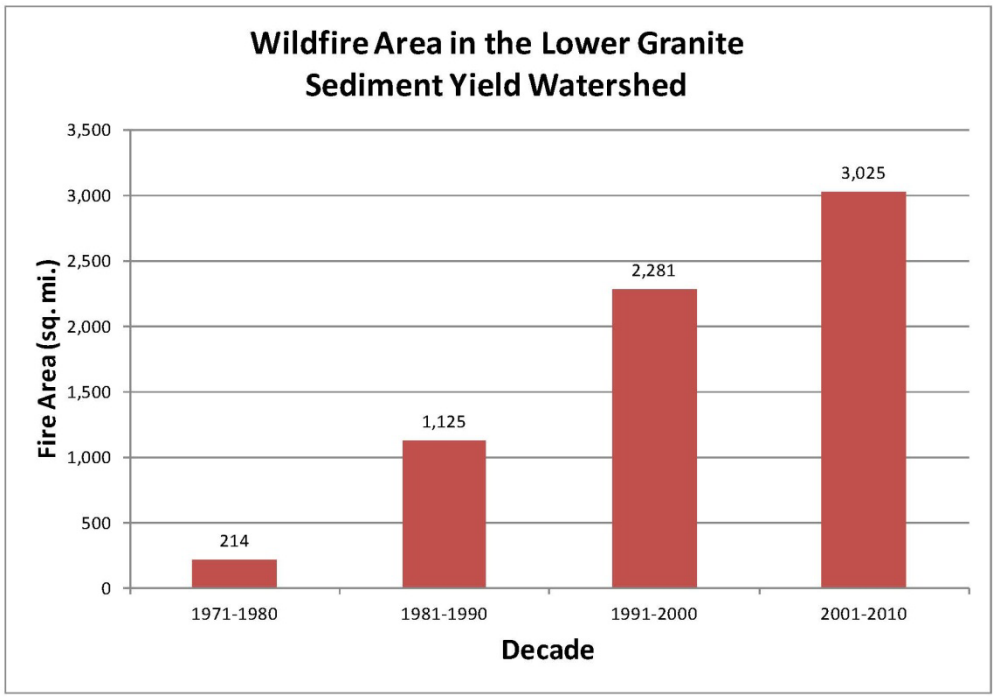


Figure 1-7. Wildfire Area in the Lower Granite Sediment Yield Watershed

Areas affected by wildfire are associated with the greatest amounts of erosion and sediment yield from forested areas (Elliot et al. 2010). This analysis of fire-affected areas is important to sediment management strategies because it illustrates the areas that are likely contributing relatively large amounts of sediment to the tributaries to Lower Granite Reservoir.

Tributary sediment load measurements provide the basis for estimating sediment yields from the subbasins draining to Lower Granite Reservoir. The USGS has measured the suspended sediment loads of each of the main tributaries and developed a set of sediment measurement data for October 2008 through October 2011. The Corps' analysis of these data has shown that:

- Suspended sediment loads generally correspond with discharges – that is, sediment loads are highest when flows are the highest, such as during high flows during spring snowmelt.
- Sediment inflows into Lower Granite Reservoir have not decreased since the 1970s and, based on the recent sediment load measurements, may be increasing in the Snake River
- At the confluence of the Snake and Clearwater Rivers (the head of Lower Granite Reservoir), the Snake River contributes 87.5 percent of incoming suspended sediment, and the Clearwater River contributes 12.5 percent. More than half of the suspended sediment load to Lower Granite Reservoir (53.5 percent) comes from the Salmon River[5].
- Contributions of sand are of particular interest in sediment management planning since the sediments that typically interfere with the authorized purposes of the LSRP are predominantly sand.
- The Snake River contributes 90.5 percent of the suspended sand load to Lower Granite Reservoir; the Salmon River is responsible for 65.2 percent of the sand load to the reservoir.
- The Grande Ronde River contributes minor amounts of sediment to Lower Granite Reservoir.

Figure 1-8 and Figure 1-9 illustrate the contributions of suspended sediment and suspended sand for the sampling period.

[5] The Salmon River is a tributary of the Snake River upstream of the Lower Granite Reservoir. Thus, the Salmon River sediment loads are a component of the Snake River load entering the reservoir.

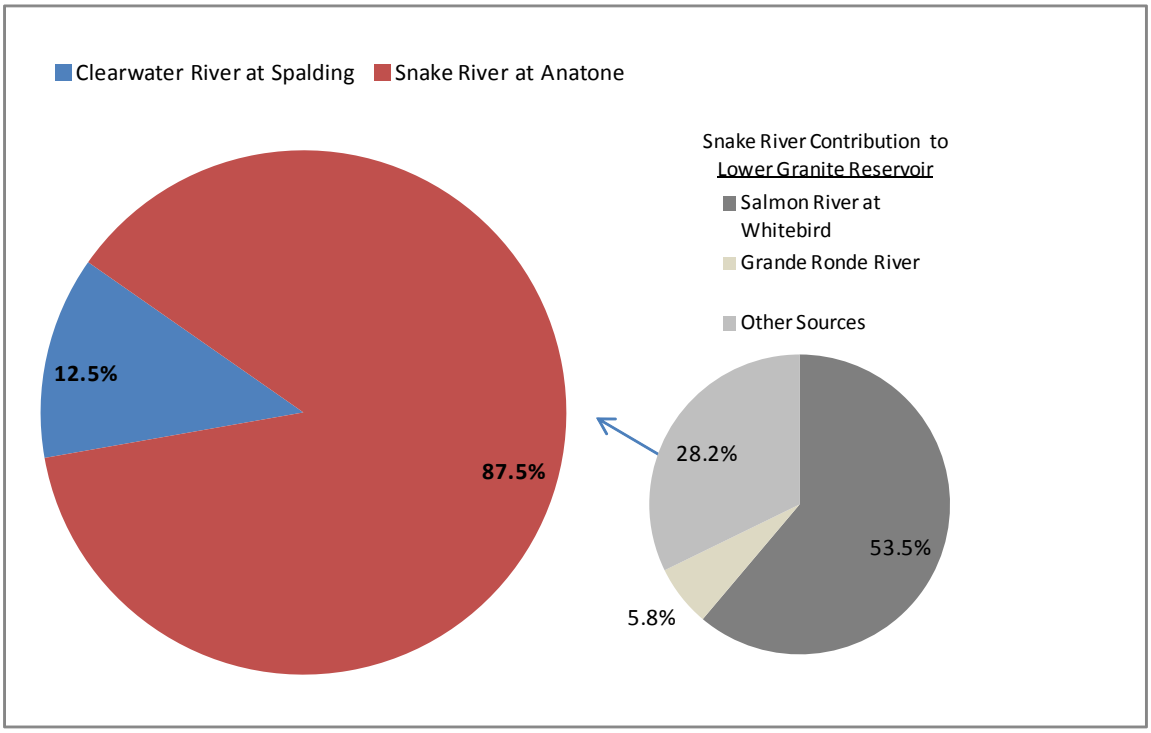


Figure 1-8. Percentage of Total Annual Suspended Sediment Load October 2008-October 2011

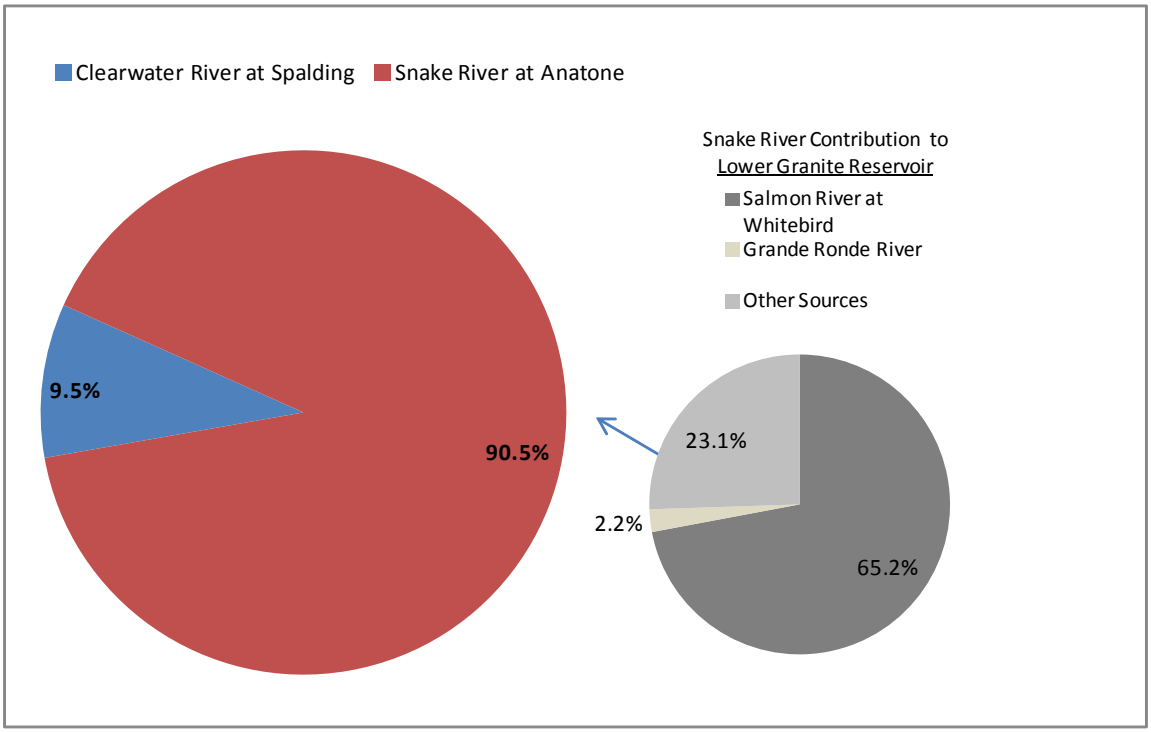


Figure 1-9. Percentage of Total Annual Suspended Sand Load October 2008-October 2011

USGS measurements of sediment and sand loads from tributaries clearly indicate that forested areas, and in particular, fire-affected areas of the Salmon River are the primary contributors of sand to the Lower Granite Reservoir (USACE 2011a). USFS assessments confirmed that landslides and debris flows from areas affected by wildfire deliver large amounts of sediment – primarily sand – in irregular, episodic events. Most of the sediment from these large events is then transported during infrequent periods of high flows (Elliot et al. 2010). Other sources of sediment from forested watersheds, such as roads, contribute smaller quantities of finer sediment than episodic large events, but erosion and sediment from these sources tends to be more chronic (occurring regularly over long periods) and potentially more controllable (Elliot et al. 2010; Goode et al. 2010).

Further, fire over recent decades has been influenced by the climatic trend of hotter, drier summers (Goode et al. 2010). The USFS projects a continuation of this trend, which may lead to increased sediment loading from forested watersheds (Morgan et al. 2008).

The preceding discussion focuses on the sediment contributions in the majority of the study area that is predominantly forest, grassland and shrub communities. The approximately 5,000 square mile portion of the study area that drains to the lower Snake River reservoirs below the confluence of the Snake and Clearwater River differs from the remainder of the study area in that agriculture is the predominant land cover type. Washington State University and the University of Idaho studied sediment yield from these agricultural watersheds, and found that:

- Widespread adoption of best management practices (BMPs) has been effective at reducing sediment yields from agricultural areas.
- Despite the reduction of sediment yield from BMPs, agricultural areas continue to contribute relatively large quantities of fine-grained sediments to tributaries, while very little sand from agricultural areas reaches the tributaries (UI/WSU 2010).
- Fine grained sediments represent a small portion of the sediments that interfere with authorized purposes of the LSRP. This is, in part, why there have historically been few locations in reservoirs below Lower Granite where sediment has interfered with authorized purposes.

In summary, the findings of sediment yield studies provide valuable information for the process of evaluating feasible and effective sediment management measures (discussed in Section 2). The findings indicate there is not a clear, quantifiable relationship between reduction of sediment at its source and reduction of sediment deposition that interferes with the authorized purposes of the LSRP. In addition, the studies enhance the Corps' (and other agencies') understanding of the existing conditions and trends of sediment yield and transport (described in detail in Section 3.10), and estimating the effects of plan alternatives. The reports documenting the studies, including details on data, methods, and findings are included as appendices to the EIS.

1.7 Environmental Review Process

The PSMP is a federally-funded effort proposed by a federal agency (the Corps); therefore, any implementation measures must comply with NEPA and other applicable Federal environmental laws and regulations. The NEPA process relies on participation of the public; local, state, and federal agencies; tribal governments; and nongovernment organizations (NGOs) to help identify the scope of issues and concerns associated with a proposed agency action. NEPA then requires study of the proposed action and alternatives to the proposed action and disclosure of their environmental consequences to decision makers and the public through preparation of an EIS and subsequent agency Record of Decision.

1.7.1 Steps in the EIS Process

The following steps are taken by the Corps (as the lead federal agency) in the EIS process:

1. Define project purpose and need.
2. Conduct public scoping to identify issues and concerns the Corps will address in the EIS.
3. Develop alternatives that meet the purpose and need.
4. Describe the potentially affected environment.
5. Evaluate environmental, economic, cultural, and social consequences of the alternatives.
6. Develop measures to avoid, minimize, and mitigate potential adverse environmental impacts.
7. Document the steps listed above in a draft EIS that is published and distributed for public and agency review and comment.
8. Consider comments and make any required revisions to the alternatives, environmental effects, or other information contained in the draft EIS.
9. Publish and distribute a final EIS.
10. Sign a Record of Decision describing the federal actions to be taken.

1.7.2 Scoping

Scoping is a critical component of the NEPA process, and one of the first steps taken in developing an EIS. During the scoping process, the Corps informs the public and agencies about the EIS preparation and allows the public and other agencies to provide input on the EIS. Public involvement allows the Corps to identify and address important issues early in the EIS process. In the case of the PSMP, it also aids the Corps in developing a range of measures and alternatives to consider in the EIS and in developing evaluation methods to assess the measures and alternatives.

The Corps conducted scoping during the fall and winter of 2006/2007. The Corps conducted targeted agency outreach to gather input and encourage participation of federal and state agencies within the study area. The Corps met with federal, state, and local agencies and groups involved in land and water resource management in each of the major subbasins to solicit input on the scope of the study and specific technical expertise on sediment management from those agencies (USACE 2007a).

The Corps also held a series of open houses and meetings during February 2007 in: Clarkston, Washington; Boise, Idaho; La Grande, Oregon; and Portland, Oregon. These meetings provided an opportunity for the public to comment on the scope of the study.

The Corps received 21 written comments from federal and state agencies, conservation districts, a county advisory committee, a city, ports, nongovernmental organizations, and citizens. Appendix G presents a complete scoping summary.

The Corps established the Local Sediment Management Group (LSMG) in July 2000 as part of the DMMP process to provide an information exchange forum between the Corps and federal and state regulatory agencies, tribes, local governments, and other stakeholders. The Corps reconvened the group in 2006 to conduct scoping for the PSMP. The group adopted a new charter and has met throughout the EIS preparation process, providing input to the Corps on sediment management on the lower Snake River. The Corps has convened the LSMG four times since 2006 to share information with the member agencies and stakeholders.

The Corps considered these comments in developing the scope of analysis and in preparing this draft EIS.

1.7.3 Commenting on the EIS

The Corps welcomes comments on this draft EIS. The public may provide written comments in multiple ways:

- Through the project Web site (http://www.nww.usace.army.mil/Missions/Projects/ProgrammaticSedimentManagementPlan.aspx),
- By e-mail at psmp@usace.army.mil,
- Mail comments to:

  U.S. Army Corps of Engineers, Walla Walla District
  PSMP/EIS, ATTN: Sandy Shelin, CENWW-PM-PD-EC
  201 North Third Avenue
  Walla Walla, WA 99362-1876

A public meeting is tentatively planned for January 24, 2013 and the public may provide comments at the public meeting. Details will be made available on the Web site and in public media when arrangements have been finalized.

1.8 Next Steps

Following publication of this draft EIS, there will be a 45-day public comment period. The public is encouraged to provide comments on the draft EIS for the Corps' consideration. After this period, the Corps will address the public comments on the draft EIS and prepare the final EIS.

1.9 Organization of this EIS

The remainder of the EIS is as follows:

Section 2, Plan Alternatives, describes the sediment management measures and alternatives considered by the Corps.

Section 3, Affected Environment, describes the existing conditions in the study area.

Section 4, Environmental Effects of Alternatives, describes the potential impacts of the alternatives on the environmental resources described in Chapter 3.

Section 5, Compliance with Applicable Environmental Laws and Regulations, provides an overview of applicable laws and regulations relevant to the Corps' management of sediment in the lower Snake River.

Section 6, Coordination, Consultation, and Public Involvement, describes how the Corps obtained input from other agencies, tribal governments, and the public.

Section 7, List of Preparers, provides names of those who contributed to the preparation of this EIS.

Section 8, Distribution, provides the Corps' distribution list for this EIS.

Section 9, References.

Section 10, Glossary.

Section 11, Index.

SECTION 2.0 ALTERNATIVES

2.1 Introduction

The Corps is considering multiple ways to manage sediment in the lower Snake River to meet authorized project purposes. The CEQ regulations implementing NEPA direct agencies to "rigorously explore and objectively evaluate all reasonable alternatives" that would meet the purpose and need as part of an EIS (40 CFR 1502.14(a)). Reasonable alternatives include actions that the Corps can undertake, but also may include alternatives that, although not within the Corps' jurisdiction as lead agency, would potentially address the identified purpose and need (40 CFR 1502.14(c)). Therefore, as part of the EIS process, the Corps identified and evaluated different measures both within and outside of their jurisdiction and organized these into potential alternatives for managing sediment in the lower Snake River.

The Corps is developing a ***programmatic*** EIS and Plan to manage sediment in the lower Snake River to meet authorized project purposes. As stated in the purpose and need, the Corps' objective in managing sediment is to maintain the authorized purposes of the LSRP. The Corps used a watershed approach to identify sources of sediment and patterns of sediment transport in order to assess the effectiveness of a range of measures for sediment management. The programmatic EIS addresses current conditions within the LSRP and provides a basis for evaluating immediate and future actions in accordance with NEPA and other applicable laws and regulations. It documents the evaluation of broad categories of actions from which the Corps, and potentially other agencies, could manage sediment. The alternatives presented in this section and evaluated in this draft EIS describe individual and combinations of potentially effective measures that the Corps or others may use to manage sediment to meet project purposes. This EIS also presents measures that the Corps may use for the immediate need to address existing conditions that are currently interfering with the authorized purposes of the LSRP. Future actions to manage sediment that involve design and implementation of measures in specific locations would undergo additional review, including a project- and site-specific environmental review tiered off of this document, prior to implementation in accordance with applicable federal, state, and local laws and agency requirements.

2.2 Alternatives Development and Evaluation

As noted in Section 1, past sediment management efforts by the Corps in the LSRP have focused largely on site-specific actions within the reservoirs, particularly dredging, to remove sediment deposits that interfere with authorized purposes of the LSRP. In preparing the PSMP EIS the Corps conducted a watershed-based study to identify dominant sediment sources within the watershed and evaluate the potential for reducing sediment input from upland sources rather than focusing solely on sediment management within the lower Snake River reservoirs. Therefore, in developing and evaluating alternatives, the Corps identified and evaluated methods of managing sediment through structures or reservoir operations in addition to dredging, as well as methods for reducing sediment entering the reservoirs from tributaries and upland sources.

The Corps used the following process to develop and evaluate the PSMP alternatives presented in this EIS:

1. Areas were identified where sediment accumulation has adversely affected or is likely to adversely affect navigation, water intakes, recreation, or flow conveyance as described in Section 1.3.1 and summarized in Table 1-1 and Section 2.2.1, below.

2. A broad range of management ***measures*** were developed that could potentially address identified problems in accordance with the purpose and need (Section 1.1.2). Measures need not completely solve all sediment-related problems identified by the Corps, but would have to reasonably contribute to resolving the problems. Measures considered were actions that could be taken by the Corps or by other agencies (Section 2.2.2).

3. Technical, environmental, and economic criteria were developed to determine the feasibility and effectiveness of the measures (Section 2.2.3).

4. All measures were screened for potential inclusion in the PSMP alternatives based on criteria developed and applied as noted in Step 3 above. Those measures that were determined to be feasible and meet the purpose and need were retained for further consideration (2.2.4).

5. A range of PSMP alternatives was developed by assembling feasible and effective measures into groups that would potentially meet the purpose and need and provide effective strategies for sediment management (Section 2.2.5).

6. Each PSMP alternative was screened to determine if implementation of the alternative would meet the project purpose and need (Section 2.2.6). The Corps developed specific evaluation criteria that reflected the purpose and need, and evaluated each of the alternatives using the criteria.

7. Any alternatives that did not meet the criteria noted in Step 6 above were eliminated from further consideration and alternatives that met the criteria were advanced for detailed analysis (Section 2.2.7).

The following sections describe steps 1 through 7 of the process used by the Corps to develop and evaluate the PSMP alternatives presented in this EIS.

2.2.1 Problem Identification

As described in Section 1.2, sediment accumulation in certain areas within the lower Snake River reservoirs interferes with authorized purposes of the LSRP. Based on historical records, observed conditions, and hydraulic modeling, the Corps has identified the areas where this sediment accumulation that interferes with authorized project purposes has occurred or may occur in the future.

The Corps conducted extensive data collection and analyses to analyze sediment sources within the entire contributing basin, identified dominant sediment sources, and identified potential measures for managing sediment both near its origin and at the locations in the lower Snake River reservoirs where its accumulation interferes with authorized purposes. (Section 1.8 presents a summary of sediment studies conducted in support of the PSMP).

2.2.2 Development of Management Measures

Through a collaborative process that included a series of workshops involving technical experts from the Corps and other agencies, and input from scoping and stakeholders (see Section 2.2.3) the Corps developed a broad range of management measures that could address identified sediment accumulation problems.

The management measures fall within four general categories: dredging and dredged material management; structural management, system operations management, and upland sediment reduction. These categories and specific measures are summarized in the table below. Section 2.2.4 provides further details on measure retained for incorporation into alternatives.

Table 2-1. Management Measures

Measure	Description
Dredging and Dredged Material Management	
Navigation and Other Dredging	Dredging typically consists of excavation, transport, and placement of dredged sediments. The excavation process for the lower Snake River involves the removal by mechanical or hydraulic means (e.g., a barge-mounted "clamshell" dredge scooping sediments from the reservoir bottom) to restore the intended dimension or use of the area where sediment has accumulated. This measure would apply to removal of sediments affecting navigation, recreation, or HMU irrigation intakes.
Dredge to improve conveyance capacity	This measure differs from the "Navigation and Other Dredging" measure in that it involves removal of substantially greater quantities of sediments from areas outside the navigation channel, access channel and port berthing areas, and/or recreation facilities. The excavation process involves sediment removal by mechanical means at the Snake and Clearwater Rivers confluence to improve flow conveyance.
Beneficial use of sediment	Beneficial use of dredged material includes a wide variety of options that utilize the dredged material for some productive purpose such as habitat restoration/enhancement, construction and industrial use, etc. This measure views dredged material as a valuable and manageable resource. The Corps has beneficially used dredged material to create fish habitat in the LSRP. Other potential beneficial uses include: habitat restoration/enhancement, beach nourishment, aquaculture, parks and recreation, agriculture, forestry, horticulture, strip mine reclamation, landfill cover for solid waste management, shoreline stabilization, erosion control, construction, and industrial use.
In-water disposal of sediment	In-water placement of dredged material is simply the discharge of dredged material into the waterway for purposes of placement and not for any beneficial use. Typically, dredged material is transported to a previously identified mid-depth or deep water location and released into the water at the upstream end of the deep water area.

Table 2-1. Management Measures

Measure	Description
Upland disposal of sediment	In upland placement, dredged material is placed on land, above high water, and out of wetland areas. The dredged material is typically placed in a cell behind levees that contain and isolate it from the surrounding environment. The dredged material is dewatered through evaporation and/or settling and discharged as clean water. The Corps has identified the Joso site in Lower Monumental Reservoir as a location where upland disposal of dredged material would occur if it was a selected measure, but may include other sites identified in the future.
Structural Sediment Management	
Bendway weirs	Bendway weirs are rock sills located on the outside of a stream or river bend that are angled upstream into the direction of flow. With the weirs angled upstream, flow is directed away from the outer bank of the bend and toward the point bar or inner part of the bend. This redirection of flow occurs at all stages higher than the weir crest. Where there is sufficient velocity and volume, the redirection of flow generally results in a widening of the channel through scour of the point bar. Bendway weirs are typically used to maintain navigation channels.
Dikes/dike fields	Dikes are longitudinal structures used to maintain navigation channels through effects on channel depth and alignment. Dikes constrict low and intermediate flows, causing the channel velocity to increase within the reach, thereby scouring a deeper channel. Dikes are typically built of rock, but may also be built of sheet piling.
Spillway deflectors	Dam spillway deflectors may be rock or concrete structures located at the base of the dam spillway to dissipate energy and reduce the velocity of the spilling water to minimize the potential for erosion and sediment movement. Spillway deflectors typically focus flow from the spillway into the navigation channel.
Agitation to resuspend	This technique involves the deliberate agitation and resuspension of deposited sediment; the sediment is then carried downriver as part of the suspended load of the river.
Agitation to prevent settling	In this measure, additional energy from propeller wash or other means is put into the water column in specific areas of concern to prevent or reduce the rate of sediment deposition.
Bubble curtains	In this measure, additional energy is put into the water column in specific areas to prevent or reduce the rate of sediment deposition. Air curtains are typically composed of a compressor, delivery pipe, and pipe manifolds. Compressed air is delivered into the water column as bubbles. The rising bubbles produce an upward-moving current field; the energy from the current field helps suspended materials remain in the water column. The system can be configured to form a “wall” of bubbles, where the current field acts to block passage of suspended sediments, form one or more columns of upward current, or form a wider net of bubbles, where the current field keeps fine-grained sediments from reaching settling velocity.
Trapping Upstream Sediments (In-Reservoir)	This measure would create a pit in a depositional part of the upstream reach of a reservoir to trap incoming sediment, thus reducing the sediment available to deposit in other areas where it may interfere with authorized purposes. Sediment would have to be periodically removed from the trap and managed by one of the measures described above (i.e., beneficial use, in-water or upland placement).
System Management	
Modify flows to flush sediment (drawdown)	In this measure, flow would be temporarily modified to increase the capacity of the river system to scour and carry sediment, thereby flushing deposited sediments downstream. The ability of a river system to carry sediment is determined by the river’s velocity and volume. Flow modification would be created by a drawdown of the Lower Granite Reservoir (e.g., increasing velocity). Flow modifications would be temporary and could be timed to take advantage of naturally-occurring periods of high and low flows.

Table 2-1. Management Measures

Measure	Description
Navigation Objective Reservoir Operation	This measure involves operating reservoirs of the LSRP at water surface elevations that would provide a 14-foot deep channel within the Federal navigation channel. The Corps would manage pool levels within the preset operating range for each reservoir to maintain 14 feet of water depth over areas where sediment deposition has occurred in the channel. Currently the Corps operates the LSRP at MOP, or as close to MOP as possible, during the juvenile salmonid outmigration season (typically from April through August, but as late as October in Lower Granite Reservoir), and at varying levels within each reservoir's 3 or 5-foot operating range through the rest of the year. This measure would provide the Corps the option of operating above MOP and even at the upper end of the operating range year-round as needed to maintain the 14 foot deep navigation channel.
Maintain channel at less than a 14 foot depth	Maintaining the navigation channel at a depth less than 14 feet forces the users to adjust their vessels and/or shipping practices to accommodate the new paradigm, or run the risk of running aground on a shoal. Maintaining the federal navigation channel at a less than 14-foot depth could be accomplished through establishing another depth as a minimum (such as 12 foot, 10 foot, etc.), or maintaining the 14-foot channel on a periodic basis with sediment deposition causing areas with less than a 14-foot depth in the interim. This measure could range from maintenance of the navigation channel at another minimum depth to no maintenance of the navigation channel.
Reconfigure affected facilities	Facilities affected by sediment deposition may be reconfigured or otherwise modified to avoid the deposited sediment. This measure could include a range of facility modifications. Water intake structures, mooring facilities, docks, and loading/unloading facilities could potentially be extended to reach out beyond nearshore areas where sediment deposition is occurring. In addition to reconfiguring water intake structures, alternative water sources for irrigation could be explored.
Relocate affected facilities	Facilities affected by sediment deposition may be relocated to avoid recurring problems with sediment deposition. Moving or relocating affected facilities is potentially suitable for commercial navigation facilities, recreational boating facilities, and water intake structures. In addition to relocating water intake structures, alternative water sources for irrigation could be explored.
Raise Lewiston Levee to Manage Flood Risk	The Lewiston levee system is an upstream extension of Lower Granite dam and was designed to protect parts of Lewiston, ID from inundation during the SPF1. The confluence of the Snake and Clearwater Rivers at upper reach of the Lower Granite reservoir collects much of the sediment carried into the reservoir. Current analysis indicates that flood risk is within acceptable limits, however if future sediment accumulation changes the flood risk to Lewiston by raising the water level in the reservoir, raising the levee would be an option for reducing flood risk. Location and height of change would be determined through detailed site- and time-specific studies.
Upland Sediment Reduction	
Vegetation filter strips	Vegetated filter strips can provide a buffer between overland flow and waterways; the vegetated filter strips slow the overland flow and remove sediment carried in runoff. The filter strips are generally grass, but can also be forested buffers. The vegetation must be dense enough to slow overland runoff and provide for filtration and settling of sediments and other particulates in the runoff.

[1] SPF, or standard project flood, is explained in Section 1.2.

Table 2-1. Management Measures

Measure	Description
Streambank erosion control	Streambank erosion can be controlled through structural measures to stabilize the eroding bank and/or influence the characteristics of the stream that are resulting in the bank's erosion. Traditional methods of addressing streambank erosion often involve armoring the streambanks with riprap or concrete, which can have negative implications for habitat, water quality, and aesthetics. Methods that incorporate natural materials and natural channel design principles can provide effective solutions without the negative impacts of traditional armoring methods. These methods include: Bioengineering – using plant materials to structurally stabilize and reinforce eroding banks. Native revetments – using native materials such as rocks, root wads, and logs to armor banks and deflect flows away from eroding areas of banks. In-stream structures – using rocks and/or logs to stabilize streambeds and banks by directing force of the stream's flow away from the bank.
Forest practices – structural	Structural practices include road construction to maximize self drainage, road removal, post-fire land treatments, and stabilizing and improving channel stability (USFS 2005, University of Arkansas 2006, Elliot et al. 2010).
Agriculture – conservation measures	Conservation districts administer a number of conservation programs that directly or indirectly seek to reduce erosion and improve water quality. Physical practices to reduce erosion and improve water quality include no-till cultivation, crop rotation, and/or taking highly erosive farmland out of production. In general, these programs are financial and technical assistance programs whereby farmers and other landowners voluntarily enter into contracts to implement conservation measures. This measure would involve implementation of additional physical practices (beyond current levels) to reduce erosion and improve water quality. In addition, rangeland conservation practices, such as fencing, moving water points away from streams, and streambank stabilization in range areas are actions that can reduce erosion and sedimentation in range and grazing areas.
Forest practices – conservation measures	Forest conservation includes measures such as concentrating vegetation treatments in larger blocks, reducing severe fire risk through prescribed fire and thinning, and protecting and restoring riparian areas (USFS 2005 and University of Arkansas 2006).

2.2.2.1 Dredging and Dredged Material Management

Dredging involves physical removal of sediments from one location, and placement of the dredged material in another location. The dredging process typically consists of excavation, transport, and placement of dredged sediments. Excavation may be by mechanical means (i.e., physically scooping sediments with a clamshell or backhoe) or hydraulic dredging, which removes sediment by suction. Once dredged, sediments are transported to a disposal or placement area. Dredged material may be placed in-water or upland, and may be beneficially used for other purposes, such as habitat creation.

2.2.2.2 Structural Sediment Management Measures

Structural sediment management measures seek to control the location and rate at which sediment is deposited at a specific location, in order to reduce or eliminate the magnitude of the sediment interference with authorized purposes of the LSRP. Examples of structural management measures include weirs to prevent sediment from accumulating in certain areas, and sediment traps to collect sediment that may otherwise interfere with authorized purposes.

2.2.2.3 System Management Measures

System management measures modify reservoir operations (such as pool depth) or facilities so that sediment deposition does not adversely affect authorized purposes. Examples of system operations measures include reconfiguring or relocating navigation facilities, managing reservoir water levels for navigation, and modifying flows to flush sediments from problem areas. These measures would occur within the lower Snake River. The Corps and public port authorities would be responsible for implementing system management measures for their respective facilities.

2.2.2.4 Upland Sediment Reduction Measures

Upland sediment reduction measures are land management actions intended to reduce the amount of sediment that enters into the lower Snake River systems. Upland sediment reduction measures include site-specific projects such as sediment traps or vegetation filter strips designed to reduce erosion of soil from land into area waterways, and programs aimed at encouraging or requiring such projects. Upland sediment reduction measures are currently implemented throughout the watershed of the lower Snake River. For the purposes of this EIS, the expansion or increase of practices beyond current levels of implementation is assumed. Sediment reduction measures would be implemented on public and private lands in contributing drainage areas through programs and actions by agencies other than the Corps. In addition, the Corps also implements upland sediment reduction measures on land it manages adjacent to the LSRP.

2.2.3 Criteria Development and Measure Screening

The Corps developed criteria (Table 2-2) to screen measures and determine which measures meet the purpose and need and is technically feasible. Those measures that met the first two of the screening criteria were determined to be reasonable to include in the PSMP alternatives; other criteria provided useful input for further consideration.

Table 2-2. Measure Screening Criteria

- Does the measure meet the purpose and need)?
- Is the measure technically feasible?
- Is the measure consistent in scale with identified sediment problems (i.e., the solution fits the problem)?
- Is the measure economically feasible?
- Is the measure consistent with existing Corps or other agency authority?
- Can the measure's effectiveness be quantified?
- Can the measure's ability to address identified sediment problems be reasonably predicted?
- If No to bullet above, would additional research be warranted?
- Does the measure have potentially significant adverse effects on fish and wildlife habitat, water quality, and/or known cultural resources?
- Does the measure have potentially adverse socioeconomic effects?
- Does the measure have potentially adverse effects on hydropower or other authorized project purposes?
- Is the measure effective in the short (0 to 10 years) or long term (11 years or beyond), or both?

In 2010 the Corps conducted three interdisciplinary technical workshops to apply the criteria and screen the measures to determine which were feasible and reasonable and therefore would be incorporated into PSMP alternatives. The process and outcomes of the workshops are summarized below.

Technical Workshop 1, held on May 25 and 26, 2010, focused on potential sediment management and system management measures (measures primarily within the Corps' authority to implement). Participants included Corps staff with specific expertise in hydraulics and hydrology, fish and wildlife biology, economics, system operations, navigation, planning, and environmental compliance.

Technical Workshop 2, held on August 11, 2010, focused on screening potential sediment reduction measures. The workshop included presentations and participation by the Corps, USGS, USFS, and University of Idaho and Washington State University staff who had conducted sediment studies. Sediment reduction measures are typically outside of the Corps' authority and therefore participants in Workshop 2 included technical experts from the organizations noted above and the U.S. Environmental Protection Agency.

During **Technical Workshop 3**, held on September 21, 2010, the Corps considered the recommendations from the first two workshops and determined the feasible and effective measures to incorporate into the alternatives. The Corps removed measures that, based on recommendations made in Technical Workshops 1 and 2, did not meet the purpose and need or were not technically feasible. For measures where the feasibility and effectiveness showed promise at addressing sediment problems but could not be definitively determined based on existing information, the Corps retained these measures subject to further research and evaluation. Table 2-3 presents the measures dismissed and the reasons for their dismissal.

Table 2-3: Measures Dismissed

Measure	Reason for Dismissal
Spillway Deflectors	Not technically feasible • Deflectors used at Ice Harbor made it very difficult for barges to move through the navigation channel. • Significant safety concerns with this measure due to changes in velocity and direction of flow that could be hazardous to barges and boats.
Agitation to Prevent Settling	Not technically feasible • Applicability would be limited and highly localized. • No known proven examples of effective application.
Bubble Curtain	Not technically feasible • Applicability would be limited and highly localized • Not feasible for types of sediment in LSRP.
Maintain Navigation Channel at Less than 14 feet	Does not meet purpose and need • Measure does not meet the purpose and need. The Congressionally-authorized channel depth is 14 feet.

The measures retained for incorporation into plan alternatives as a result of the workshop process are discussed in Section 2.2.4.

2.2.4 Measures Retained

The following subsections present general information on the measures retained for incorporation into plan alternatives. The descriptions do not identify specific actions or designs applicable to the lower Snake River or tributary watersheds, nor do they describe environmental impacts of specific actions. Table 2-4 provides a brief overview of the measures retained and their applicability to the LSRP authorized purposes.

Table 2-4. Management Measures Retained

Measure	Applicability to Authorized Purpose			
	Navigation	Recreation	Fish and Wildlife	Flow Conveyance
Dredging and Dredged Material Management				
Navigation and Other Dredging	Yes	Yes	Yes	Yes
Dredge to improve conveyance capacity	Yes	No	No	Yes
Beneficial use of sediment	Yes	N/A	Yes	Yes
In-water disposal of dredged material	Yes	Yes	Yes	Yes
Upland disposal of dredged material	Yes	Yes	Yes	Yes
Structural Sediment Management				
Bendway weirs	Yes	No	No	No
Dikes/dike fields	Yes	No	No	No
Agitation to resuspend	No	Yes	Yes (partial need flow)	No
Trapping Upstream Sediments (In-Reservoir)	Yes	No	No	Yes
System Management				
Modify flows to flush sediment (drawdown)	No			Yes (partial medium/higher flows are better)
Navigation objective reservoir operation	Yes	Yes	No	No
Reconfigure affected facilities	No	Yes	Yes	No
Relocate affected facilities	Yes	Yes	Yes	N/A
Raise Lewiston Levee to Manage Flood Risk	No	No	No	Yes
Upland Sediment Reduction Measures				
Vegetation filter strips	No	Yes	Yes	No
Streambank erosion control	No	Yes	Yes	No
Forest practices – structural	No	Yes	Yes	No
Agriculture – conservation measures	No	Yes	Yes	No
Forest practices – conservation measures	No	Yes	Yes	No

2.2.4.1 Dredging and Dredged Material Management

Dredging – Dredging consists of removal, transport, and placement of dredged sediments. For the purposes of this analysis, the term "dredging" will refer to the excavation process, as placement and use options are discussed separately. The excavation process involves the removal of deposited sediment as part of maintenance activities. After excavation, the sediment is transported from the dredging site to a site where it will be used or permanently placed. This transport operation is typically accomplished by the dredge itself or by using additional equipment such as barges. Use and/or placement can occur in-water or in an upland area.

Backhoe and bucket (such as clamshell, or dragline) are types of mechanical dredges (Figure 2-1). Clamshell buckets are the most commonly used dredges in McNary Reservoir and the lower Snake River. Sediments excavated with a mechanical dredge are generally placed onto a barge or truck (for near-shore excavations) for transportation to the use or placement site.

Hydraulic, or suction, dredging may also be used to remove sediments. Hydraulic dredging involves barge-mounted mechanical equipment to generate suction through a large hose that may be equipped with a cutter head to dislodge sediments. Sediments are sucked up through the hose along with large amounts of water to create a slurry which is collected for beneficial use or placement.

Figure 2-1. Dredging Operation on the Columbia River

Selection of equipment and method to perform a dredging operation is typically dependent on:

- Physical characteristics of the material to be dredged.
- Quantities of material to be dredged.
- Dredging depth.
- Distance to reuse or placement area.
- Physical environment of the dredging and placement areas.
- Contamination level of sediments (if any).
- Method of placement or beneficial use.
- Production required.
- Type of dredges available.
- Cost.

Dredging has historically been the most common method used to remove unwanted sediment and maintain navigation channels and docking areas. However, due to concerns over potential impacts to listed endangered anadromous species and other aquatic resources, dredging in the lower Snake River is typically limited to an in-water work window of December 15 to March 1.

Maintenance dredging actions are in response to a variety of conditions including, but not limited to: emergency situations which would result in an unacceptable hazard to navigation; periodic maintenance of known persistent shoal areas that impede navigation; and removal of sediment that presents a hydraulic flow impediment.

Dredged Material Management – Disposal options available to the Corps for dredged materials are indentified in accordance of Corps regulations (33 CFR 335-338). The "Federal standard" for disposal of dredged material is defined as "[T]he least costly alternatives consistent with sound engineering practices and meeting the environmental standards established by the 404(b)(1) evaluation process. . . ." (33 CFR 335.7). 33 CFR 336.1(c)(1) states, "[I]t is the Corps' policy to regulate the discharge of dredged material from its projects to assure that dredged material disposal occurs in the least costly, environmentally acceptable manner, consistent with engineering requirements . . . ." Additionally, it is the Corps' policy to always consider beneficial use of dredged material when evaluating disposal options (Engineer Manual 1110-2-5026).

Beneficial Use of Sediment **–** Beneficial use of dredged sediment includes a wide variety of options which utilize the dredged material for some productive purpose. Broad categories of beneficial uses based on the functional use of the dredged material include:

- Habitat restoration/enhancement (wetland, upland, island, and aquatic sites including use by waterfowl and other birds).
- Beach nourishment.
- Aquaculture.
- Parks and recreation (commercial and noncommercial).
- Agriculture, forestry, and horticulture.
- Landfill cover for solid waste management.
- Shoreline stabilization and erosion control (fills, artificial reefs, submerged berms, etc.).
- Construction and industrial use (including port development, airports, urban, and residential).
- Fill for other uses (dikes, levees, parking lots, and roads). (USACE 1992; USACE 2007b).

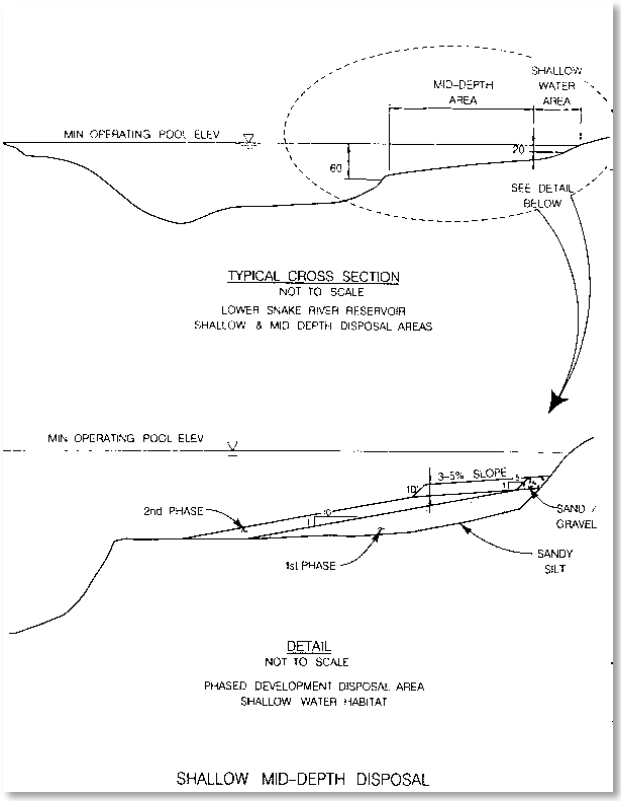


Figure 2-2. Schematic of In-water Sediment Placement

It is Corps policy to secure the maximum practicable benefits of dredged material within authority and funding limitations. Detailed guidelines for various beneficial use applications and cost-share requirements, as applicable, are given in EM 1110-2-5026 (USACE 1987). Specific applications are dependent on opportunities available at the time the dredging is occurring. Opportunities for beneficial use should be identified and evaluated as part of the planning for each dredging activity.

In-water Disposal of Sediment – In-water disposal of dredged material is simply the discharge of dredged material into the waterway for purposes of disposal (as opposed to in-water habitat creation or beneficial use). Typically, dredged material is transported to a previously identified mid-depth or deep water location in a bottom dump barge, and released into the water at the upstream end of the deep water area.

In-water disposal is typically used for materials without a practicable beneficial use or when beneficial use options are unavailable (e.g. lack of funding/authority, infeasible) . For example, silts and fines not suitable for the creation of shallow water fish habitat could potentially be discharged to a mid-depth or deep water placement area.

All noncontaminated dredged material is a candidate for in-water disposal; the practicality of in-water disposal depends on the opportunities available for beneficial use of the dredged material at the time of the dredging activity and the cost of such use.

Upland Disposal of Sediment – Upland disposal of sediment is the placement of dredged material on land, above high water and out of wetland areas, but not as a beneficial use. The dredged material is typically placed in a cell behind berms that contain and isolate it from the surrounding environment and is dewatered through evaporation and/or settling and discharge of clean water. There may be other uses of the land during and after the site is used for dredged material placement.

Upland disposal can be used for any dredged material, coarse or fine-grained. The material would be transported to and placed on the upland site.

The Corps has identified the Joso HMU (Figure 2-3) as a potential upland disposal site for dredged material placement. In general, the site would be used for placement of dredged material if in-water placement options are not available. Placement of dredged sediments at Joso could potentially contribute to restoration of the site. Material would be placed within the extensive borrow area occupying the center of the HMU. Off-loading facilities would likely need to be constructed as currently there are no provisions for barge access or off-loading.

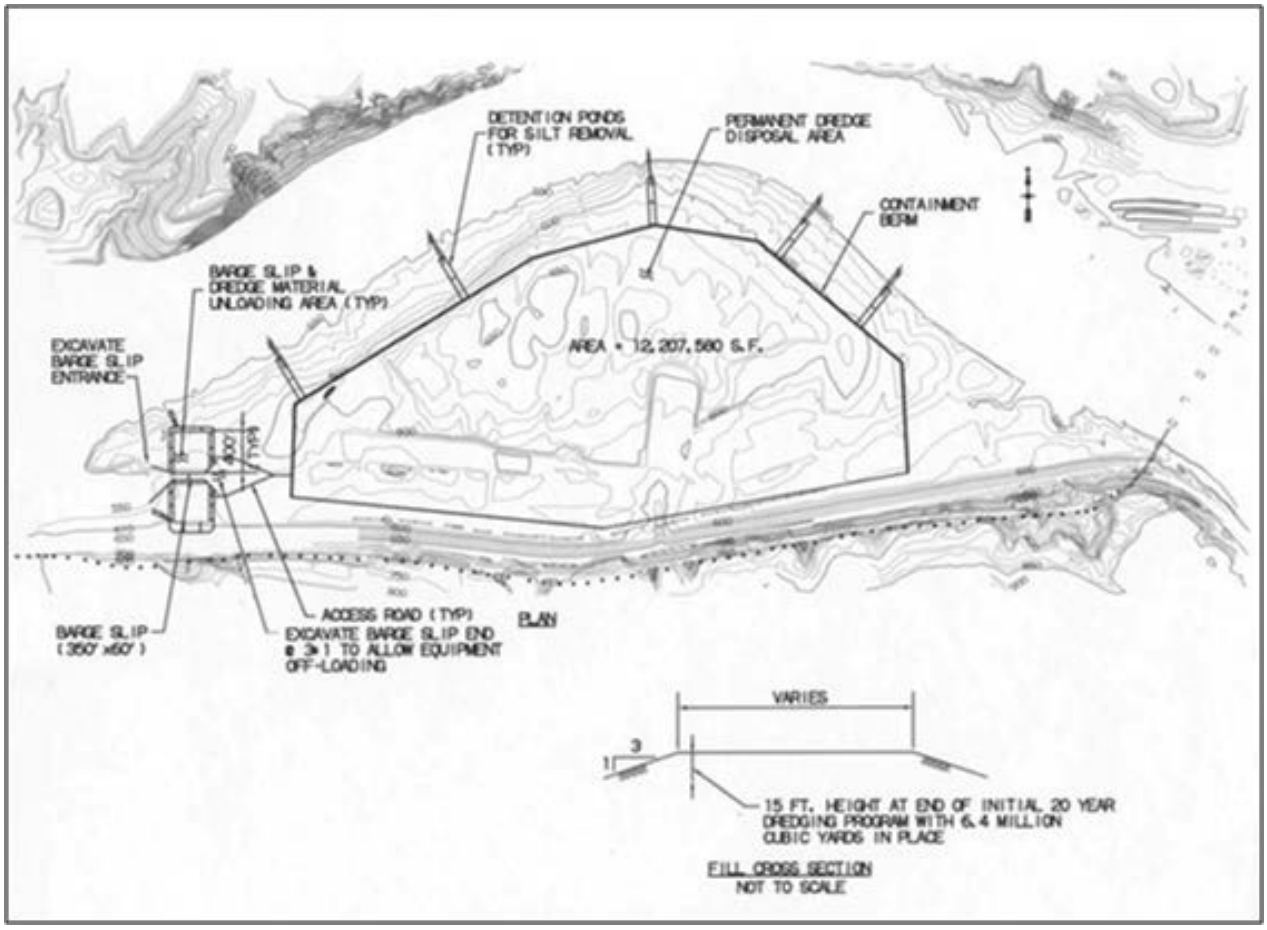


Figure 2-3. Joso HMU Upland Disposal Site

2.2.4.2 Structural Sediment Management

Structural sediment management measures described below could be considered by the Corps subject to authority and funding.

Bendway Weirs – Bendway weirs would be placed at strategic locations along the banks of the Lower Snake to redirect water flow in a manner that would prevent problem sediment accumulation and maintain navigation channel dimensions**.** Bendway weirs are rock structures located on the outside of a stream or river bend, angled upstream into the direction of flow. Water flowing over the bendway weirs is redirected at an angle perpendicular to the middle of the weir. With the weirs angled upstream, flow is directed away from the outer bank of the bend and toward the ***point bar*** or inner part of the bend. This redirection of flow occurs at all stages higher than the weir crest. Where there is sufficient velocity and volume, the redirection of flow generally results in a widening of the channel through scour of the point bar (Figure 2-4). Other possible effects include:

- Deposition at the toe of the ***revetment*** (river bank stabilization armoring) on the outside of the bend, thus increasing bank stability.
- Scouring on the point bar creating a flow path on the inside of the bend.
- Surface water velocities are more uniform across any cross-section.
- Flow patterns in the bends are generally parallel with the banks (not concentrated on the outer bank of the bend).
- The ***thalweg*** (deepest, continuous line in river) of the channel is moved from the toe of the outer bank revetment to the stream ends of the weirs.

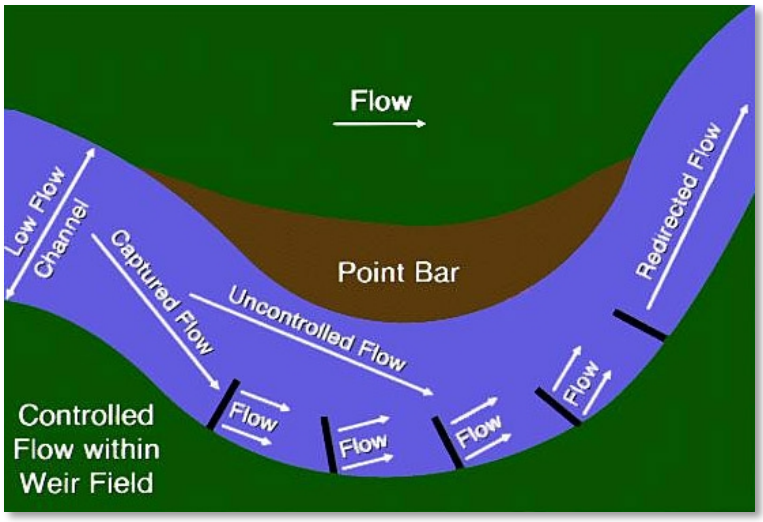


Figure 2-4. Schematic of Bendway Weirs

Weirs are generally built in sets (4 to 14 weirs per bend) and are designed to act as a system to control velocities and current directions through the bend and well into the downstream crossing.

Typically, bendway weirs are applied to unimproved or revetted bends where growth of the point bar is restricting the navigation channel width, or an improved navigation channel alignment is desired. Bendway weirs are commonly used on both navigable rivers and smaller streams.

Dikes and Dike Fields – Dikes would work in a similar manner as bendway weirs to redirect river flows and velocities and prevent problem sediment accumulation and maintain navigation channel dimensions. Dikes are linear structures used to maintain navigation channels through effects on channel depth and alignment. Dikes constrict channels at low and intermediate flows, causing the channel velocity to increase within the reach and thereby scour a deeper channel. Dikes are typically built of rock, but may also be built of sheet piling (Figure 2-5).

Figure 2-5. Dike Construction

Dikes are generally used to contract river channels at low and intermediate flows, forcing all flow through a narrower width (Figure 2-6). The resulting increased velocity erodes, or scours, the bed to a lower elevation. Scour is commonly needed only to provide navigable depths during periods of low flow; therefore, low dikes are more desirable than high dikes which can cause excessive scour at high flows. Scour can also be greater for dikes angled upstream rather than perpendicular to flow or angled downstream.

Figure 2-6. Dike on the Mississippi River

Maintenance of open water areas in dike fields can be encouraged through variations in the design, such as notches or rootless (e.g., not attached to the river bank) dikes. Dikes have traditionally been designed to induce sediment deposition within the dike fields although stone dikes do not necessarily have to fill with sediment to be effective.

Agitation to Resuspend – Agitation to resuspend sediments involves the deliberate agitation and resuspension of deposited sediment. Following agitation, the sediment is then carried downriver as part of the suspended load of the river. This technique requires both some form of agitation mechanism, and sufficient river flow (velocity and volume) to carry the additional sediment load away from the targeted area. There are numerous potential means to mechanically agitate and resuspend sediment, including hydraulic dredges, high pressure air and water pumps, and using propellers to move sediment. In this technique, jets of air and/or water are applied to the deposited sediments at sufficient pressure to dislodge them from the bottom causing the sediments to become resuspended in the water column and carried downriver by the current.

The effectiveness of this measure is dependent on the ability of the agitation mechanism to resuspend the deposited sediment and the ability of the river to carry the resuspended sediment a sufficient distance downriver to avoid problems with resettling. The Corps has used this method before in the lower Snake River. It is suited to addressing smaller, localized sediment issues with fine sediments. Assuming conditions are met for the measure to work, agitation and resuspension could be used as a short-term sediment management measure. The measure would not prevent sediment from depositing in the same location in the future, nor does it control where resuspended sediment is transported and potentially resettles.

Trapping Upstream Sediments (In-Reservoir) – Trapping upstream sediment involves creating a location within a depositional reach at the upstream end of a reservoir where sediments settle and are captured, thus preventing them from reaching other locations where they may interfere with authorized purposes of the LSRP. A pit in the river bottom would need to be excavated to create

the trap and sediments would need to be collected, either through periodic dredging or other means. Removed trapped sediments would then need to be managed through one of the measures described above. This technique has been successfully applied on small river systems (Lipscomb et al. 2005).

2.2.4.3 System Management

Reservoir Drawdown to Flush Sediment – Reservoir drawdown to flush sediments involves drawing down Lower Granite Reservoir to create high flow and velocity conditions that would scour and transport accumulated sediment from the confluence of the Snake and Clearwater Rivers. Drawdown of Lower Granite Reservoir would scour some sediment from the confluence of the Snake River and Clearwater River; however, most of the sediment scour would occur within the main channel. The scoured sediment would be transported downstream and redeposited. Much of the sediment would likely redeposit within Lower Granite Reservoir or in the upper reaches of Little Goose Reservoir. Sediments could potentially deposit in areas where they would interfere with authorized purposes of the LSRP. There must be adequate high flow prediction and modeling allowing the Corps to conduct drawdown operations in a timely manner for this measure to function effectively.

Navigation Objective Reservoir Operation – This measure involves operating reservoirs of the LSRP at water surface elevations that would provide a 14-foot-deep channel within the Federal navigation channel. The Corps would manage pool levels within the preset operating range for each reservoir to maintain 14 feet of water depth over areas where sediment deposition has occurred in the channel. This measure would provide the Corps the option of operating above MOP and even at the upper end of the operating range as needed to maintain the 14 foot deep navigation channel.

Raising the operating pool as part of this measure provides a temporary means to provide desired water depths; however, there are physical limits as to how much the pool levels can be raised based on design specification for the dams. For example, the operating range of Lower Granite Reservoir is 733 to 738 feet above means sea level, so the pool cannot be raised any higher than 738. Also the Corps does not have the authority to raise the pool above maximum operating pool. Once the pool has been raised to the maximum level, it cannot be raised further and the measure ceases to be effective. Additionally, raising the operating pool in a reservoir has a greater effect near the dam than upriver due to the normal change in elevation moving upstream.

The McNary Reservoir and lower Snake River reservoirs are typically operated within a three to five-foot range with the lowest end of the range designated as the MOP. Currently the Corps operates the lower Snake River reservoirs at MOP or near MOP during the juvenile salmonid outmigration season, typically from April through August, and as late as October at Lower Granite, to ensure compliance with the 2008/2010 BiOp. Under this measure, the Corps would operate the projects as needed at a pool level above MOP to provide temporary relief from sediment accumulated in the navigation channel. The Corps would coordinate with NMFS when proposing to operate above MOP during the juvenile salmonid outmigration season.

Reconfigure/Relocate Affected Facilities – Facilities affected by unwanted sediment deposition may be relocated or otherwise modified to avoid those areas where sediment deposition tends to accumulate and interfere with facility uses. This measure could include a range of facility modifications, from extending a dock or mooring facility to relocating an entire port facility. Moving or relocating affected facilities is potentially suitable for commercial navigation facilities, recreational boating facilities, and water intake structures. It is not practicable to move the existing navigation channels, locks, or lock approach channels.

Water intake structures and some docks could potentially be extended to reach out beyond near-shore areas where unwanted sediment deposition is occurring. This technique has been successfully used on several water intake structures in the program area. In lieu of reconfiguring or relocation water intake structures, alternative water sources for irrigation that would alleviate the need for the intake, such as a well, could be explored. Other facilities, such as boat ramps, would likely need to be completely relocated. The effectiveness and applicability of this measure is highly site- and facility-specific and would have to be determined on a case-by-case basis.

Raise Lewiston Levees to Manage Flood Risk – This measure involves raising critical portions of the Lewiston levee system to limit the risk of being overtopped during a high flow event. The Lewiston levee system is an upstream extension of Lower Granite dam and was designed to protect parts of Lewiston, Idaho from being flooded by the creation of the reservoir and from inundation during the standard project flood. As noted in Section 1, the Corps' criteria for managing flood risk at facilities like the Lewiston levee has changed over time. Currently, in accordance with ER 1105-2-101, the Corps uses risk analysis to determine the appropriate approach to managing flood risk. Current analysis indicates that flood risk is within acceptable limits, however if future sediment accumulation changes the flood risk to Lewiston, raising portions of the levee system would be a viable option for reducing flood risk, subject to authority. Location and height of change would be determined through detailed site- and time-specific studies. Based on past analysis of levee modification, any future levee raise would likely involve raising the earthen embankments or building low walls on portions of the existing levees, and modifying surrounding roads and other infrastructure affected by the levee raise (USACE 2002b).

2.2.4.4 Upland Sediment Reduction Measures

Vegetation Filter Strips – This measure involves either planting a strip of vegetation along a waterbody or preserving a strip of existing vegetation along a waterbody to provide a buffer between overland flow and receiving waterbodies. The vegetated filter strips slow the overland flow and remove sediment, organic material, nutrients, and chemicals carried in runoff. Strips have been designed to treat runoff from agricultural fields, roadways, parking lots, and construction sites. Filter strips are generally grass, but can also be forested buffers (Figure 2-7).

Figure 2-7. Vegetation Filter Strip Surrounding Agricultural Area

Soil particles (sediment) settle from runoff water when flow is slowed by passing through a vegetative filter strip. The larger particles (e.g., sand) settle within the shortest distance. Finer particles (silt and clay) are carried the farthest before settling from runoff water, and may remain suspended when runoff velocity is high. Land use practices above vegetative filter strips affect the ability of strips to filter sediment. Fields with steep slopes and/or exposed soils will deliver more sediment to filter strips than more gently sloping fields and those with good vegetative cover. Large amounts of sediments entering vegetative filter strips can overload their filtering capacity. For the vegetation strip to be effective, runoff must pass through the strip as overland flow. If the runoff is concentrated in ***rills*** (narrow and shallow incision in topsoil) or gullies, the filter strip will not be effective.

Streambank Erosion Control – This measure uses structural features to control streambank erosion by stabilizing the eroding bank and/or influencing the characteristics of the stream that are resulting in the bank's erosion. Techniques of streambank erosion control include:

- Bank armoring with riprap or ***gabions*** (caged riprap) (Figure 2-8)
- Bioengineering
- Native material revetments
- In-stream structures, such as cross vanes and bendway weirs.

Figure 2-8. Gabion Baskets Installed for Slope Stabilization Along a Stream

Streambank erosion control measures are commonly applied where accelerated streambank erosion is occurring. Bank erosion can be a normal process; however, erosion can be accelerated by removing or damaging riparian vegetation, changing stream hydrology, and changes in watershed land uses. Traditional methods of addressing streambank erosion often involve armoring the streambanks, which has negative implications for habitat, water quality, and aesthetics.

Methods that incorporate natural materials and natural channel design principles can provide effective solutions without the negative impacts of traditional armoring methods. These methods often benefit habitat, water quality, and aesthetics, in addition to reducing streambank erosion. These methods include:

- Bioengineering – using plant materials to structurally stabilize and reinforce eroding banks.
- Native revetments – using native materials such as rocks, root wads, and logs to armor banks and deflect flows away from eroding areas of banks.
- In-stream structures – using rocks and/or logs to stabilize streambeds and banks by directing force of the stream's flow away from the bank.

Streambank erosion control measures are generally effective at stopping site-specific erosion problems. Where erosion control practices involve bioengineering, the protection needs to allow for establishment of vegetation to provide for long-term stability. Streamside vegetation also improves riparian and in-stream habitat by providing shade, cover, and food.

Forest Practice, Structural – This measure involves a variety of techniques to reduce erosion from forest land or stop eroded sediments from entering waterways. Erosion and sediment control structures are designed to control a variety of surface drainage, erosion, and sediment migration conditions through methods such as:

- Decommissioning and restoring unused forest roads and/or structural changes to reduce erosion from and around existing roads.
- Preventing the formation or advancement of rills and gullies,
- Reducing the flow velocity in watercourses or providing structures capable of with standing high flow velocity,
- Stabilizing the grade and controlling head cutting in natural or artificial channels,
- Conveying water from one elevation to another,
- Diverting water away from unstable slopes, and
- Filtering and retaining sediment.

Erosion and sediment control structures utilized in forest practices include road construction to maximize self drainage, road removal, post-fire land treatments, and stabilizing and improving channel stability.

Forest Vegetation Management – Forest vegetation management includes measures to manage forest lands to reduce severe fire risk through prescribed fire and thinning, and protecting and restoring riparian areas.

Forest fires are a natural part of a forest's life cycle and they can be detrimental or desirable, depending on when and where they occur. Prescribed fires are controlled burns used to change the character of a vegetation community (e.g., adding strata or "layers" to the vegetation structure), improve watershed conditions, and provide protection from uncontrolled fires by removing fuel sources and creating vegetative fire breaks. Thinning and vegetation management are also used in order to maintain a healthy forest community by encouraging desirable plants and strata variation while removing invasive species and vegetation that serve as fuel sources for fire.

Riparian protection and restoration can be accomplished through:

- Limiting harvest within riparian zones
- Harvesting just one side of a stream channel, if feasible
- Retaining trees within riparian zones
- Retaining a vegetated buffer strip within riparian zones

Protecting riparian zones provides a vegetated barrier that prevents eroded soils, nutrients, and pesticides from entering stream systems, stabilizes stream banks, and provides food and cover for wildlife.

Agricultural Conservation – This measure involves the use of conservation measures available to the agricultural community to reduce soil erosion on land used for agricultural purposes. Conservation measures focus on vegetative, engineering, and crop and livestock management to control erosion, preserve water quality, and support healthy ecosystems while providing a sustainable food supply. Cultivation and range management conservation measures that can be implemented include:

- Avoid disturbing any areas with landslides, gullies and slips.
- Avoid intact riparian areas; if altered, they should be revegetated and restored.
- Fence around streams to prevent cattle from entering.
- Add streambank stabilization in range areas.

In addition, conservation measures available to reduce erosion include no-till cultivation, crop rotation, and/or taking highly erosive farmland out of production.

2.2.5 Range of Alternatives

The Corps formulated a range of alternatives by assembling the feasible and effective measures into groupings based on how measures could be implemented and what agencies could implement them (Table 2-6). In accordance with NEPA, the Corps included a No Action Alternative, defined here as no change in current practices. As noted previously, the alternatives are programmatic and describe broad categories of actions that could be implemented to meet the purpose and need.

Each alternative represents a plan that the Corps (or potentially other agencies) would implement over time, and thus contains both action to address the immediate need to reestablish the authorized navigation channel and a framework for decision-making on future actions. For any alternative, the Corps would monitor sediment accumulation in the LSRP and assess conditions with respect to sediment accumulation that would affect authorized purposes. Those conditions are:

- Immediate need:
  - Federal navigation channel (including channel, lock approaches, and port berthing areas) is less than authorized dimensions at MOP.
- Future needs:
  - Sediment accumulation that interferes with an authorized purpose recurs at the same location more frequently than every five years.
  - Sediment accumulation that interferes with an authorized purpose is anticipated at a particular location (or locations) in less than five years.
  - Unanticipated sediment accumulation interferes with an authorized purpose.

When any of those conditions exist, the Corps (or others) would initiate actions to address them. For the immediate need, the Corps would initiate action to reestablish the authorized dimensions of the navigation channel; for future needs, the Corps (or others) would initiate planning and evaluation of applicable measures, consistent with the framework of the adopted plan. Currently, the immediate need exists at several locations within the LSRP (see Section 1.1.2). In addition, several sites within the LSRP have recurring sediment accumulation conditions that represent future needs.

The alternatives the Corps developed are described in the following sections. Each description includes a summary which measures are included and how the immediate and future needs would be addressed.

2.2.5.1 Alternative 1 - No Action (Continue Current Practices)

The No Action Alternative represents a continuation of the Corps' current operational practices of managing the LSRP through navigation objective reservoir operations in the lower Snake

River, and sediment reduction measures implemented in the Snake River watershed by other agencies and land managers.

The Corps would continue its current operation of monitoring sediments that affect the authorized purposes of the LSRP. The Corps operation of the dams and reservoirs would comply with the terms and conditions of the 2008/2010 BiOp, or subsequent ESA consultation, and other applicable requirements. The Corps would continue to operate the Lower Granite reservoir (and other LSRP reservoirs if necessary) above MOP if needed to provide for safe navigation (see RPA 5 of 2008/2010 BiOp).

The Corps' ongoing monitoring of sediment accumulation and evaluation of sediment transport in Lower Granite Reservoir shows that sediment accumulation in the upper part of the reservoir has slowed over time and that some segments of the channel between Silcott Island (river mile [RM] 143) and the Snake/Clearwater confluence (RM 139) have not changed much in recent years. The depth and shape of the river near the confluence is adjusting to balance deposition of the incoming sediment load in some locations (inside of river bends) with scouring of sediment in other places (outside of river bends) through operation of the reservoir, resulting in no net increase in the amount of sediment deposited. The long-term risk of flooding at Lewiston, while not eliminated, is reduced from earlier projections because the flow conveyance of the levee system can be maintained by normal reservoir operation for a longer period of time. Fine sediment, mostly silt and very fine sand that is carried easily by high flows in the main channel, still settles in the shallow areas of the confluence where it can degrade habitat (by filling spaces between substrate particles and smother any eggs and benthic organisms that may be present) and cause problems for navigation and recreational boating.

Sand and coarse silt sediment entering at the confluence of the Snake and Clearwater Rivers cannot escape Lower Granite reservoir. Therefore, other segments of Lower Granite Reservoir, particularly near and downstream of Silcott Island, have achieved the same condition as the confluence and will therefore continue to accumulate sediment. It is not possible to predict with certainty how the reservoir will adjust to future sediment loads. As such, the Corps would continue to monitor sediment accumulation and periodically reevaluate flow conveyance in the reservoir levee system and the need for sediment management.

The Corps assumes agencies and land owners responsible for land management in the basins that drain into the LSRP (including federal and state agencies, tribes, and conservation districts) would continue to implement existing land management programs and practices related to erosion control, consistent with their current authorizations and funding. The Corps would continue implementing erosion and sediment control on its lands adjacent to the LSRP.

Measures

- Navigation objective reservoir management
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Implementation

Alternative 1 would address immediate and future needs in the same way. The Corps would continue to manage the LSRP through operating reservoirs at or as close to MOP as possible during juvenile salmonid outmigration and above MOP (consistent with 2008/2010 BiOp, or other applicable biological opinion) to provide sufficient water depth for safe navigation. As such, this alternative would address the immediate need only to the extent that raising pool levels to maximum operating pool would reestablish the authorized channel dimensions and would not, by itself, reestablish the navigation channel to its authorized dimensions. It would not address future needs once reservoir(s) have been raised to maximum operating pool and sediment would continue to accumulate in areas where it interferes with authorized purposes. Table 2-5 in Section 2.2.7 summarizes how this and other alternatives did or did not meet the alternatives screening criteria.

2.2.5.2 Alternative 2 – Increased Implementation Sediment Reduction Measures

Under this alternative, the Corps would operate the reservoirs for the navigation objectiveas similar to Alternative 1, and would rely solely on increased implementation of sediment reduction measures implemented by other agencies and land owners[2] to address sediment accumulation that interferes with authorized purposes of the LSRP. The watershed approach of this PSMP EIS considers methods that could reduce sediment loads to the lower Snake River as a means of addressing sediment accumulation that interferes with authorized purposes of the LSRP. The Corps identified land management techniques (sediment reduction measures) that reduce erosion from upland sources within the Snake River watershed. The Corps coordinated with land management agencies and sponsored research and analysis by the USFS, USGS, the University of Idaho and Washington State University to assess the effectiveness of sediment reduction measures. Through these coordination and analytical efforts, the Corps identified expanded implementation of several sediment reduction measures as potentially reducing sediment loads to the system.

The Corps would continue its current program of monitoring sediments in the lower Snake River as described for Alternative 1.

[2] For this alternative, sediment reduction measures were assumed to increase from there current levels of implementation. It should be noted that sediment reduction measures are currently implemented throughout the Lower Snake River's sediment contributing basin.

Measures

- Navigation objective reservoir operation
- Expanded implementation of structural and nonstructural sediment reduction measures by other land managers/owners
  - Vegetation filter strips
  - Streambank erosion control
  - Structural forest practices
  - Forest vegetation management
  - Agriculture conservation measures

Implementation

Implementation of Alternative 2 would be the same for immediate and future needs. Under this alternative, the Corps assumes land managers – federal, state, and local agencies – and land owners would expand the implementation of sediment reduction measures (beyond current levels) throughout the sediment contributing watershed. The Corps would continue navigation objective reservoir operation, similar to Alternative 1, to address sediment accumulation that interferes with authorized purposes, as well as erosion control on Corps lands adjacent to the LSRP.

Agencies and land owners responsible for land management in the basins that drain into the LSRP (including federal and state agencies, tribes, and conservation districts) would continue to implement existing land management programs and practices related to erosion control, consistent with their current authorizations and funding. The Corps would continue implementing erosion and sediment control on lands adjacent to the LSRP.

The effectiveness of Alternative 2 would have similar limitations to Alternative 1 with respect to immediate needs. Expanded implementation of sediment reduction measures in the watershed would result in reduced sediment loading to tributary streams and, ultimately, to the lower Snake River reservoirs. Analysis of current sediment loading from major tributaries indicates that there is not a quantifiable relationship between reduced sediment loads and sediment accumulation that interferes with authorized purposes of the LSRP (See Section 1.6). Thus, enhanced implementation of sediment reduction measures is not expected to have a measurable effect on sediment deposition in the LSRP and would be ineffective at meeting future needs.

2.2.5.3 Alternative 3 – System Management

Under the System Management Alternative, the Corps would evaluate and implement system management measures only to manage sediment accumulation that interferes with authorized purposes of the LSRP. Measures include navigation objective reservoir operation, increasing

flow velocities (by reservoir drawdown) to flush sediments, and modifying, relocating, or reconfiguring facilities affected by sediment accumulation.

The Corps would continue its current program of monitoring sediments in the lower Snake River and would include in the PSMP plans to implement system management measures to address sediment accumulation that affects the authorized purposes of the LSRP.

Measures

- Navigation objective reservoir operation
- Modify flows to flush sediments (drawdown)
- Reconfigure affected facilities
- Relocate affected facilities
- Raise Lewiston levees to manage flood risk
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Implementation

The Corps would evaluate and implement system management measures to address sediment accumulation that interferes with authorized purposes of the LSRP based on a management framework presented in an adopted sediment management plan[3]. The Corps would monitor sediments in the lower Snake River and assess the effectiveness of management actions. Based on this monitoring and assessment, the Corps would adapt the system management measures as needed to optimize management of sediment accumulation that interferes with the authorized purposes of the LSRP. Sediment reduction measure implementation by other agencies or landowners would not change.

To address the immediate need the Corps would operate Lower Granite Reservoir (and other LSRP reservoirs if necessary) above MOP to provide for 14-foot deep navigation channel. The Corps would monitor and assess sediment accumulation and for future needs would initiate planning and implementation of system management measures to address sediment accumulation that interferes with authorized purposes of the LSRP.

Agencies and land owners responsible for land management in the basins that drain into the LSRP (including federal and state agencies, tribes, and conservation districts) would continue to implement existing land management programs and practices related to erosion control,

[3] At the level of formulating a range of alternatives, the Corps assumed that a programmatic sediment management plan would be adopted for whatever alternative was ultimately selected at the conclusion of the NEPA process. That plan would guide the Corps monitoring of conditions, planning of sediment management actions, and adaptation of measures based on monitoring and implementation.

consistent with their current authorizations and funding. The Corps would continue implementing erosion and sediment control on lands adjacent to the LSRP.

Alternative 3 would have the same effectiveness as Alternatives 1 and 2 in addressing the immediate need, but would provide a variety of measures for potentially addressing future needs that may be more effective than simply navigation objective reservoir operation, but would not provides sufficient means for addressing unanticipated sediment accumulation that interferes with authorized project purposes.

2.2.5.4 Alternative 4 – Structural Sediment Management Measures

The Structural Sediment Management Measures Alternative involves using measures that control the location and rate at which sediment is deposited at a specific location, in order to reduce or eliminate the magnitude of the sediment interference with authorized purposes of the LSRP. Under this alternative, the Corps would monitor sediment in the lower Snake River and, as applicable, plan, design, and implement structural sediment management measures based on the framework presented in an adopted PSMP and subject to authority. This alternative builds on the No Action (Continue Current Practices) Alternative and therefore includes the option of navigation objective reservoir operation.

Measures

- Navigation objective reservoir operation
- Bendway weirs
- Dikes and dike fields
- Agitation to resuspend sediments
- Trapping upstream sediment (in reservoir)
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Implementation

The Corps would evaluate and implement structural sediment management measures to address sediment accumulation that interferes with authorized purposes of the LSRP based on a management framework presented in an adopted sediment management plan. The Corps would monitor sediments in the lower Snake River and assess the effectiveness of management actions. Based on this monitoring and assessment, the Corps would adapt the structural measures as needed to optimize management of sediment accumulation that interferes with the authorized purposes of the LSRP. Sediment reduction measure implementation by other agencies or landowners would not change.

To address the immediate need the Corps would operate the LSRP to provide for navigation (as provided for in Reasonable and Prudent Alternative 5 of 2008 FCRPS BiOp, similar to

Alternatives 1, 2, and 3). The Corps would monitor and assess sediment accumulation and for future needs would initiate planning and implementation of system management measures to address sediment accumulation that interferes with authorized purposes of the LSRP.

Agencies and land owners responsible for land management in the basins that drain into the LSRP (including federal and state agencies, tribes, and conservation districts) would continue to implement existing land management programs and practices related to erosion control, consistent with their current authorizations and funding. The Corps would continue implementing erosion and sediment control on lands adjacent to the LSRP.

Alternative 4 would have the same effectiveness as Alternatives 1, 2, and 3 in addressing the immediate need. Alternative 4 would provide a variety of structural measures for potentially addressing future needs and would provide opportunities to potentially reduce sediment accumulation in some areas, but would not provides sufficient means for addressing unanticipated sediment accumulation that interferes with authorized project purposes.

2.2.5.5 Alternative 5 – Dredging-Based Sediment Management

Alternative 5 represents a continuation of the Corps historical practices of using dredging as the primary tool for managing sediment that interferes with authorized uses of the LSRP. The Corps would continue its current program of monitoring sediments that affect the authorized purposes of the LSRP. Sediment management would consist of dredging and dredged material management. Sediment management activities would be undertaken in response to or anticipation of sediment accumulation problems.

Agencies and land owners responsible for land management in the basins that drain into the LSRP (including federal and state agencies, tribes, and conservation districts) would continue to implement existing land management programs and practices related to erosion control, consistent with their current authorizations and funding. The Corps would continue implementing erosion and sediment control on lands adjacent to the LSRP.

Measures

- Navigation objective reservoir operation (on temporary basis until dredging is implemented)
- Navigation and other dredging
- Dredging to improve flow conveyance capacity
- Beneficial use of dredged material
- In-water disposal of dredged material
- Upland disposal of dredged material
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Implementation

Over the long term, the Corps would monitor sediment in the LSRP and would dredge accumulated sediment that interferes with the authorized purposes of the LSRP. Based on Corps regulations, the Corps would evaluate disposal options to identify the least costly, engineeringly feasible, environmentally acceptable option (Federal standard). It is also the Corps' policy to always consider potential beneficial use of dredged material. "Beneficial use" refers to utilizing dredged sediments as resource materials in productive ways (USACE 2011a). Potential beneficial use of dredged materials would include creating submerged fish habitat or establishing woody riparian habitat consistent with the Lower Snake River Fish and Wildlife Compensation Plan (USACE 1975a, 2004a) or using the material as fill for future development. Dredged material could also be disposed of in upland areas or in-water.

If monitoring and evaluation of the Snake and Clearwater confluence area indicate conditions are changing and the flood risk is increasing above acceptable levels, the Corps would dredge to address the need to increase flow conveyance capacity and reduce flood risk.

To address the immediate need, the Corps would dredge areas of accumulated sediment that interfere with commercial navigation. Based on current conditions, the Corps would perform maintenance dredging at four locations in the lower Snake and Clearwater Rivers. One site is the downstream navigation lock approach for Ice Harbor Dam, and the other three sites are located at the confluence of the Snake and Clearwater Rivers in Lower Granite reservoir. The three sites in Lower Granite Reservoir are the Federal channel and the berthing areas for the Port of Lewiston and Port of Clarkston. The Corps proposes to undertake the dredging during the first available in-water work period (December 15 – March 1) following the approval of the Record of Decision for this PSMP EIS. The Corps currently estimates that it would dredge approximately 421,675 cubic yards of sediment from the four locations (1,950 cubic yards from Ice Harbor lock approach, 407,000 cubic yards from the Federal channel, 3,000 cubic yards from the Port of Lewiston, and 10,225 cubic yards from the Port of Clarkston). The Corps identified a location in the Lower Granite reservoir, Snake River Mile (RM) 116 just upstream of Knoxway Canyon, for in-water disposal of the dredged materials as a beneficial use for the immediate need. The Corps proposes to use the dredged material to create additional shallow water habitat for juvenile salmonids. Appendix H presents detailed information on the proposed immediate action to address sediment that interferes with commercial navigation.

The Corps conducted detailed analysis of options to restore the navigation channel to its authorized dimensions as part of the 2005 Lower Snake River Navigation Maintenance EIS (Corps 2005). Current conditions are similar to those when the Corps undertook its analysis for that EIS and the Corps employed a similar framework for proposing the immediate action taken under this alternative.

The Corps would continue monitoring sediment in the LSRP, as well as the effectiveness of habitat created by placement of dredged material.

2.2.5.6 Alternative 6 – System Management and Non-Dredging Sediment Management

Alternative 6 combines system management and structural sediment management measures to represent the nondredging measures potentially available for managing sediments in the LSRP. This alternative is a combination of Alternatives 3 and 4.

Measures

- Navigation objective reservoir operation
- Modify flows to flush sediments (drawdown)
- Reconfigure affected facilities
- Relocate affected facilities
- Raise Lewiston levees to manage flood risk
- Bendway weirs
- Dikes and dike fields
- Agitation to resuspend sediments
- Trapping upstream sediment (in reservoir)
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Similar to other alternatives with the exception of Alternative 2, this alternative would include agencies and landowners implementing sediment reduction measures at current levels.

Implementation

Over the long term, the Corps would monitor sediment in the LSRP and would plan and implement sediment management actions based on the framework presented in an adopted sediment management plan. When conditions meet criteria for action, the Corps would initiate review of site-specific conditions, screening of alternative measures (including consideration cost, engineering, and environmental factors), and determine which measure (or measures) to implement to address sediment accumulation.

Agencies responsible for land management in the basins that drain into the LSRP would continue to implement existing sediment reduction measures, consistent with their current authorizations and funding.

If monitoring and evaluation of the Snake and Clearwater confluence area indicate conditions are changing and the flood risk is increasing above acceptable levels, the Corps would evaluate and implement a levee raise to address the need to increase flow conveyance capacity and reduce flood risk.

To address the immediate need the Corps would operate Lower Granite Reservoir (and other LSRP reservoirs if necessary) above MOP to provide for navigation. The Corps would monitor and assess sediment accumulation and would initiate planning of system management measures to address sediment accumulation that interferes with authorized purposes of the LSRP.

2.2.5.7 Alternative 7 – Comprehensive (Full System and Sediment Management Measures)

Alternative 7 is a combination of Alternatives 5 and 6 and provides all available dredging, system and structural measures for the Corps to manage sediments that interfere with the authorized uses of the LSRP. The alternative includes dredging and dredged material management along with other sediment and system management measures, and provides the Corps with a complete toolbox for addressing sediment that interferes with the authorized purposes of the LSRP.

Measures

- Navigation objective reservoir operation (on temporary basis until dredging is implemented)
- Navigation and other dredging
- Dredging to improve flow conveyance capacity
- Beneficial use of dredged material
- In-water disposal of dredged material
- Upland disposal of dredged material
- Modify flows to flush sediments (drawdown)
- Reconfigure affected facilities
- Relocate affected facilities
- Raise Lewiston levees to manage flood risk
- Bendway weirs
- Dikes and dike fields
- Agitation to resuspend sediments
- Trapping upstream sediment (in reservoir)
- Continued upland sediment reduction measures by the Corps, other land managers/owners (at current levels of implementation)

Alternative 7 includes the all measures included in Alternatives 5 and 6 described above. This alternative also includes implementation of sediment reduction measures at current levels.

Implementation

Over the long-term, the Corps would monitor sediment in the LSRP. When conditions meet criteria for action, the Corps would initiate review of site-specific conditions, screening of

alternative measures (including consideration cost, engineering, and environmental factors), and determine which measure (or measures) to implement to address sediment accumulation.

Agencies responsible for land management in the basins that drain into the LSRP would continue to implement existing sediment reduction measures, consistent with their current authorizations and funding.

If monitoring and evaluation of the Snake and Clearwater confluence area indicate conditions are changing and the flood risk is increasing above acceptable levels, the Corps would implement dredging or raise the levees to address the need to increase flow conveyance capacity and reduce flood risk.

To address immediate needs the Corps would dredge areas of accumulated sediment to reestablish the navigation channel and port berthing areas at the authorized dimensions, as described for Alternative 5. Dredged material would be placed in-water in Lower Granite Reservoir (near Snake RM 116) as a beneficial use to create fish habitat. The Corps would continue monitoring sediment in the LSRP, as well as the effectiveness of habitat created by placement of dredged material.

2.2.6 Alternatives Screening

The Corps developed screening criteria to evaluate alternatives. The screening criteria were applied to the range of alternatives described above to determine which alternatives would satisfy the identified purpose and need (see Section 1). The criteria applied were:

- Alternatives must provide sufficient measures to remedy sediment deposition that interferes with authorized purposes of the LSRP, for both future and immediate needs.
- Alternatives must provide for reestablishing the navigation channel from current conditions to authorized dimensions (14 feet deep by 250 feet wide at MOP throughout the designated navigation channel) to allow for unimpeded commercial navigation and compliance with any ESA biological opinion requiring operation at MOP.
- Alternatives must provide the ability to address flood risk at Lewiston and Clarkston if it reaches unacceptable levels.

The criteria helped eliminate those alternatives that could not reasonably or practically meet the project purpose and need. Only those alternatives that met all of the screening criteria were moved forward for further evaluation. The exception was the No Action Alternative. As a standard NEPA practice this alternative was carried forward to serve as the baseline for comparison.

2.2.7 Alternatives Removed from Further Consideration

By applying the screening criteria listed in Section 2.2.6, the Corps determined that the alternatives described in the following sections did not meet the purpose and need and were therefore removed from further consideration in the EIS. Alternatives 1 and 2 did not meet any

of the criteria; Alternative 1 was retained since NEPA requires evaluation of the No Action alternative. Alternatives 3, 4, and 6 partially met some of the needs described in the criteria, but did not provided sufficient measures to comprehensively address the immediate and future sediment management needs in the LSRP; each of these alternatives was therefore excluded from further analysis in the EIS. Alternatives 5 and 7 met all the screening criteria and each provide a complete set of measures to comprehensively address LSRP sediment management needs; as such, both were retained from detailed analysis in this EIS. Table 2-5 summarizes the screening of the range of alternatives, and the following sections further discuss the reasons for removing some alternatives from further consideration.

Table 2-5: Range of Alternatives Screening

Alternative	Does the alternative			Retain for further evaluation in EIS?
	Provide long-term solution(s) to sediment that interferes with authorized purposes of LSRP?	Reestablish the navigation channel to authorized dimensions at MOP?	Provides the ability to address flood risk in future?	
1 – No Action	No	No	No	Yes
2 - Increased Implementation Sediment Reduction Measures	No	No	No	No
3 - System Management	Partial	No	Partial	No
4 - Non-Dredging Sediment Management Measures	Partial	No	Partial	No
5 - Dredging-Based Sediment Management	Yes	Yes	Yes	Yes
6 - System Management and Non-Dredging Sediment Management	Partial	No	Partial	No
7 - Comprehensive (Full System and Sediment Management Measures)	Yes	Yes	Yes	Yes

2.2.7.1 Alternative 2 – Increased Implementation of Sediment Reduction Measures

Under this alternative, increased sediment reduction measures would be implemented by other agencies and land owners to address sediment accumulation that interferes with authorized purposes of the LSRP. The Corps would not dredge or undertake other system or sediment management measures to address sediment that interferes with the authorized purposes of the LSRP (for either immediate or future needs).

The watershed approach employed by the Corps considered methods to reduce sediment loads to the lower Snake River as a means of addressing sediment accumulation that interferes with authorized purposes. The Corps identified land management techniques that could reduce erosion from upland sources within the Snake River watershed. The Corps also coordinated with land management agencies and collaborated on research and analysis by the USFS, USGS, and the

University of Idaho and Washington State University to assess the effectiveness of sediment reduction measures. Several sediment reduction measures were identified as potentially reducing sediment loads to the system. However, the analysis by the above-mentioned agencies demonstrated that sediment reduction from upland sources would not, by itself, be effective at reducing sediment accumulation that interferes with authorized purposes of the LSRP, either for future or immediate needs, particularly given the possibility of sediment loads increasing in the future.

As noted in Section 1.6, recent studies indicate that the largest sources of sediment within the LSRP system are attributable to uncontrollable, large scale, episodic events. Although studies indicate that land management practices in the watershed do contribute to a reduction in sediments entering the system (as well as provide some localized water quality and habitat benefits), there is no reliable scientific analysis that indicates sediment reduction measures alone would have a measurable effect on sediment accumulation that interferes with the authorized purposes of the LSRP.

Sediment reduction as a stand-alone alternative would not fully address sediment accumulation that interferes with the authorized purposes of the LSRP, would not meet the stated purpose and need, and was therefore excluded from further consideration in the PSMP EIS.

2.2.7.2 Alternative 3 - System Management

Similar to increased sediment reduction, expanded system management measures implemented by the Corps (as a stand-alone alternative) were considered as measures to address sediment accumulation that interferes with authorized purposes. While several system management measures potentially could address sediment accumulation at some areas or provide a partial solution to some sediment accumulation problems, system management measures alone would not address sediment accumulation that interferes with the authorized purposes of the LSRP. Further system management measures would not reestablish the navigation channel. Therefore Alternative 2 was excluded from further consideration.

2.2.7.3 Alternative 4 – Non-Dredging Sediment Management Measures

Non-dredging sediment management measures, like system management measures, provide partial solutions to some sediment accumulation needs. Alternative 4 would provide partial solution to future sedimentation that interferes with authorized purposes of the LSRP, but would not reestablish the navigation channel. Therefore Alternative 4 was excluded from further consideration.

2.2.7.4 Alternative 6 – System Management and Non-Dredging Sediment Management

Alternative 4 combines the elements of Alternatives 3 and 4 providing a broader array of tools available to the Corps to potentially address sediment that interferes with the authorized purposes of the LSRP. While Alternative 5 provides more measures, the combination it presents does not fully address the purpose and need. Like Alternatives 3 and 4, Alternative 5 provides partial

solutions to future needs and does not provide a means for addressing immediate needs of reestablishing the navigation channel at MOP. Therefore Alternative 5 was also excluded from further consideration.

2.2.8 Plan Alternatives Evaluated in Detail

The Corps determined that Alternatives 5 and 7 met the purpose and need and should be evaluated in detail. Both alternatives provide solutions for future sedimentation that interferes with authorized purposes of the LSRP as well as immediate reestablishment of the dimensions of the authorized navigation channel at MOP. Similarly, both alternatives provide the ability to address flood risk and are consistent with the FCRPS Bi Op RPA 5. Alternative 1, No Action, is evaluated in detail in accordance with NEPA (40 CFR 1502.14(d)). Table 2-6 presents measures associated with the retained alternatives.

Table 2-6. Alternatives and Associated Measures

Measures	Alternative 1 No Action Alternative: Continue Current Practice	Alternative 5 Dredging-Based Sediment Management	Alternative 7 Comprehensive (Full System and Sediment Management Measures)
Dredging and Dredged Material Management			
Navigation Channel and Other Dredging		●	●
Dredging to Improve Flow Conveyance Capacity		●	●
Beneficial Use of Sediment		●	●
In-water Disposal of Sediment		●	●
Upland Disposal of Sediment		●	●
Structural Sediment Management			
Trapping Upstream Sediments (in reservoir)			●
Agitation to Resuspend Sediment			●
Bendway Weirs			●
Dikes and Dike Fields			●
System Management Measures			
Reservoir Drawdown to Add Conveyance Capacity			●
Modify Flows to Flush Sediment			●
Navigation Objective Reservoir Operation	●	●	●
Reconfigure Affected Facilities			●
Relocate Affected Facilities			●
Raise Lewiston Levee to Manage Flood Risk			●

[1]For all alternatives existing sediment reduction measures by other agencies are assumed to continue at current levels.

2.3 Environmental Effects of Alternatives

Table 2-7 provides a summary of the environmental effects for each alternative. Detailed discussion of environmental effects is presented in Section 4.0.

Table 2-7. Environmental Effects Summary Table

Discipline	Alternative 1: No Action (Continue Current Practices)	Alternative 5: Dredging-Based Sediment Management)[1]	Alternative 7: Comprehensive (Full System and Sediment Management Measures)[1]
Aquatic Resources	Temporary adverse effects on listed salmonid species during implementation of Navigation Objective Reservoir Operation.	Temporary adverse effects on aquatic resources during implementation of dredging-based sediment management activities. Long-term beneficial effects from beneficial use of dredged material.	Some temporary and longer-term adverse effects on aquatic resources during implementation of various measures. Long-term beneficial effects through beneficial use of dredged material. Potential adverse effects from weirs and dike fields that may provide habitat for predators on juvenile salmonids.
Terrestrial Resources	Minor adverse effects on plant/wetlands at the margins of reservoirs due to fluctuating reservoir levels of navigation objective reservoir operations.	Minor temporary adverse effects on wildlife during implementation of dredging-based sediment management. Upland beneficial use could have long-term benefits through habitat creation.	Minor temporary adverse effects on wildlife during construction activities associated with implementation of measures. Relocated or reconfigured facilities and upland disposal could have long-term adverse effects from loss of habitat; upland disposal could also have long-term benefits to wildlife from habitat creation.
Recreation	Beneficial effects on recreational boating.	Minor temporary adverse effects on boating/fishing during dredging and dredged material placement.	Minor temporary adverse effects on boating/fishing during measure implementation. Potential temporary adverse effects to recreation on Lewiston levee system during measure implementation.
Cultural Resources	Potential adverse effect on shoreline archaeological sites due to potentially prolonged exposure to water..	Potential adverse effects to cultural resources from implementation of dredging-based sediment management measures.	Potential adverse effects to cultural resources from construction activities associated with implementation of sediment and system management measures.
Socioeconomics	Benefit to commercial navigation by providing for safe navigation. Duration of benefit is limited to the point where pool levels can no longer be raised.	Temporary benefits to employment and income during dredging related activities. Long-term economic benefit by providing for safe commercial navigation and recreation opportunities.	Temporary benefits to employment and income during construction activities. Long-term economic benefit by providing for safe commercial navigation and recreation opportunities.
Water Quality and Sediment Quality	No effect on water quality or sediment quality.	Temporary adverse effects on water quality during dredging activities. No long-term effect on water quality or sediment quality.	Temporary adverse effects on water quality during construction activities associated with measure implementation. Drawdown to flush sediments would adversely affect water quality temporarily by increasing turbidity and suspended sediments.

Table 2-7. Environmental Effects Summary Table

Discipline	Alternative 1: No Action (Continue Current Practices)	Alternative 5: Dredging-Based Sediment Management)[1]	Alternative 7: Comprehensive (Full System and Sediment Management Measures)[1]
Hydrology and Sediment	No effect on sediment loading or transport dynamics of the Lower Snake River.	No effect on sediment loading or transport dynamics of the Lower Snake River.	No effect on sediment loading in the Lower Snake River. Beneficial localized effect of creating conditions to avoid or minimize long-term accumulation of sediment in specific problem areas.
Hazardous, Toxic, and Radioactive Waste (HTRW)	No effect from HTRW.	Minor temporary adverse effect if hazardous substances are released during dredging and dredged material management.	Minor temporary adverse effect if potentially hazardous substances are released during implementation of sediment or system management measures.
Air Quality	No effect on air quality..	Minor temporary adverse effect during dredging and dredged material placement.	Minor temporary adverse effect during sediment and system management measures implementation.

[1] *Alternatives 5 and 7 both include the navigation objective reservoir operation as a measure for future actions. As such, both alternatives would have environmental effects associated with that measure as documented for Alternative 1*

2.4 Corps' Preferred Alternative

In comparing the best available information with regard to each alternative (see Table 2-7 and Section 4), the Corps determined that Alternative 7 - Comprehensive (system and sediment management measures), best satisfies the project purposes of managing sediments that interfere with the authorized purposes of the LSRP and reestablishing the authorized navigation channel at MOP. Therefore, the Corps identified Alternative 7 as the preferred alternative. In addition to fully addressing immediate needs, the alternative provides for proactive monitoring and planning for addressing potential sediment accumulation rather than reacting to accumulation once it becomes an identified problem. It also provides a broad array of measures the Corps could implement to address sediment accumulation within the LSRP. The proposed future and immediate actions and associated measures comprise the framework of the PSMP.

Any sediment and system management measures associated with Alternative 7 would be implemented by the Corps subject to authority and funding. The Corps assumes sediment reduction measures would continue to be implemented by other land use agencies and authorities at current levels.

Because Alternative 7 provides nondredging options for the Corps to evaluate when planning sediment management actions, and provides measures for the immediate need action that uses dredged material to create fish habitat, the Corps also determined it was the environmentally preferred alternative.

SECTION 3.0 AFFECTED ENVIRONMENT

This section describes the existing environmental resources that could be affected by the alternatives considered in this EIS. The descriptions of the physical, biological, cultural, recreational, and socioeconomic resource areas serve as a basis for evaluation and comparison of the anticipated effects of the alternatives described in Section 4, Environmental Consequences. The study area for this EIS is the lower Snake River (from the upstream extent of Lower Granite Reservoir in the Snake and Clearwater Rivers to the confluence with the Columbia River below Ice Harbor Dam).

3.1 Aquatic Resources

This section provides an overview of the aquatic resources present in the study area. Aquatic resources include ***planktonic*** and ***benthic*** species, aquatic plants, and fish. The following discussions present general descriptions of the key aquatic species that may be affected by the proposed action. Although the majority of research on aquatic resources has focused on Lower Granite Reservoir, this information is also applicable to the other reservoirs within the LSRP.

A summary of available data on fish spawning requirements, life histories, and predation on juvenile ***salmonids*** by resident fish is also presented.

3.1.1 Plankton

Zooplankton and ***phytoplankton*** occur throughout the study area. These organisms form an important part of the aquatic food chain. Both phytoplankton and zooplankton are food sources for larger aquatic organisms, such as snails and small fish. In addition, zooplankton can compose an important component to the diet of rearing ***anadromous*** and resident fish species (Bennett et al. 1983).

High concentrations of zooplankton in backwater areas attract smaller prey species that feed on these organisms. In turn, high concentrations of prey fish attract larger predator fish species. Therefore, higher concentrations of zooplankton in backwater areas may affect the habitat selection of several species (USACE 1999b, 2002a).

Primary productivity describes the rate at which plants and other photosynthetic organisms produce organic compounds in an ecosystem and is measured by evaluating phytoplankton and ***periphyton.*** Primary productivity as measured at sampling stations in the lower Snake River reservoirs is lowest during December and highest from March through May (Seybold and Bennett 2010).

Phytoplankton presence in the Snake River has been typically measured by sampling for ***chlorophyll a***, a pigment in plants that facilitates photosynthesis. Studies in Lower Granite Reservoir have shown peaks in concentrations of chlorophyll a primarily in April before peak

flows and again in the periods of declining flows from July until approximately October, depending on the location of sampling in the reservoir and year (Ledgerwood et al. 2000).

3.1.2 Benthic Invertebrates

Benthic organisms contribute significantly to the diets of many riverine and reservoir fish species. The benthic ***invertebrate*** community consists of organisms such as aquatic worms, insects, crayfish, and mussels that live on the river bottom. These benthic organisms, also referred to as ***macroinvertebrates***, provide significant input into the food chain by providing a food source for fish and other aquatic species. Where reservoirs are established, the invertebrate species composition and abundance convert from flowing riverine species typically found in the shallower and higher velocity environments of the predam river to still water or open water reservoir invertebrate species found in the deeper and slower velocity environments of the post-dam reservoir. Species diversity of macroinvertebrate communities at shallow sites increases with downstream movement or colonization of drifting organisms scoured from upriver habitats, provided that like substrate and associated habitat components are available and similar to the substrate from which the organisms were transported (Bennett et al. 1983). Some of these organisms "drift" in the upstream portion of the reservoirs primarily in the seasons of higher flow, which increases their availability to rearing and downstream migrating juvenile salmonids and resident fishes.

Studies from the 1980s indicated shoreline areas less than 15.5 feet deep generally had the highest invertebrate abundance, species diversity, and species evenness (similar number of individuals for each species) in the Lower Granite Reservoir (Bennett and Shrier 1986, Bennett et al. 1988). These studies also found that annual and seasonal population abundance was more variant for species exhibiting seasonal emergence as they pupated into adults and left the aquatic environment (e.g., ***chironomids***, a type of fly) than species that are aquatic through all life stages (e.g., aquatic ***oligochaetes*** – worms).

Chironomids, a type of fly that resembles mosquitoes, can make up a substantial portion of the diets of juvenile salmonids and other local fish species. Chironomids are most likely located in sandy silt sediments and decrease in both finer and coarser sediment-type environments. The chironomid communities within the LSRP are composed of several different species, thus resulting in chironomids being readily susceptible to predation by rearing salmonid ***smolts*** across the duration of the smolt migration seasons.

Crayfish are an important component to the diet of smallmouth bass, northern pike minnow, channel catfish, and white sturgeon and predominantly inhabit shallow water riprap areas from which they forage riverward for primarily oligochaetes and other soft substrate inhabitants (Bennett et al. 1983). Crayfish were found in the Lower Granite Reservoir during the physical drawdown test in 1992 (Bennett et al. 1995a; Curet 1994), and in the unimpounded Snake River between Lower Granite Reservoir and Hells Canyon Dam (Nelle 1999). The important role of crayfish in resident and predatory fish diets is extensively documented for every year of sampling in both Lower Granite Reservoir since 1988 (Bennett et al. 1988) and in the

unimpounded Snake River upriver of Lower Granite Reservoir (Nelle 1999; Petersen et al. 1999).

Freshwater mussels (e.g., Mollusca: Unionoida) are vital components of intact salmonid ecosystems and are culturally important to Native Americans. Historically, at least seven mussel species occurred in Oregon and Washington (NWPCC 2004a). However, due to their sensitivity to ambient pollutants such as metals and pesticides, freshwater mussels are one of the most endangered faunal groups in North America (NWPCC 2004a). A recent study found that during the fall and spring, mollusks were the dominant macroinvertebrate community in the majority of sampled locations in the LSRP (Seybold and Bennett 2010).

3.1.3 Aquatic Plants

Aquatic plants within the study area include phytoplankton, algae, and various ***macrophytes*** (large vascular aquatic plants). These plants provide many important roles in the aquatic environment, including cover for fish, oxygen production, substrate for invertebrates, and food sources for fish and wildlife. Phytoplankton was previously discussed in Section 3.1.1 as part of the plankton community. Algae and macrophytes are discussed below.

Filamentous green algae was identified as part of the diet for several of the fish species in the Little Goose Reservoir, but was not prominent in any diet (Bennett et al. 1983). Filamentous green algae can be found attached to rocks, woody debris, and other structures.

Macrophytes are large plants that typically grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers. They can be entirely submerged or emergent (partially above the water surface). Macrophytes supply surfaces for fish eggs to incubate, provide protection for fish species during various life stages, and function as a direct food source for many aquatic organisms. These plants are especially important for young fish that hide among plant stems and leaves to escape predators. Emergent macrophytes are an important element in the food chain because they provide habitat for insects which, in turn, can be food for fish.

Macrophytes help stabilize shorelines by reducing erosion and recycling nutrients, particularly oxygen. Both submerged and emergent macrophytes are far more extensive in the lower reservoirs (Lower Monumental and Ice Harbor) than in the upper reservoirs (Lower Granite and Little Goose) and upstream Snake River stations (Seybold and Bennett 2010).

3.1.4 Fish

The lower Snake River supports diverse populations of fish, including resident and anadromous species (Table 3-1). Within the study area, anadromous salmonids and trout are seasonally present, with juveniles of some stocks present year-round in rearing tributaries and the LSRP. Such species include Chinook salmon, coho salmon, sockeye salmon, and steelhead trout. Anadromous Pacific lamprey is also present in the study area. In addition to the species noted above, other native and introduced resident fish are also abundant in the LSRP (Bennett et al.

1983). Table 3-1 lists the anadromous and resident species that have been collected during various studies within the study area.

Table 3-1. Anadromous and Resident Fish Collected in the Study Area[1]

Common Name[2]	Scientific Name	Native (N) or Nonnative (E)
Anadromous Species		
Pacific lamprey	*Lampetra tridentate*	N
Chinook salmon • **Snake River spring/summer** • **Snake River fall**	*Oncorhynchus tshawytscha*	N
Snake River sockeye	*Oncorhynchus nerka*	N
Coho salmon	*Oncorhynchus kisutch*	Reintroduced
Snake River steelhead	*Oncorhynchus mykiss*	N
American shad	*Alosa sapidissima*	E
Resident Species		
White sturgeon	*Acipenser transmontanus*	N
Mountain whitefish	*Prosopium williamsoni*	N
Rainbow/redband trout	*Oncorhynchus mykiss/O.m. gibbsi*	N
Brown trout	*Salmo trutta*	E
Bull trout	*Salvelinus confluentus*	N
Chiselmouth	*Acrocheilus alutaceus*	N
Carp	*Cyprinus carpio*	E
Peamouth	*Mylocheilus caurinus*	N
Northern pike minnow	*Ptychocheilus oregonensis*	N
Speckled dace	*Rhinichthys osculus*	N
Leopard dace	*Rhinichthys falcatus*	N
Longnose dace	*Rhinichthys cataracae*	N
Redside shiner	*Richardsonius balteatus*	N
Bridgelip sucker	*Catostomus columbianus*	N
Largescale sucker	*Catostomus machrocheilus*	N
Mountain sucker	*Catostomus platyrhynchus*	N
Yellow bullhead	*Ictalurus natalis*	E
Brown bullhead	*Ictalurus nebulosus*	E
Black bullhead	*Ictalurus melas*	E
Channel catfish	*Ictalurus punctatus*	E
Flathead catfish	*Pylodictis olivaris*	E
Tadpole madtom	*Noturus gyrinus*	E
Sand roller	*Percopsis transmontana*	N
Pumpkinseed	*Lepomis gibbosus*	E
Warmouth	*Lepomis gulosus*	E
Bluegill	*Lepomis macrochirus*	E
Smallmouth bass	*Micropterus dolomieu*	E

Table 3-1. Anadromous and Resident Fish Collected in the Study Area[1]

Common Name[2]	Scientific Name	Native (N) or Nonnative (E)
Largemouth bass	*Micropterus salmoides*	E
White crappie	*Pomoxis annularis*	E
Black crappie	*Pomoxis nigromaculatus*	E
Yellow perch	*Perca flavescens*	E
Walleye	*Stizostedion vitrium*	E
Prickly sculpin	*Cottus asper*	N
Paiute sculpin	*Cottus beldingi*	N
Mottled sculpin	*Cottus bairdi*	N
Banded Killifish	*Fundulus diaphanus*	E

Sources: Bennett et al. 1991, Bennett et al. 1983, Mundy and Witty 1998; Ashe et al. 2000; Ecovista 2003, Ecovista et al. 2004; NWPCC2004a.
[1] [2]Federally listed species are ***bolded****. Arntzen et al. 2012*

The lower Snake River system contains the reservoirs of the dams from the mouth of the Snake River upstream to the City of Asotin. The types of habitats found within each individual reservoir highly influence a reservoir's use by anadromous salmonids as well as resident fish species.

Although there is a difference in numbers, there is little difference in the species composition of resident fish within the reservoirs. Species found in high abundance in all reservoirs include suckers, northern pike minnow, bass, chiselmouth, and redside shiners (Bennett et al. 1983; Bennett and Shrier 1986; Bennett et al. 1988). Species such as crappies, sunfish, and largemouth bass are highly abundant in backwaters of all reservoirs. Minor variations in species composition are related to variations in the availability of backwater habitats and flowing waters in the various reservoirs.

An important element of fish use of the lower Snake River reservoirs is the availability and use of shallow water habitat (less than 20 feet deep). Currently, less than 10 percent of Lower Granite Reservoir consists of shallow water habitat (Seybold and Bennett 2010). Furthermore, about 630 acres (255 ha) of juvenile fall Chinook (i.e., subyearling Chinook salmon) shallow water rearing habitat exists at a flow of 143,000 cfs, which translates to about 7 percent of the reservoir area (Tiffan and Hatten, 2012). Because shallow water habitat is considered the most productive habitat in aquatic ecosystems in terms of supporting the largest populations and most diverse array of species (Wetzel 2001), the aquatic productivity of the reservoirs could potentially be enhanced by increasing the amount of shallow water habitat. In light of this, the Corps has created several dredged material placement sites in the lower Snake River reservoirs, and has supported numerous research and monitoring efforts in the Lower Granite Reservoir to assess the biological impacts and potential benefits of in-water placement of dredged material to enhance fish habitat (Tiffan and Connor 2012; Arntzen et al 2012; Gottfried 2011; Bennett and Seybold 2004; Bennett and Shrier 1986; Seybold et al. 2007). Although some researchers have associated deposited sediments in reservoirs with unproductive habitat (Summerfelt 1993;

Waters 1995), outmigrating subyearling Chinook salmon have exhibited preference for sand substrates in the lower Snake River reservoir (Bennett et al. 1988, 1998; Curet 1994, Gottfried et al. 2011, Tiffan and Connor 2012; Tiffan and Hatten 2012). Results of these studies have indicated in-water placement of dredged material has improved habitat conditions for listed juvenile salmonids by providing feeding and rearing habitat, while maintaining the overall fish community composition and structure (Chipps et al. 1997; Gottfried et al. 2011, Tiffan and Connor 2012; Tiffan and Hatten 2012). Based on recent biological monitoring and modeling, creation of new shallow water habitat in the lower portion of Lower Granite Reservoir in ribbons less than 6 feet in depth along the shoreline is likely to be most beneficial for outmigrating juvenile fall Chinook (Arntzen et al. 2012, Tiffan and Connor 2012, Tiffan and Hatten 2012).

The following subsections describe use of the LSRP by the species of interest discussed throughout this EIS and include sockeye, Chinook, and coho salmon, steelhead, bull trout, pacific lamprey, and white sturgeon.

3.1.4.1 Focal Anadromous Fish Species

The following sections present a brief life history of the focal fish species found within the study area, including federally listed threatened or endangered stocks. (Additional information on threatened and endangered fish species noted in Section 3.1.5) A generalized summary of the juvenile and adult migration timing of various anadromous salmonid stocks originating in the Snake River, including its contributing watersheds, is presented in Figure 3-1. While juvenile salmonid rearing, and adult holding and spawning occurs throughout the Snake River watershed, the amount of spawning and rearing in the lower Snake River reservoir system is relatively low and primarily restricted to Chinook stocks.

Source: USACE 2002a; Fish Passage Center 1999

Figure 3-1. Typical Migration Timing of Anadromous Salmonid Stocks at McNary and Lower Granite Dams

For juvenile fall Chinook, and to a much lesser extent spring Chinook, the period of residency in the reservoirs may span a few months as juvenile salmonids either migrate through these areas or rear within them prior to migrating downstream to the Columbia River estuary (further discussed by species and run type in section). Depending on the stock, migrating adults will be present in the LSRP for weeks to months as they migrate upriver.

In addition to anadromous salmonids, several other sensitive or locally important species are present in the study area. Pacific lamprey, a species of concern, is at least seasonally present in the study area. White sturgeon, a historically ***diadromous*** species, is also present in portions of the study area. White sturgeon populations have become isolated after construction of the dams and, therefore, are discussed in the resident fish section.

Sockeye Salmon

One run of ESA-listed sockeye salmon is known to occur in the study area. Snake River sockeye salmon were listed as endangered in November 1991. No spawning or rearing habitat for sockeye salmon is present in the lower Snake River reservoirs. However, this portion of the mainstem Snake River is used as a migratory corridor for both juveniles and adults as they travel to higher elevation tributary lakes for spawning and rearing (Gustafson et al. 1997). In the study area, adult Snake River sockeye salmon passage typically occurs from May through early August (USACE 2002a; Fish Passage Center 2012). Juveniles rear in lakes for one to two years and typically actively migrate to the ocean (with minimal rearing in the reservoirs) from April to July; however, limited migration can occur through November (USACE 2002a).

Sockeye salmon are unique in that they are the only species of Pacific salmon that depend on higher elevation tributary lakes for spawning and rearing (Gustafson et al. 1997). Snake River sockeye are native to Idaho's high mountain lakes, but currently, Redfish Lake in the Stanley Basin supports the only remaining substantial run of Snake River sockeye. In 1991 the Snake River sockeye captive broodstock program was initiated by the Idaho Department of Fish and Game (IDFG) and NMFS to prevent species extinction. In 1999, the first hatchery-produced anadromous sockeye salmon returned to the program. In 2000, 257 adult sockeye returned up the Snake River to collection facilities on Redfish Lake Creek and the upper Salmon River at the IDFG Sawtooth Fish Hatchery. In 2010, the number of adult sockeye passing over Lower Granite Dam (presumed to be Redfish Lake origin) was over 2,200 (as of October 1, 2010). NMFS (2010) reported that adult sockeye returns to Lower Granite Dam in 2009 (1,219), almost entirely produced by the captive broodstock program, were nearly 9.7 times the 10-year average.

Wild Snake River juvenile sockeye salmon generally migrate downriver during April, May, and June. During sampling in May and June 2002, Bennett (2003) found 21 and 14, respectively, juvenile sockeye salmon rearing along shallow water shorelines in Lower Granite and Little Goose Reservoirs (USACE 2005). During recent sampling of the LSRPLSRP, Seybold and Bennett (2010) and Arntzen (2012) found that juvenile sockeye salmon were infrequently caught, in Lower Granite and Little Goose Reservoirs; however, some individuals were caught in the Ice Harbor Reservoir.

Sockeye Critical Habitat Essential Snake River salmon habitat consists of spawning and juvenile rearing areas, juvenile migration corridors, areas for growth and development, and adult migration corridors (58 FR68543). Critical habitat components for Snake River sockeye spawning, rearing, or overwintering are not present in the study area.

The mainstem Snake River is designated as critical habitat for both juvenile and adult migration corridors for Snake River sockeye salmon. The essential components of the juvenile migration corridors include adequate substrate, water quality and quantity, water temperature, cover and shelter, food, space, and safe passage conditions (58 FR68543). For adult migration, the essential components are the same, with the exclusion of food. These components of designated critical habitat are needed during the juvenile and adult migrations, which occur between April and August (Figure 3-1).

Spring/Summer Chinook Salmon

The Snake River Spring/Summer Chinook salmon are found in the study area. This ***evolutionary significant unit*** (ESU) was listed as threatened in 1992.

Upon returning to fresh water after spending two to three years in the ocean (Howell et al., 1985), adult spring Chinook salmon typically pass through the LSRPLSRP from mid-April to mid-June with 90 percent passing in the month of May (Stuehrenberg et al. 1995). Adult summer Chinook salmon typically pass the mainstem dams by September, with the majority passing between mid-June and mid-August. All populations are believed to spawn from August through October in tributaries upstream of the LSRPLSRP (USACE 1999b). Elevation appears to be the key factor influencing run/spawn timing. In tributary systems with both spring and summer runs, spring Chinook salmon tend to spawn farther upstream and earlier than summer run salmon (Matthews and Waples 1991); however, spawning area and timing may overlap in some areas

After rearing in their natal tributaries for a year, the juvenile Snake River spring and summer Chinook typically migrate through the LSRP from April through June. Little, if any rearing of spring and summer Chinook salmon occurs in the lower mainstem Snake River Reservoirs (Chapman et al. 1995). When the outmigrants reach the lower Snake River they tend to move steadily out of the system as indicated by relatively short reservoir residence times (Giorgi and Stevenson 1994). However, a few individuals of spring Chinook salmon from undetermined origin have been documented as using backwater areas of the McNary Reservoir for rearing, feeding, or overwintering (Easterbrooks 1995, 1996, 1997, 1998) during the period sampled (mid-March through July). This is consistent with finding of Keefer and Perry (2008), who noted that some subyearling spring/summer Chinook move long distances downstream and overwinter in large tributary or mainstem Snake River habitats (Myers et al. 1998).

The Tucannon River supports spring Chinook spawning in the mainstem Tucannon from the mouth of Sheep Creek (RM 52) downstream to King Grade (RM 21) (WDFW 2004). Spawning has not been observed in Tucannon tributaries (NWPCC 2004a). Spawners enter the Tucannon from late April to early July, and spawning typically occurs from late August through September

(WDFW 2004). Juvenile spring Chinook rear in the Tucannon system for 12 to 15 months prior to migrating to the ocean, and outmigration takes place from October to July, peaking from April to late May.

Spring/Summer Chinook Critical Habitat – The essential components of critical habitat for Chinook salmon are the same as those listed above for sockeye salmon. Essential features of spawning and juvenile rearing areas include adequate spawning gravel, water quality, water quantity, water temperature, cover/shelter, food, ***riparian*** vegetation, and space. The migratory corridor for Snake River spring/summer Chinook includes the Snake River and the Columbia River to the Pacific Ocean, in addition to all spawning and juvenile rearing areas (NMFS 1993). In the lower Snake River reservoirs, critical habitat elements are predominately related to migration and overwintering.

Fall Chinook Salmon

There is only one recognized run of ESA-listed fall Chinook that occurs in the study area. The Snake River fall Chinook ESU was listed as federally threatened in 1992, and the status was reconfirmed in 2005. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam (to the confluence with the Columbia), and in the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater Rivers, as well as four artificial propagation programs, including the Lyons Ferry Hatchery (Federal Register 70FR37175). The Lyons Ferry Hatchery is located on the north shore of the Snake River Lower Monumental Pool downstream from the mouth of the Palouse River.

After two to three years in the ocean, adult Snake River fall Chinook return to the Snake River and contributing watershed between late summer and early winter. Spawning begins around mid-October (Connor et al. 1993) and continues through December (Groves and Chandler 1999). The current major spawning areas for Snake River fall Chinook include an approximately 40-mile reach of the lower Clearwater River downstream of Dworshak Dam and the 103 miles of the Snake River basin below Hells Canyon Dam (Garcia et al. 2010; USACE 2002a). The majority of all ***redds*** counted within the watersheds upstream of Lower Granite Dam were located within this section of the Snake River itself with fewer redds located in the tributaries (Garcia et al. 2010). Spawning of fall Chinook has also been known to occur in deeper water areas of the Little Goose, Lower Monumental, and Ice Harbor Reservoirs, but only in ***tailwater*** areas directly downstream of the dam, typically in areas where water velocity is high and substrate is relatively large (Dauble et al. 1995, 1996; Mueller and Coleman 2007; Mueller and Coleman 2008; Mueller 2009).

In the reservoirs of the lower Snake River, most fall Chinook salmon spawn from mid-October through late November upstream of the confluence of the Snake and Clearwater Rivers and in navigation lock approaches (USACE 2005). However, a few have spawned within high velocity, large substrate tailwater habitats outside the navigation lock approaches (Bennett et al. 1983, 1992; Kenney 1992; Dauble et al. 1994, 1995; Mueller 2005) including the tailwaters of Lower

Granite, Little Goose, and Lower Monumental dams. No redds have been located in the tailrace areas downriver of Lower Monumental since 1992 or Little Goose since 1994 (USACE 2005), nor have any been detected below the Lower Granite juvenile fish facility bypass outfall from 1994 until December 2004 (Mueller 2005;) Mueller and Coleman 2007; Mueller and Coleman 2008; Mueller 2009)

During studies conducted from 1993 to 1997 to identify potential spawning habitat for fall Chinook downstream of the four Snake River dams, Dauble et al. (1995, 1996) found fall Chinook salmon redds in the tailrace downstream of Lower Granite, Little Goose, and Ice Harbor Dams. Redds were in water from 13.1 to 26.6 feet deep and on cobble substrate, and all redds were adjacent to the outfall flow from juvenile fish bypass systems. The total area used for spawning was approximately 27,555 square feet (ft^2) for the Lower Granite site and 6,243 ft^2 for the Little Goose site (Mueller 2005).

In 1998, Dauble et al. characterized habitat suitability in the tailraces of the Lower Granite and Lower Monumental Dams. They found that four percent of the lock approach area at Lower Granite Dam and less than 1 percent of the lock approach area at Lower Monumental Dam provided conditions suitable for Snake River fall Chinook spawning. They also observed that the portions of the tailraces near the discharges from the powerhouses contained substantially more suitable Snake River fall Chinook spawning than the lock approaches. Mueller (2003) concluded that water depth and substrate size at the two lock approaches were suitable for Snake River Fall Chinook spawning, but riverbed slope and water velocity were not.

Starting in 2006, USACE Walla Walla District conducted a three year study to determine if fall Chinook salmon spawn within the immediate tailrace regions of Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams as part of developing a Programmatic Sediment Management Plan for the lower Snake River. As part of this comprehensive evaluation, zones were established downstream of all four lower Snake River dams in which habitat criteria met the requirements for fall Chinook salmon spawning (Mueller and Coleman 2007, 2008; Mueller 2009). In 2006, Mueller and Coleman (2007) confirmed one redd in the tailwaters below Lower Granite Dam and two redds in the tailwaters below Little Goose Dam during comprehensive deepwater video surveys. In 2007, six redds were found in the tailrace regions of two of the four dams—four at Lower Granite Dam and two at Ice Harbor Dam (Mueller and Coleman 2008). In 2008, surveys showed a total of 15 redds in the tailrace regions of two of the four dams – eight redds downstream of Lower Granite Dam; seven redds in the tailrace region of Lower Monumental Dam (Mueller 2009).As presented by the USACE and EPA (2003a) and subsequent evaluations, due to the presence of suitable gravel substrate, adult fall Chinook salmon have the potential to spawn in the lower Snake River navigation channel. However, typical low water velocities in the navigation channel appear to severely limit (USACE 2003a), though not entirely preclude, spawning in the vicinity of the navigation channel. In 1992, a redd was destroyed while dredging the access channel to the juvenile fish facility at Lower Monumental Dam.

After emergence in the early spring and initial dispersal, juvenile fall Chinook salmon exhibit a high fidelity for lower velocity backwater areas for rearing. The majority of Snake River fall Chinook juveniles exhibit an ocean-type life history (Connor et al. 2005) and outmigrate as subyearlings in the mid-summer following spring emergence (Healey 1991) and pass through the lower Snake River from June through September. However, some subyearlings can cease migration and are present in the mainstem reservoir and tributary habitats from spring through winter (Achord et al. 1996; Marshall et al. 2000; Connor et al. 2001; Tiffan and Connor 2012). Passive integrated transponder (PIT) tag detections of fall Chinook migrating from the Clearwater River (USACE 2002a) suggest that some fall Chinook migrate as yearlings and exhibit a stream-type life history. This is supported by recent studies that illustrate that some subyearling fall Chinook overwinter in the lower Snake River reservoirs (Connor et al. 2005; Tiffan and Connor 2012). Individuals expressing such behavior, referred to as "reservoir-type" Chinook, emerge later in spring and then overwinter in reservoirs as subyearlings and migrate seaward as yearlings the following spring (Connor et al. 2005). According to Connor et al. (2005), the expression of this reservoir-type life history appears to be inversely proportional to rearing temperature. Connor et al. (2002) observed higher overwintering rates following years with cooler spring water temperatures (Connor et al. 2002). Although it is not definitively known if this reservoir-type life history is advantageous over the typical fall Chinook ocean-type life history, some researchers speculate that reservoir-type fish may be more likely to survive to adulthood because they have some size- and timing-related migration advantages (Keefer and Perry 2008).

Recent radio-telemetry and PIT tag studies (Tiffan et al. 2006, Kock et al. 2007; Tiffan and Connor 2012).Recent studies (Kock et al. 2007) have provided additional information regarding overwintering subyearlings in the lower Snake River reservoirs. These studies have indicated that while fish are distributed throughout the lower Snake River, a relatively large percentage overwintered in the Little Goose Reservoir. The telemetry data suggested many fish resided in dam ***forebays*** for extended periods (e.g., weeks to months) (Kock et al. 2007). Behaviors overall were quite variable, with some salmon showing directed downstream movements and some showing increased movement during runoff events from winter rainfall (Keefer and Peery 2008).

Seybold and Bennett (2010) and Tiffan and Connor (2012) report that both subyearling spring and fall Chinook salmon were caught more frequently than other salmonids at selected dredged-sediment placement sites in the lower Snake River reservoirs. The created shallow water sites had abundant primary production with a wide variety of benthic invertebrates that serve as prey items for subyearling Chinook (Seybold and Bennett 2010). Within the reservoirs, Seybold and Bennett (2010) found that higher mean catch per unit effort values for subyearling Chinook salmon occurred at sampling stations located in the two upper reservoirs, Lower Granite and Little Goose, and the lowest catch per unit effort occurred at the Tucannon River in the Lower Monumental Reservoir. They report that this may have been attributed to the presence of suitable habitats in the upper reservoirs; however, it might have been due to mortality as fish moved downstream through the dam system.

Tiffan and Connor (2012) found natural juvenile fall Chinook salmon highly used water less than 6.5 feet (2m) deep for rearing from early spring through early summer based on duration of use and relative group abundances during spring and summer; whereas the 6.5-to-20 feet (2-to-6 meter) depth interval was more highly used by hatchery fall Chinook salmon subyearlings and spring, summer and fall Chinook salmon yearlings. Overall mean spring-summer apparent density of natural subyearlings was 15.5 times higher within the less than 6.5 feet (2 meter) depth interval than within the 6.5-to-20 feet (2-to-6 meter) meter depth interval. While a sizeable portion of juvenile fall Chinook salmon remained in the lower Snake River after the spring and summer migrations, use of shallow water habitat during the fall and winter is limited. Radio-tagged fish located during mobile tracking were pelagically oriented and were generally not found over shallow water or close to shore during fall tracking efforts.

Fall Chinook Critical Habitat – Designated critical habitat for Snake River fall Chinook includes all river reaches presently or historically accessible to the species, with the exception of reaches above impassable natural falls, and the Dworshak and Hells Canyon dams (NMFS 1993). Essential features of spawning and juvenile rearing areas are the same as for Snake River spring/summer Chinook. The migratory corridor for Snake River fall Chinook includes the Snake River and the Columbia River to the Pacific Ocean, in addition to all spawning and juvenile rearing areas (NMFS 1993). Limited spawning habitat for wild Snake River fall Chinook salmon is present in the study area, immediately downstream of each of the lower Snake River mainstem dams (USACE 2005).

Coho Salmon

Historically, coho salmon were abundant in the lower Snake River basin. Although coho salmon runs throughout the Snake River basin were officially declared extinct in 1986 (Cichosz 2001; HSRG 2009), reintroduction efforts in the Clearwater River system have been met with marginal success in portions of the study area. Coho salmon reintroduced in the Clearwater subbasin, are considered out-of-ESU, and are not listed (HSRG 2009). As a result of reintroduction efforts in the Clearwater River system (Cichosz 2001; HSRG 2009), coho salmon have been collected in all four lower Snake River reservoirs during recent sampling (Seybold and Bennett (2010); Arntzen et al 2012).Seybold and Bennett (2010). In 1995, in cooperation with the USFWS and the IDFG, the Nez Perce Tribe initiated a coho salmon reintroduction program in the Clearwater system. Coho salmon from the program first returned in 1997 with 85 fish over Lower Granite Dam, and increased to 884 and 1,035 fish in 2000 and 2001, respectively (USACE 2002a). From 2003 to 2007, adult coho counts at Lower Granite Dam have averaged over 2,100 fish (HSRG 2009). These coho typically pass the Lower Granite dam between September and November (USACE 2002a). Juvenile coho rear for at least 1 prior to migrating downstream. They pass through the lower Snake River during their juvenile outmigration around April and May (Figure 3-1).

Steelhead

The Snake River basin summer steelhead ***distinct population segment*** (DPS) was listed as threatened in 1997. Snake River steelhead spawn in tributaries to the Snake River in southeast Washington, northeast Oregon, and Idaho. Adults enter fresh water from May through October and spawn the following spring from March to June (Thurow 1987). The majority of Snake River basin steelhead adults migrate upstream through the lower Snake River beginning in late May and continue through to November (USACE 2002a). They spawn in upstream tributaries the following spring from March to June (Thurow 1987). Spawning streams need clean gravels for successful egg development and fry emergence. Suitable spawning area consists of 1.3 cm t o 11.4 cm diameter gravel and well-aerated water having a flow of approximately 76.2 cm/sec (Pauley et al. 1986). Unlike Pacific salmon, many steelhead do not die after spawning and return to their natal streams often two, three, and (rarely) four times (Wydoski and Whitney 2003).

After spending one to four years in the ocean, most adult steelhead pass McNary Dam between May and November and Lower Granite Dam between July and December during their upstream migration. Some adult steelhead overwinter in the lower Snake River and resume their migration to spawning grounds the following spring as water temperatures begin to increase. Snake River steelhead are unlikely to spawn in the reservoir portion of the study area; they typically spawn in tributaries outside the influence of the hydro system between December and June (Bell 1991). Spawning usually occurs between December and June within tributaries outside the influence of the hydropower system. Steelhead migration timing is highly variable and these fish can be present at some life stage year round. Inland summer steelhead found in the Columbia River and Snake River basins can be subdivided into either A-run or B-run based on their upstream migration timing at Bonneville Dam. A-run summer steelhead pass upstream of Bonneville Dam from June to August, while B-run steelhead pass from late August to October (Wydoski and Whitney 2003). A-run steelhead passing Lower Granite Dam are predominantly one year of ocean age, while the B-run fish are predominantly two years of ocean age and typically three to four inches longer (Wydoski and Whitney 2003). A-run summer steelhead spawn throughout the Snake River system, and B-run summer steelhead are produced only in the Clearwater and the Middle and South Fork Salmon Rivers (Wydoski and Whitney 2003).Summer steelhead in the Tucannon River are a typical Snake River “A”-run stock that appear to hold in the mainstem Snake River, rather than in the Tucannon, prior to spawning (WDFW et al. 1990). Entry into the Tucannon probably does not begin until September, when water temperatures drop (WDFW et al. 1990). Spawning occurs from late February through mid-May. Juveniles emerge from spawning grounds in late May or June (WDFW et al. 1990). Juveniles typically rear in the Tucannon for one to two winters before outmigrating between December and June (WDFW et al. 1990), with a peak in April (WDFW 2004).

NMFS (2008a) reported that population-specific adult abundance is generally not available for Snake River steelhead due to difficulties conducting surveys over much of their range. Based on adult returns through 2004, abundance has been stable or increasing for both A-run and B-run

populations (NMFS 2008a). However, with respect to natural production, it appears that A-run Snake River steelhead have generally replaced themselves, while B-run steelhead have not.

Steelhead fry typically emerge from April through mid-June, and rear in areas close to where spawning occurs in natal tributaries for 2 to 3 years before beginning their seaward migration (USACE 2002a). Out-migrants actively migrate through the lower Snake River and reservoirs from late April through June and typically rear very little during their out-migration. During recent sampling of the lower Snake River reservoirs, steelhead smolts were collected more frequently at the downstream sampling stations than at stations in the upper reservoirs (Seybold and Bennett 2010).Iteroparity, the ability to repeat spawn, is a natural life history strategy that is expressed by some steelhead. These individuals may spawn more than once during their lifetime, returning to the ocean following each spawning episode. Current rates of observed steelhead iteroparity in the Columbia River Basin are severely depressed due to human stressors including the hydropower system and other habitat degradations. In the Snake River Basin, post-spawn steelhead (kelts) must pass up to eight dams during their seaward migration in the spring, and again during their return to freshwater migration to spawning tributaries. Kelt passage in the lower Snake River occurs in March through June (USACE 2005), including observation of steelhead kelts passing through the juvenile bypass system at the lower Snake River dams, including Lower Granite Dam. From April – June 15 of 2002, 8,678 adult steelhead were counted passing the Lower Granite Dam juvenile collection facility, and the majority of those sampled were in the kelt life stage (Hatch et al. 2003). Of the portion of kelts sampled and sexed, 83.1 percent were female. Snake River steelhead kelt travel rates increased during outmigration through the LSRP, and that fish in good external condition were most likely to successfully navigate downstream (Megli et al. 2009).

Steelhead Critical Habitat – Within the study area, the lower Snake River mainstem and reservoirs, the Tucannon, Deadman Creek, Almota creek, and Alpowa Creek are designated as critical habitat for the Snake River steelhead DPS. Critical habitat attributes suitable for migration corridors as well as potential rearing or overwintering for Snake River steelhead are present in the study area.

In the lower Snake River reservoirs and contributing tributaries that support the DPS, components of designated critical habitat for juvenile migration are most suitable from mid-March to August, ***kelt*** (steelhead that have spawned) passage occurs in March to June, and adult migration occurs primarily between late May and November (USACE 2005). Although habitat components related to spawning are not present in the lower Snake River reservoirs, upstream tributaries support the majority of spawning in the Snake River basin from March through June. Some rearing, feeding, or overwintering may occur in the confluence area of the lower Snake River and Clearwater River (USACE 2005).

In consideration of those physical and biological features that are essential to the conservation of steelhead and their critical habitat, NMFS has identified habitat factors necessary for the survival and recovery of the species (NMFS 2005). Within the LSRP, these include:

- Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development (gravel and small cobble with little to no finer sediments).

- Freshwater rearing sites with: (i) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) water quality and forage areas that support juvenile development; and (iii) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

Pacific Lamprey

Pacific lamprey are members of a primitive group of anadromous fish with cartilage instead of bones. Spawning habitat requirements for Pacific lamprey are similar to those of salmonids, including clean gravel and cold water. Although habitat within the LSRP may potentially be suitable for lamprey spawning and rearing, there is no evidence that Pacific lamprey have used or currently use the mainstem Snake River for spawning or rearing (USACE 2005; USACE 2010a).

After spending 20 to 40 months in the Pacific Ocean, adult Pacific lamprey return to spawn in freshwater rivers (Kan 1975) and migrate through the Snake River to reach spawning areas in tributaries. Adults enter freshwater typically between April and June, migrating to spawning areas by September (Close et al. 1995). Peak upstream dam passage typically occurs during July, August, and September (USACE 1980-2000). Adult Pacific lamprey spawn in low gradient stream reaches with gravel substrate often at the tailouts of pools and riffles at depths of 1.0 to 13.1 ft and water velocities of 1.6 to 3.3 fps (Luzier et al. 2011). Consequently little, if any, spawning is known to occur within the reservoirs, but spawning by Pacific lamprey has been observed in small tributaries entering the lower Snake River reservoirs (Wydoski and Whitney 2003). Pacific lamprey was once common in the Tucannon River. Surveys conducted in the 1990s documented the presence of lamprey at RM 12.5 and RM 1.8 (Close 1998), and a WDFW survey found 94 Pacific lamprey ammocoetes, and one dead adult Pacific lamprey in smolt trap operations (NWPCC 2004a). As of 2004, lamprey counts in the Tucannon River in the early 2000s were relatively low (NWPCC 2004a).After hatching, ammocoetes (a stage of juvenile lamprey) drift downstream to burrow into the substrate sand or mud. Ammocoetes rear in the substrate for 5 to 6 years until they metamorphose into juvenile lamprey. During metamorphosis, they move from low velocity areas with fine substrates to gravel in moderate current, then finally to gravel and boulder substrates where the currents are stronger (Luzier et al. 2011). Juvenile lamprey migrate downstream after completing metamorphosis in late fall through spring, becoming parasitic on soft-scaled fish.

Juvenile lamprey habitat use in the lower Snake River is largely unknown. In response to concerns regarding potential impacts to juvenile Pacific lamprey as part of potential sediment management actions, a minimally obtrusive electroschocking sled with an optical camera was developed in 2011 to survey for presence or absence of juvenile Pacific lamprey. Arntzen et al. (2012) conducted surveys at 24 sample sites within the lower Snake River to determine presence of juvenile Pacific lamprey including locations where sediment accumulation is interfering with commercial navigation (Clarkston Upper and Lower, RM 138), past dredge disposal sites, and reference sites. No lamprey were observed at any of the 24 sample sites during either of the two sample periods in late July and September 2011. It is plausible that juvenile lamprey were present but not observed with this electroshocking sled as it was recently developed for this specific objective and had a limited testing period prior to deployment. However, while juvenile lamprey are often found in silt/sand substrate (Arntzen et al 2012), it is unlikely that juveniles are present in moderate or high numbers within the reservoirs of the lower Snake River due to a paucity of available rearing habitat and relatively low expected abundance of juveniles. Juvenile lamprey typically have a patchy distribution related to other environmental variables such as water depth and velocity, light level, organic content, chlorophyll concentration, proximity to spawning area and riparian canopy (Moser et al. 2007). Recent studies conducted in the lower Snake River by the Corps indicate that adults do not spawn in the federal navigation channel of the lower Snake River, and as of August 2010, no lamprey had been detected during sampling (USACE 2010a).

3.1.4.2 Resident Fish

Resident fish species in the study area (See Table 3-1) include native and introduced riverine species as well as introduced species that are associated with ***lacustrine*** (lake-like) habitats (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Mullan et al. 1986). Coldwater resident species (such as trout and whitefish) that were once common in the Snake River basin have declined since the construction of the dams and their predominance has been replaced by cool- and warm-water species. This change in species composition has been due to the blockage of spawning migrations in some areas and modification of habitats (Mullan et al. 1986). Resident fish in the lower Snake River reservoirs occupy numerous habitats and often use different habitats for different life history stages (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Bennett et al. 1991).

Each reservoir has three general zones that are characterized by different habitats (Hjort et al. 1981). The first zone is the forebay area, which is typically lacustrine in nature. At the upper end of the reservoir is a second zone that tends to be shallower and have significant water velocities. In between these two zones is a transition area that changes in the upstream end from riverine to more lake-like in the downstream direction. Each zone can include several habitat types; however, most can be characterized as either backwater (including ***sloughs*** and ***embayments***) or open-water habitats (Hjort et al. 1981; Bennett et al. 1983).

Backwaters in the lower Snake River reservoirs generally provide low water velocity, slightly warmer water, finer substrate, and submerged and emergent vegetation. Bass, crappie, bluegill, yellow perch, and carp use backwater areas for spawning and rearing (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Bennett et al. 1991; Zimmerman and Rasmussen 1981). The centrarchids (sunfishes, including bass and crappie) normally spawn in shallow water less than 6.5 feet deep (Bennett et al. 1983) while yellow perch generally utilize waters less than 10 feet deep (Stober et al. 1979). Spawning and incubation times vary between species; however, most of these backwater species spawn from May through mid-July (USACE 1999b).

Juvenile fish are found in abundance in backwater and open-water areas where flowing water is found. The two habitats are occupied by distinctly different fish species. Introduced species, which are primarily lake-dwelling fishes, are more common in the forebay zone and backwater areas, while native species are more common in the flowing water regions found in the tailrace zone (Hjort et al. 1981; Bennett et al. 1983; Bennett and Shrier 1986; Mullan et al. 1986).

Adult distribution is generally similar to spawning and juvenile distribution, but often varies depending on feeding strategies of the particular species. Adults may occur throughout different habitats and move seasonally or daily to different areas (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981). Although adults use a variety of habitat types, lake-dwelling species are generally more abundant in shallow, slower-velocity backwater areas, and native riverine species occur abundantly in areas with flowing water (Bennett et al. 1983).

Cyprininds (minnows, dace, and chub), catostomids (suckers), walleye, and sandroller spawn in open water. White sturgeon, a species that is considered nonanadromous above Bonneville Dam (ODFW and WDFW 1998), spawn over areas with rocky bottoms and high water velocity (Parsley et al. 1993). Prickly sculpin spawn in both open water and backwater based on the distribution of ***prolarvae*** (Hjort et al. 1981). Most fish larvae are generally found in the backwaters and near-shore areas. Yellow perch and prickly sculpin larvae are commonly found in open-water areas. Most of the native species spawn in flowing water at the headwaters of the reservoirs or in tributary streams and in the ***tailraces*** of dams in the reservoirs. Northern pike minnow may spawn either in flowing water or along gravel beaches in reservoirs (Wydoski and Whitney 2003).

Bull Trout

Bull trout, listed as threatened under the ESA in 1998, are found primarily in colder streams, although individual fish are found in larger river systems throughout the Columbia River Basin (Fraley and Shepard 1989; Rieman and McIntyre 1993; Buchanan and Gregory 1997). The only subpopulation of bull trout associated with the four lower Snake River reservoirs spawns and rears in the Tucannon River basin (USACE 2002a).

Bull trout typically spawn from August to September during periods of decreasing water temperatures. Migratory bull trout frequently begin spawning migrations as early as April and have been known to move upstream as far as 155 miles to spawning grounds. Temperature

during spawning generally ranges from 39 to 51°F with redds often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989). Water temperatures exceeding 59°F are believed to limit bull trout distribution. Bull trout require spawning substrate consisting of loose, clean gravel relatively free of fine sediments.

Bull Trout Critical Habitat – In 2010, the USFWS finalized revisions to designated critical habitat for bull trout. Within the study area, critical habitat was designated for Unit 15: lower Snake River Basins (USFWS 2010).

Within designated critical habitat, the primary constituent elements for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering:

- Springs, seeps, groundwater sources, and subsurface water connectivity (known as ***hyporheic flows***) to contribute to water quality and quantity and provide thermal ***refugia***.
- Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
- An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- Complex river, stream, lake, reservoir, and shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure.
- Water temperatures ranging from 36 to 59°F, with adequate thermal refugia available for temperatures at the upper end of this range. Specific temperatures within this range will vary depending on bull trout life history stage and form, geography, elevation; ***diurnal*** and seasonal variation, shade (such as that provided by riparian habitat) and local groundwater influence.
- Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount (e.g., less than 12 percent) of fine substrate less than 0.03 inches in diameter and minimal embeddedness of these fines in larger substrates are characteristic of these conditions.
- A natural ***hydrograph***, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph.
- Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
- Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); inbreeding (e.g., brook trout); or competitive (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Adult bull trout that are adfluvial generally spend about half of every year associated with a reservoir (November-May). These fish most likely forage in shallow areas where the majority of prey exists. Depending on water conditions, bull trout will occupy deeper areas of the reservoir where water temperatures are cooler (45 to 54°F/7.2 to 12.2°C) and move to the surface when water temperatures drop to or below 54°F (12.2°C).

There have been several observations of adult bull trout passing Lower Monumental and Little Goose. From 1994 to 1996, 27 bull trout passed the adult fish counting station (mainly in April and May) at Little Goose. At least six bull trout passed counters at Lower Monumental and Little Goose in 1990 and 1992 (Kleist 1993). Kleist also observed one bull trout in 1993 just downstream of the count window at Lower Monumental. One bull trout was captured in the Palouse River below Palouse Falls in 1998. These were likely migratory fish from the Tucannon River; however, one bull trout was observed at Lower Granite in 1998 that may indicate fluvial fish are migrating to other upstream populations (USACE 2002a). Bull trout have been observed passing lower Snake River dams, primarily Little Goose, during the spring from April to June (Bretz 2011)

During recent sampling of shallow water habitats in the lower Snake River reservoirs, single bull trout have been collected some years at a sampling site in the Lower Tucannon River (Seybold and Bennett 2010, Arntzen et al. 2012). Researchers speculated that this sampling was probably not indicative of widespread bull trout use of the lower Snake River reservoirs; instead, it is potentially indicative of an adfluvial life history strategy (Seybold and Bennett 2010). During sampling and tracking of bull trout in the lower Tucannon River, bull trout have been found to enter the lower Snake River during October to January, returning to their natal streams January to March (Bretz 2011, DeHaan and Bretz 2012).

White Sturgeon

Historically, white sturgeon in the Snake River basin made extensive seasonal migrations within the Snake River system in response to changing habitats (Bajkov 1951). Today, however, they occur as residents and do not migrate extensively due to blockage by dams (USACE 2005). This species is considered relatively abundant in the Snake River above Lower Granite (USACE 2002a). Landlocked populations of white sturgeon in the Snake River basin are classified as a species of special concern (Mosley and Groves 1990) for the states of Washington and Idaho.

Studies on the Columbia River have shown the importance of benthic invertebrates, particularly the amphipod *Corophium salmonis*, in diets of juvenile white sturgeon (McCabe et al., 1992a; McCabe et al. 1992b). Sprague et al. (1993) indicated that white sturgeon may be feeding on organisms in the water column rather than exclusively on organisms associated with the substrate. ***Corophium species*** (river drift organisms) were the predominant prey item eaten by ***young-of-the-year***, or fish that have not reached the age of one year, and juvenile white sturgeon in two Columbia River impoundments and the Lower Columbia River (Sprague et al. 1993; McCabe et al. 1992a; Muir et al. 1988). *Corophium* species abundance in Lower Granite

Reservoir appear low (Bennett et al. 1991); however, crayfish were abundant near the upper end of Lower Granite Reservoir.

Crayfish and chironomid species were dominant food items identified from white sturgeon stomachs in the middle Snake River (Cochnauer 1981). The presence of these food species may explain the high density of juvenile white sturgeon in the upper section of Lower Granite Reservoir relative to lower areas of the reservoir.

Presence of young-of-the-year and high abundance of juvenile white sturgeon in Lower Granite Reservoir indicate recruitment has been occurring in the Lower Granite-Hells Canyon population. The high abundance of juvenile and young-of-the-year fish near the upper end of Lower Granite Reservoir also suggests that the reservoir may serve as rearing habitat. McCabe and Tracy (1993) suggested that wide dispersal of white sturgeon larvae allowed more use of feeding and rearing habitats while minimizing competition. Lepla (1994) assumed no spawning occurred in Lower Granite Reservoir as velocities measured in the reservoir (0.0 to 1.96 fps) are below threshold levels perceived to elicit spawning (3.28 fps) (Anders and Beckman 1993). However, white sturgeon may spawn in higher velocity habitats with sandy substrate in the unimpounded, free flowing reach of the lower Snake River above the river/reservoir pool transition zone of Lower Granite near RM 147 (Lepla 1994).

Seasonal changes in distribution occur in Lower Granite Reservoir (Lepla 1994). Relative numbers of white sturgeon in the upper section of the reservoir increased from May through November, implying upriver redistribution/movement as the summer to fall season progressed. However, multiple comparison tests indicated seasonal use of mid- and lower reservoir transects was not significant with exception to RM 116.8 (1.6 RM upriver of Knoxway Bay). The number of white sturgeon sampled at RM 116.8 was highest (0.31 fish/hr) only during April-July 1991 and declined sharply as summer progressed. Catch rates at RM 116.8 in 1990 were low and were also similar in 1992 (Bennett et al. 1994; 1995b). Catch rates at remaining mid- and lower reservoir locations were low regardless of season. Movements from 0 to 16 miles were observed from recaptured white sturgeon with the majority of fish traveling 0.6 to 3.1 miles. Differences in fish size did not appear to affect distance traveled in the reservoir. Approximately 65 percent of the fish recovered were collected within the upper 6.2 miles of Lower Granite Reservoir where densities of white sturgeon were highest. Water velocities used by white sturgeon range from 0 to 2 fps, with a maximum suitability index for mean and near-substrate velocities near 1.2 fps (USACE 2005).

Piscivorous Species

During recent sampling of all four reservoirs in the lower Snake River, studies found that smallmouth bass were the most common predator of all of the eight ***piscivorous*** (fish-eating) species (northern pikeminnow, smallmouth and largemouth bass, walleye, yellow perch, white and black crappies, and channel catfish) (Seybold and Bennett 2010). Smallmouth bass were most abundant in Lower Granite Reservoir, while northern pikeminnow were more abundant at sampling stations downstream of Lower Granite Dam. Walleye were only caught in Lower

Monumental and Ice Harbor Reservoirs. Largemouth bass, crappies, yellow perch, and channel catfish were most frequently caught in Lower Monumental and Ice Harbor Reservoirs, though catch rates were low.

Larger piscivorous individuals may seasonally forage for juvenile salmonids residing in, or migrating through, the reservoirs. However, other than juvenile fall Chinook salmon, fish predation appears to be relatively low for yearling Chinook salmon and steelhead (USACE 1999b; 2002a). Due to their abundance, the most prevalent predator on juvenile salmonids is likely smallmouth bass (USACE 1999b). Smallmouth bass catch rates were high in created shallow water habitats in the lower Snake River; however, no yearling or subyearling Chinook salmon were identified in piscivore stomachs (Seybold and Bennett 2010). This may be attributed to the fact that most smallmouth bass were caught in the fall, and outmigrating salmonid juveniles were only abundant during spring. Further, approximately half of the smallmouth bass captured were below the predatory size threshold of 6 inches (i.e., too small to prey on juvenile salmonids). Recent sampling by Arntzen et al. (2012) found that small mouth diets consisted of less than six percent of juvenile Chinook salmon by weight, indicating that salmonids were not a significant portion of their diet at shallow water habitat sites.

Recently, predation by northern pikeminnow on juvenile salmonid migrants in the Columbia River Basin has been reduced from 8 percent to 6 percent of all predation-related mortality. This reduction has been accomplished by the Sport Reward Program under the Northern Pikeminnow Management Program (NMFS 2004) and by scientific sampling funded by the BPA (USACE 2002a). Both of these programs removed significant numbers of northern pikeminnows from the basin. The BPA and the Corps propose to expand the program through the 2014 time period evaluated in the 2004 FCRPS BiOp (NMFS 2004). The 2008 FCRPS BiOp and subsequent 2010 supplement (NMFS 2008b; 2010) also included a Reasonable and Prudent Alternative for reducing predation by northern pikeminnow in the Columbia River Basin. The 2010 supplement (NMFS 2010) concluded that new scientific information indicates that NMFS' expectations in its 2008 analysis for reducing pikeminnow predation at this point in the 10-year term of the 2008/2010 BiOp have been largely met.

3.1.5 Threatened and Endangered Species

Five anadromous salmon populations and three anadromous steelhead trout populations are present in the study area. Four of the five salmon populations have been designated as ESUs and are listed as threatened or endangered under the ESA (Table 3-2). These ESUs include Snake River Sockeye, Snake River Spring/Summer Chinook, Snake River Fall Chinook, and Upper Columbia River Spring Chinook. Steelhead have been designated as DPSs and include Snake River Steelhead, and Upper and Middle Columbia River Steelhead; all of which are currently designated as threatened under the ESA. Within the study area, the presence of Columbia River stocks is likely limited to infrequent straying in the lower Snake River. Snake River basin stocks occur throughout the study area.

Table 3-2 below lists the populations within the study area that are threatened or endangered. Descriptions of the life histories and use of the study area and designated critical habitat is provided in Section 3.1.3 above.

Table 3-2. Anadromous Populations Present in the Study Area

Population (ESU)	Designation
Snake River Sockeye	Endangered
Snake River Spring/Summer Chinook	Threatened
Snake River Fall Chinook	Threatened
Snake River Steelhead	Threatened
Upper Columbia River Spring Run Chinook*	Endangered
Middle Columbia River Steelhead*	Threatened
Upper Columbia River Steelhead*	Threatened
Bull Trout	Threatened

**Possible occurrence in the Snake River below Ice Harbor Dam of strays entering the mouth from the Columbia River*

3.2 Terrestrial Resources

This section describes the generalized vegetative communities, terrestrial wildlife presence and use, and ESA-listed terrestrial wildlife species in the study area.

3.2.1 Vegetation

The study area passes through steppe and shrub-steppe plant communities (Franklin and Dyrness 1973; Daubenmire and Daubenmire 1984). Steppe communities are dominated by bunchgrasses, such as Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass, while shrub-steppe communities are dominated by sagebrushes, such as big sagebrush. The Snake River is a major migration and dispersal corridor for plants and wildlife and has a high degree of local variation (Franklin and Dyrness 1973). The lower reservoirs have influenced the extent and distribution of numerous plant and wildlife communities that have existed in the river corridor for many years. Local plant communities have become established under normal reservoir fluctuations and periodic drought.

The riparian zone includes areas with woody vegetation that are too dry to be considered wetlands, sand and gravel bars, wet meadows, flood-scoured areas, and other stream-related habitats and vegetation. Riparian areas serve as important wildlife habitat and are integral to the function of river aquatic ecosystems (Corps 2002a). Currently, approximately 1,804 acres of riparian habitat exists in varying proportions along the lower Snake River reservoirs (Corps 2002a). In general, riparian forests on the lower Snake River are dominated primarily by Russian olive (*Elaeagnus angustifolia*), but also include black cottonwood (*Populus trichocarpa,* black locust (*Robinia pseudo-acacia),* hackberry (*Celtis reticulata*), and white alder (*Alnus rhombifolia*). Scrub-shrub vegetation includes coyote willow (*Salix argophylla*), other willows (*Salix* spp.), and false indigo (*Amorpha sp.*). Herbaceous plants in this area include dotted smartweed (*Polygonum punctatum*), cocklebur (*Xanthium sp.*), thistle (*Carduus sp.),* and mustard *(Brassica sp.*).

A number of factors contribute to the lack of extensive riparian areas along the lower Snake River (Corps 1992, 2002a). The steep shorelines associated with project reservoirs are primarily responsible for limiting development of riparian communities in the study area. Furthermore, extensive grazing (Lewke and Buss 1977), the expansion of railroads, arid climate, and the inundation of the low-lying flood plain by dams have limited riparian vegetation to narrow vegetation corridors and backwater areas. The woody plant community that remains is drought resistant and composed of black locust, Russian olive, and various hybrid cherries (*Prunus sp*.) (Asherin and Claar 1976).

Wetlands along the river and inside stream deltas serve a variety of physical and biological functions including wildlife habitat (waterfowl, big game, furbearers, etc.), fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation. The amount of wetlands on the Snake River increased from less than 10 acres in 1958 to over 350 acres today (Corps 2002a).

The lower Snake River reservoirs are characterized by emergent wetland vegetation at the edge of the water surface and in backwater areas. Wetland acreage in these reservoirs was estimated as follows: Lower Granite with 18 acres, Little Goose with 84 acres, Lower Monumental with 65 acres, and Ice Harbor with 186 acres (Corps 2002b). These wetland locations and their structure are typically influenced by reservoir elevation. Wetlands along the lower Snake River reservoirs are characterized by emergent plant communities. Cattails (*Typhus latifola*) and bulrush (*Scirpus sp.*) are the predominant wetland plants along the reservoirs.

3.2.2 Terrestrial Wildlife

The study area includes land adjacent to the LSRP and provides habitat for numerous birds, reptiles, amphibians, small mammals, bats, and big game animals. The following section presents a general description of the wildlife species present in the study area.

Table 3-3. Number of Terrestrial Wildlife Species known to Occur in the Study Area

Wildlife Species Type	Lower Snake River[1]
Mammals	87
Birds	257
Amphibians	5
Reptiles	11
Total	360

[1]*Source: Lower Snake River Subbasin Plan (NWPCC 2004b); includes species in area draining to the lower Snake River.*

Much of the wildlife in the study area is generally found to be dependent on tree-shrub riparian habitat associated with the reservoirs and river systems (Lewke and Buss 1977). In general, habitats associated with water, e.g., riparian and wetland areas, support higher population densities and species numbers than dry grassland and shrub community habitat. Habitats associated with the river generally support trees or dense grass-forb cover, which provides more structurally complex habitat and more abundant forage resources than adjacent uplands.

The reservoirs and river systems provide food, water, and cover for numerous wildlife species and are especially important where moisture is extremely limited. Riparian areas serve as important wildlife habitat and are integral to the function of river aquatic ecosystems (USACE 2002b). Currently, approximately 1,804 acres of riparian habitat exists in varying proportions along the lower Snake River reservoirs (USACE 2002b). Wildlife that typically uses riparian and wetland habitats associated with the study area can be divided into four main groups: birds, mammals, and amphibians and reptiles. These species groups are discussed below.

Waterfowl (ducks, geese, and swans) and shorebirds (plovers, sandpipers, and similar birds) represent two of the most abundant groups of birds reported from the study area. Many of these species exhibit extensive migrations from breeding areas in Alaska and Canada to wintering grounds in Mexico and southward (Lincoln et al. 1998). While many of these species nest in Canada and Alaska, a number of species, such as the killdeer, spotted sandpiper, gadwall, and

blue-winged teal, also nest in the study area (National Geographic 1999). Most species are ground-level nesters, and many forage in flocks (sometimes relatively large) on the ground or water; as such, they are generally associated with riparian areas and open water. Resident, breeding waterfowl numbers are generally low except for Canada geese, mallard, and American widgeon, which occur throughout the study area year-round at lower elevations.

Songbirds (also referred to as ***passerines*** or perching birds) represent the most diverse category of birds. The songbirds exhibit a wide range of seasonal movements; some species are year-round residents in some areas and migratory in others and still other species migrate hundreds of miles or more (Lincoln et al. 1998). Nesting occurs in vegetation from near ground level to the upper canopy of trees. Some species, such as the thrushes and chickadees, are relatively solitary throughout the year, while others such as swallows and blackbirds, may occur in small to large flocks at various times of the year. Foraging may occur in flight (i.e., swallows and swifts), in vegetation, or on the ground (i.e., warblers, finches, thrushes).

Gallinaceous birds (sometimes referred to as upland game birds) include ring-necked pheasant, chukar, California quail, and gray partridge. All of the gallinaceous birds within the study area are year-round residents and are relatively common. They are ground-dwelling birds, and their flight is generally brief but strong. The birds of prey include the raptors (hawks, falcons, eagles, and osprey), owls, and vultures; many of these species represent the top avian predators in the study area. Common species include the sharp-shinned hawk, red-tailed hawk, northern harrier, Swainson's hawk, American kestrel, bald eagle, and golden eagle. Owls are also present in the study area, including the great horned owl, short-eared owl, and burrowing owl. The raptors and owls vary considerably among species with regard to their seasonal migrations; some species are nonmigratory (year-round residents), others are migratory in the northern portions of their ranges and nonmigratory in the southern portions of their ranges, and still other species are migratory throughout their ranges.

Raptors forage on a variety of prey, including small mammals, reptiles, other birds, fish, invertebrates, and at times, carrion. They typically perch on trees, utility posts, highway signs, and other high structures that provide a broad view of the surrounding topography; they may soar for extended periods of time at relatively high altitudes. Raptors forage from either a perch or on the wing (depending on the species), and all forage during the day. The owls also perch on elevated structures and forage on a variety of prey, including mammals, birds, and insects.

Riparian areas provide perching and nesting opportunities, and concentrated prey (e.g., small mammals, insects, songbirds) for raptors (Asherin and Claar 1976; Tabor 1976; Asherin and Orme 1978). In general, cliffs and large trees along riverbanks typically support diverse raptor populations. The lower Snake River reservoirs include cliff areas in proximity to the rivers that provide potential nest and roost sites for bald eagles, golden eagles, red-tailed hawks, osprey, and prairie falcons (Payne et al. 1975; Asherin and Claar 1976; Tabor 1976).

Many of the bird species identified within the study area are seasonal residents and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical

songbirds. The study area lies within the Pacific Flyway, which includes the Pacific Coast Route and occurs between the eastern base of the Rocky Mountains and the Pacific coast of the United States. This ***flyway***, or migratory route, encompasses the states of California, Nevada, Oregon, and Washington, and portions of Montana, Idaho, Utah, Wyoming, and Arizona. Birds migrating south from Canada pass through portions of Montana and Idaho and then migrate either eastward to enter the Central Flyway, or turn southwest along the Snake and Columbia River valleys and then continue south across central Oregon and the interior valleys of California (Birdnature 2004). This route is not as heavily used as some of the other migratory routes in North America (Lincoln et al. 1998).

Large and small mammals are found throughout the study area. Large mammals include mule and white-tailed deer, elk, bighorn sheep, bobcat, and cougar.

Small mammals include deer mouse, western harvest mouse, Great Basin pocket mouse, house mouse, long-tailed vole, montane vole, northern pocket gopher, vagrant shrew, Merriam's shrew, bushy-tailed woodrat, and Ord's kangaroo rat (Asherin and Claar 1976; Johnson and Cassidy 1997; Rocklage and Ratti 1998).

Aquatic furbearers occur in the study area and include muskrat, beaver, river otter, and mink. In general, the furbearers are dependent on riverine areas, embayments, ponds, tributaries, and riparian forests for den sites and foraging areas. Beaver distribution within the study area is strongly associated with the presence of cottonwoods and protected areas (Asherin and Claar 1976). Muskrats are particularly abundant in embayments and sloughs where aquatic plants are abundant. Mink and river otter use the project reservoirs, ponds, sloughs, and backwater areas for foraging and denning. Asherin and Claar (1976) observed four species of terrestrial furbearers (bobcat, coyote, raccoon, and striped skunk), along with the aquatic furbearers.

Six species of bats have been documented in the study area and five more are suspected to occur based on habitat suitability, their range, and their expected occurrence in the study area (Asherin and Claar 1976; Mack et al. 1994; Johnson and Cassidy 1997). Documented species include Yuma myotis, western pipistrelle, pallid bat, small-footed myotis, California myotis, and Townsend's big-eared bat. Other species of bats that may also be present include long-legged myotis, long-eared myotis, fringed myotis, hoary bat, and big brown bat (Asherin and Claar 1976; Johnson and Cassidy 1997).

Mule and white-tailed deer are the most common big game inhabiting the study area (Tabor 1976). Mule deer make up approximately 80 percent of the deer population with the white-tailed deer making up the remaining 20 percent (Asherin and Claar 1976). Populations of deer have recovered to preimpoundment carrying capacity in the areas surrounding the lower Snake River reservoirs (USACE 1990). This increase is at least partly due to the development of habitat in HMUs and the exclusion of livestock from much of the study area (USACE 2002b). Deer use a wide variety of habitats including shrub communities for cover and fawning as well as grassland for foraging.

The amphibians in the study area include frogs, toads, and salamanders that occupy a variety of wildlife habitat types, including forested headwater streams in mountain regions, marshes, and wetlands. The most common occurring species were the Pacific tree frog, bullfrog, , long-toed salamander and western toad. Other species that occur include the tiger salamander and northern leopard frog.

Reptile species in the study area include a wide variety of turtles, snakes, and lizards. The most commonly occurring species were the Great Basin gopher snake, night snake, western rattlesnake, western yellow-bellied race,r bull snake, and painted turtles. Other species that occur include the short-horned lizard, sagebrush lizard, rubber boa, and the ringneck snake.

3.2.2.1 Habitat Management Units

As part of the Lower Snake River Fish and Wildlife Compensation Plan, a terrestrial wildlife mitigation program was initiated to compensate for habitat lost in the development of the LSRP. The plan called for the creation of a number of HMUs to provide high quality upland habitat for a variety of wildlife and for obtaining additional land to fully compensate for upland game habitat losses that resulted from the construction of the lower Snake River dams (USACE 2004). HMUs help address the LSRP-authorized purposes of fish and wildlife conservation.

HMUs are Corps-owned lands designated primarily to be managed as wildlife habitat. These areas provide essential habitat for the vast array of plants and wildlife species that use the LSRP study area. The HMU habitats were developed either purposefully by restoration activities, including irrigation intake facilities, or established naturally over time through long periods of normal reservoir conditions. Sixty-two HMUs have been designated along the lower Snake River; 11 of these HMUs are irrigated to provide intended habitat conditions and 51 are dry-land (nonirrigated) (USACE 2002b). Sedimentation around some HMU irrigation can interfere with their operation.

The Joso HMU is a nonirrigated HMU located above Lower Monumental Dam. As noted in Section 2, the Corps has identified the Joso HMU as a location for the upland placement of dredged material (a measure included in alternatives 5 and 7). The majority of the Joso HMU is basalt bedrock and gravel, with minimal soil and vegetation development. Vegetation over most of the site is consistent with upland species in the area, including rabbit-brush and yarrow; the site is covered with introduced and invasive species, including cheat grass, medusa head wild rye, and thistle, species that provide minimal wildlife value (Pellant 1996). The riparian area at the Joso HMU contains minimal vegetation and does not connect to large areas of shrub steppe, minimizing vegetation continuity and connectivity. Species present in the riparian area include black cottonwood, Russian olive, false indigo, and various willow species.

3.2.3 Threatened and Endangered Species

The study area provides habitat that supports species of plants and animals that are threatened, endangered, or of special concern at the national, regional, and state level.

Currently, 6 plant and terrestrial animal species are listed as threatened or endangered and 2 species are considered candidates under the ESA within the study area. (Table 3-4).

The following federally-listed terrestrial species may be present within or adjacent to the study area: Canada lynx, gray wolves, pygmy rabbit, Ute ladies'-tresses, and Spalding's catchfly. The Washington ground squirrel, North American wolverine, and yellow-billed cuckoo are federal candidate species that may be present in the study area.

Table 3-4. Lower Snake River ESA-listed Species (Threatened, Endangered, Proposed, Candidate)

Species	Listing Status
Canada lynx	Threatened
Gray wolf	Endangered
North America wolverine	Candidate
Pygmy rabbit[22]	Endangered
Washington ground squirrel	Candidate
Yellow-billed cuckoo	Candidate
Ute ladies'-tresses	Threatened
Spalding's catchfly	Threatened

[1]Source: Lower Snake River Subbasin Plan (2004)

[2]Only the Great Basin DPS in Douglas County Washington is Endangered; pygmy rabbit is a Species of Concern elsewhere.

3.2.3.1 Canada Lynx

Canada lynx was listed as threatened in April 2000. The counties that border the lower Snake River are included in the listing. Canada lynx populations in Washington, Oregon, and Idaho were probably always quite low; however, human disturbance from logging and recreation likely contributed to a decline of lynx numbers in these states. Lynx also were trapped for their fur in Washington, Idaho, and possibly Oregon, as late at the early 1990s. There are very few historic records of lynx harvest, partially because lynx and the more common bobcat were often combined in the records.

Lynx is a medium-sized cat with long legs and large paws. The lynx's long legs and large paws make it well adapted for living in areas that receive deep snow. The home range of a lynx may extend over a few hundred square miles. Young lynx may disperse great distances from their birthplace. Lynx use downed logs and windfalls, generally in mature forests, for den sites. Lynx primarily prey upon snowshoe hares, but also may prey on squirrels or other small animals when hare populations are low. They typically do not tolerate human presence very well, so they need large areas of uninhabited forest.

Fluctuating prey abundance and habitat changes likely play a large role in keeping lynx numbers low in any given area. Timber harvest and tree thinning may reduce the quality of snowshoe hare and red squirrel habitat. These activities could negatively affect lynx. Human encroachment into lynx habitat could also cause lynx to leave an area. Some lynx may inadvertently be mistaken for bobcat and be trapped or shot. Increased coyote populations may also negatively affect lynx through competition for prey. Critical habitat for Canada lynx was designated in February 2009 and none is located in the study area.

3.2.3.2 Gray Wolves

As a subspecies, Gray wolves in the northern Rocky Mountains were originally listed as endangered in 1973. In 1978, the entire species of gray wolves was listed throughout the lower 48 states (except Minnesota). Due to extremely low wolf populations, several packs of gray wolves were reintroduced from Canada to Idaho in 1995. These reintroduced wolves have been de-listed in Idaho.

Adult wolves range in size from 75 to 100 pounds, 4.5 to 6.5 feet from nose to the tip of the tail, and stand from 26 to 32 inches tall at the shoulder. Wolves depend on ungulates (hoofed mammals) for food. They also eat smaller mammals and carrion when available. They typically need 8 to 12 pounds of meat per day.

Wolf packs can travel several miles per day and typically have home ranges from 50 to 200 square miles. Wolves depend on large tracts of land that are uninhabited by humans. Wolves typically avoid humans and can be displaced if too much human presence occurs in an area. Wolf populations are dependant on ungulate populations so declines in ungulate populations can affect wolf populations. Some wolves are relocated or killed if they prey on livestock. The biggest limiting factor for the gray wolf population is the limited amount of land available that is uninhabited by humans. As the wolf population increases, there will be more conflicts with humans.

Reintroduced wolves have generally done very well. The wolf population and range in Idaho is expanding. There have been some wolves that have ranged into Oregon and eastern Washington. Wolves in the northern Rocky Mountains have recovered more rapidly than anticipated. The USFWS may initiate a delisting process in the near future. Critical habitat for gray wolves has not been designated.

3.2.3.3 Ute Ladies'-Tresses

Ute ladies'-tresses was listed as threatened in 1992. It is an orchid, a lowland species typically occurring beside or near moderate gradient, medium to large streams and rivers in the transition zone between mountains and plains. The species tends to occupy graminoid (grasses, rushes, and sedges) dominated openings in shrubby areas. It occasionally occurs in spring-fed wetlands in broad valleys isolated from watercourses. Soil moisture must be at or near the surface throughout the growing season. The species tolerates periodic flooding, but does not occupy constantly inundated areas (USFWS 1998). Ute ladies'-tresses occur in a variety of settings including

floodplains, moist to wet meadows on floodplains, abandoned meander channels, moist to wet meadows irrigated by freshwater springs, riparian streambanks, borrow pits, upper edges of riverbanks, islands, point bars, and various topographic positions up to 200 feet horizontally and 0.5 to 4 feet vertically from the water's edge, but not on steep slopes (USFWS 1998).

Ute ladies'-tresses were found in northern Washington (the Okanogan River valley) for the first time in 1997. They also were found in the Snake River basin in southeastern Idaho in 1996. The species is now known to be present in northern Washington, southern Idaho, and nearby parts of Montana. The USFWS has determined that, in the absence of adequate surveys, this species may be expected to occur in suitable habitat throughout Idaho and Washington (USFWS 1998).

3.2.3.4 Spalding's Catchfly

Spalding's catchfly was listed as a threatened species in 2001. This plant that has white flowers and is found in virgin Idaho fescue (*Festuca idahoensis*) habitat types in the Palouse region (Sheehan and Schuller 1981). Although not documented in the study area, this species has been found in Whitman and Asotin Counties in Washington and in Nez Perce County in Idaho.

3.2.3.5 Pygmy Rabbit

The Columbia Basin pygmy rabbit DPS was listed as an endangered species by USFWS under an emergency regulation in 2001. The species was confirmed listed as endangered in 2003, without designation of critical habitat. There are no known pygmy rabbit populations along the lower Snake River in the study area.

3.2.3.6 North American Wolverine

The USFWS has added the North American Wolverine to its list of candidate species and will review its status annually. Currently, wolverine populations are restricted to the North Cascades Range in Washington and the Northern Rockies of Montana, Idaho, and Wyoming, and are not present in the study area.

3.2.3.7 Washington Ground Squirrels

Washington ground squirrels, a Federal candidate species, are found in steppe and open shrub-steppe, where they prefer deep, loose soil for digging burrows. One existing colony in Walla Walla County is in the study area, and five additional colonies are located nearby.

3.2.3.8 Yellow-Billed Cuckoos

The yellow-billed cuckoo is a candidate for listing under the ESA. In the study area, yellow-billed cuckoos may be located in Asotin, Columbia, Garfield, and Walla Walla counties in Washington. It is a medium-sized bird, about 12 inches in length. These cuckoos breed in large blocks of riparian habitats with cottonwoods and willows. Dense understory foliage appears to be an important factor in nest site selection, while cottonwood trees are an important foraging habitat.

3.3 Recreation

The study area provides a variety of opportunities for outdoor recreation, which in turn provide intrinsic value to residents as well as economic opportunities through tourism. Due largely to its rural nature and scenic terrain the study area provides many areas used for recreation that attract visitors from the region and around the world.

Recreation facilities and land available for recreational use are managed by federal, state, and local agencies. Recreation sites in the study area include parks, rivers, trails, lakes/reservoirs, and wildlife areas. These facilities are managed and operated by the Corps, USFWS, local and state recreation agencies, state wildlife agencies, and public port authorities. The Corps manages the water-based recreation areas and facilities located along the lower Snake River reservoirs. In addition, some Corps-owned facilities are managed under lease agreements by other agencies.

Recreational facilities adjacent to the lower Snake River and Corps-operated reservoirs provide opportunities such as picnicking, camping, boating, swimming, hiking, wildlife viewing, fishing, and hunting. Recreation activities take place throughout the year, with the highest levels of use occurring during the periods of late spring, summer, and early autumn when fair weather is typical. Table 3-5 presents information on annual visitation to facilities located within each of the Lower Snake River Reservoirs (McNary Reservoir is not included as visitation figures do not distinguish between facilities on the Snake and Columbia Rivers).

Table 3-5. Total Recreation Visits and Visitor Hours at Lower Snake River Recreation Facilities

Reservoir	Fiscal Year (FY) 2008		FY 2009		FY 2010	
	Visitor Hours	Visits	Visitor Hours	Visits	Visitor Hours	Visits
Ice Harbor	3,823,791	336,112	6,780,371	482,234	5,036,047	479,553
Lower Monumental	497,848	92,256	585,316	102,755	605,947	103,427
Little Goose	1,302,838	198,847	1,297,889	205,715	2,338,880	225,777
Lower Granite	4,856,524	1,494,504	5,717,187	1,682,042	7,398,244	2,090,904

Source: Corps of Engineers

There are several riverfront parks in Clarkston and Lewiston that are associated with the levee system, average annual number of visitors to these parks for 2004 to 2011 were:

- Swallows Park in Clarkston: 217,321 visitors.
- Lewiston Levee Park: 270,038 visitors.
- Chief Looking Glass in Asotin: 25,315 visitors.

These parks see heavy day use throughout the summer except on very hot days, when the usage is generally in the morning and late evening. Peak usage for all these areas is summer. Spring, fall, and winter receive light to moderate use that is generally weather-dependent. Lewiston Levee Park, for example, features a multi- use trail that runs along the levee, as well as picnic tables and other day use facilities.

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3.4 Cultural Resources

The following sections provide prehistoric, historic, and ***ethnographic*** context for cultural resources within the study area, and a summary of the general character and condition of cultural resources.

Cultural resource laws require the Corps, in consultation with the public, Tribal governments, and other interested parties to take into account the effects of the project on cultural resources. The prehistoric, historic, and ethnographic context and information on the general character and condition of known resources provide a basis for assessing the potential for proposed PSMP actions to adversely affect cultural resources.

3.4.1 Cultural Resources Property Types

Cultural resources within the study area are composed of precontact (i.e., pre-EuroAmerican contact and settlement) and historical period archaeological sites, elements of the historical built environment (historic buildings and structures), cultural landscapes, and traditional cultural properties. These can be individual sites, districts, landscapes, buildings, structures, objects, and districts. Archaeological resources, historic buildings and structures, and traditional cultural properties that have been evaluated on the basis of specific criteria and found eligible for the National Register of Historic Places are referred to as historic properties.

3.4.1.1 Archaeology

Archaeological resources are the locations of the tangible, physical remains of human activity. The age of these resources within the study area ranges from thousands of years to recent time. Precontact resources date from the post-glacial arrival of humans in the area approximately 10,000-11,000 years ago, up until the ***protohistoric*** period when first European explorers documented their forays into the region, and into the historic period characterized by intensive immigration and settlement.

Precontact archaeological sites include occupation sites (pit house villages, caves, rock shelters, and open campsites). Storage activities may be represented at these sites or in areas related to specific resource procurement locations. Sites related to resource procurement activities include hunting stations, fishing stations, butchering sites, rock alignments, quarry sites, and resource-specific task areas such as ***camas*** (edible plant) fields and nut-gathering camps. Sites related to resource processing include ***lithic***/tool scatters, fire pits and hearths, and shell ***middens***.

Historical archaeological resources are related to a number of different historic themes during and following post-contact settlement and development of the area, such as exploration, industry (mining and logging), settlement and community development, commerce, transportation, agriculture and stock-raising, public lands management, and recreation.

3.4.1.2 Historic Properties of Religious and Cultural Significance

A historic property of religious and cultural significance is a type of cultural resource that is associated with cultural practices or beliefs of a living community that are rooted in that community's history, and plays an important role in maintaining the continuing cultural identity of the community. These properties may be archaeological sites but may also be represented by nonarchaeological features such as distinctive shapes in the natural landscape, named features in local geography, natural habitat for significant faunal and floral resources, traditional fisheries and sacred religious sites. Although most properties in the study area are associated with Native American groups, they can also be related to other ethnic communities, e.g., African American, Chinese, or Japanese groups. Other types of properties include those of importance to maintaining the cultural identity of rural communities. Because a property is defined in relation to a specific group, the intangible qualities associated with such resources may be known only to that group or a subset of their members.

3.4.1.3 Built Environment

Historic buildings and structures refer to elements of the aboveground built environment typically related to historical themes identified in the study area: exploration, missions and settlement, industry (mining and logging), transportation (trail systems, railway systems, road systems), agriculture and stockraising, and modern land use (dam projects, federal land management).

3.4.2 Cultural Resources in the Study Area

General information about the character and condition of cultural resources within the study area is summarized, with some description of representative sites included.

Within the lower Snake River study area, a variety of human activities have altered the landscape, particularly vegetation in the river bottoms where agricultural practices have replaced native grass and shrub lands, riparian areas, and wetlands. Road building has contributed to sedimentation in areas with ***loess*** (windblown deposition) soils, concentrating runoff which results in gullying. Logging and agricultural conversion of grasslands to annual cropping systems and grazing have increased runoff and erosion of fine sediments. Construction of the four lower Snake River dams led to inundation of some areas, including large stretches where archaeological sites were identified. Channel modifications and straightening, diking, banking, and armoring have altered portions of the river and its tributaries. Many sites along the lower Snake River are now completely or partially inundated by the reservoirs constructed in association with the four dam projects along this stretch of the river. Historic period archaeological resources are related to the historic themes identified in this portion of the study area. Current and historic operations of the reservoirs involve varying water levels within the reservoirs' operating rages; periodic fluctuations of pool levels within the operating range have been known to cause erosion of the shoreline and exposure of archaeological material.

The study area contains the lower Snake River Archaeological District near the confluence of the Snake and Columbia Rivers. The district groups a variety of resources that include villages and burials. Upriver, the area of the Snake River-Clearwater confluence in the Lewiston Basin is also archaeologically rich, with numerous precontact sites making up a long series that comprise the Snake River Archaeological District on the Washington side and the Nez Perce Snake River Archaeological District on the Idaho side. Sites include seasonal campsites, house pit sites, burials, storage shelters, pictographs, petroglyphs, fish walls, storage pits, and rock piles thought to be remains of sweat lodges.

The Confederated Tribes of the Yakama Reservation, Confederated Tribes of the Umatilla Reservation, the Confederated Tribes of the Colville Nation, the Nez Perce Tribe, and the Wanapum Band have interests in traditional resources in this area. These groups have provided confidential preliminary information on TCPs within the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite study areas on the lower Snake River as part of the Federal Columbia River Power System (FCRPS) consultation. Property types include sacred and sensitive locales, legendary locales, and resource utilization locales, including base camps, work camps, hunting and fishing camps, special resource camps (e.g., lithic resources, medicinal plants), and village sites..

National Register-listed or eligible resources of the historic period built environment found in this area include community buildings (including historic houses, courthouses, and libraries), commercial and industrial buildings, bridges, railroad depots, and viaducts. Most of these are found in urban areas, and specifically within the cities of Lewiston, ID and Clarkston, WA. Other kinds of resources that could be found in nonurban areas include remains of early town sites, early farms and ranches (foundations, irrigation improvements, fence lines and rock piles, farm machinery, debris scatters, privies, orchard remnants), and railroad-related sites (tracks and grades, construction camps).

Buildings and structures associated with the Ice Harbor Lock and Dam have reached 50 years of age, and the remaining LSRP are nearing the age of 50 years, when inventory and evaluation will be required to determine if they are eligible for listing on the National Register.

As a result of the management needs for the LSRP, the study area has been the focus of intensive archaeological research leading to the development of regional cultural sequences. The Lower Snake area contains the type sites for phases identified as a foundation of the cultural chronology: Windust Cave, the Tucannon site, and the Harder site. The earliest dates in the region come from Marmes Rock shelter and the Granite Point (10,000-9,000 years ago), Windust Cave (before 5,000 years ago), and Ash and Burr Caves (8,000 years ago).

The earliest archaeological work in the study area included ethnographic studies under the sponsorship of the Peabody Museum of Archaeology and Ethnology, which led to identification of numerous Nez Perce village locations and sites along the middle Snake River. Archaeological investigation was carried out as part of the Columbia Basin Project of River Basin Surveys of the late 1940s and early 1950s, was carried out during a period of dam building and reservoir

construction in the post World War II Cold War era. Because of the threat to archaeological resources, the National Park Service and the Smithsonian Institution established the office of River Basin Surveys. In 1948 the Columbia Basin Project of the River Basin Surveys conducted an intensive reconnaissance of Ice Harbor, Lower Monumental, and Lower Granite Reservoirs as well as the Hells Canyon Dam area.

During the period between the initial service for McNary Dam in 1953 and the Lower Granite Dam in 1975, salvage archaeology was carried out in areas scheduled for inundation. Much of this work was carried out by Washington State University under the supervision of Richard Daugherty and Frank Leonhardy. Salvage excavations were undertaken at a number of places along the Snake River and on major tributaries, including the Palouse River and Alpowa Creek. Most of the data was never formally reported and many of the assemblages were not analyzed.

Excavations include several important prehistoric sites, including Marmes Rock shelter (45FR50) on the Lower Palouse River and the Palus burial site (45FR36), the Tucannon site and Burial site (45CO1A &B), Squirt Cave (45WW25), and the Alpowa Village (Alpaweyma) site and cemetery (45AS82 and 45AS81).

The cultural resource management era has resulted in investigations associated with specific actions in limited areas. For instance, in the 1970s and early 1980, investigations were undertaken at historic period sites associated with construction of the Joso Trestle (45WW97H) between 1911 and 1914 and the late nineteenth-early twentieth century town of Silcott (45AS87, 45AS88, 45AS89, and 45WT104). With the management responsibilities of federal agencies under the National Historic Preservation Act of 1966, the focus has shifted from large-scale salvage programs to identification and evaluation of cultural properties..

Leonhardy and Rice (1970) developed a cultural sequence for the lower Snake River based on results of their excavation at pit house villages, rock shelters, and burials that yielded rich artifact assemblages and good chronological markers dating back to 10,800 B.C., but provided a limited understanding of land use systems or functional changes. Subsequent studies in the area have contributed to refine the model.

Today, ongoing survey, evaluation, and conditions monitoring is being carried out in the Lower Snake reach under the FCRPS Cultural Resources Management Program. The first annual (2010) report to the FCRPS, in conjunction with the System wide Programmatic Agreement for Management of Historic Properties, provided summary information to date for the four lower Snake River dam projects.

Most areas with high potential for cultural resources in the lower Snake River portion of the study area were inundated by reservoirs associated with the four dam projects on the Lower Snake. Cultural resource sites in these areas may contain both prehistoric and historic period components. The areas with high potential for cultural resources include mesa tops and overhangs, talus slopes, confluences, tributary streams, springs, terraces, alluvial fans, flood channels, and channel bars.

To date, a total of 76 archaeological sites have been identified within the Ice Harbor Lock and Dam study area. Thirty five of these resources are partially or completely inundated. Three of the newly recorded sites were recommend eligible for the National Registry of Historic Places (NRHP): 45FR71, 45FRWW14, and 45WW115. A monitoring program developed in 2003 conducts conditions assessments on a schedule linked to the type of resource and imminent threats to site integrity. No sites have been stabilized under the FCRPS management program.

A total of 207 archaeological sites have been identified within the Lower Monumental study area. Twenty-nine of these resources are partially or completely inundated. One site and an archaeological district have been recommended listed on NRHP, with ten sites recommended eligible and ten additional sites considered potentially eligible.

The proposed Joso HMU is located on a bend of the Snake River west of the Palouse confluence, immediately downstream from Lyons Ferry State Park, between RM 56.5 and RM 58.6 in the Lower Monumental Reservoir. The site is bounded on the south side by the Union Pacific Railroad. The site is approximately 568 acres. The site is constrained along the Snake River by a 600-foot-wide riparian habitat area and by wetlands in the eastern corner. The site provides a barge slip, material unloading areas, and an area of approximately 280 acres for permanent placement of dredged material.

A review of Department of Archaeology and Historic Preservation records showed seven archaeological sites have been reported from within the site. Thirteen additional sites have been recorded within one mile. The seven sites within the Joso HMU site area include two precontact lithic isolates and five historic can dumps. Precontact sites within 0.2-0.3 miles include a village site with burials, a habitation site, and a campsite initially reported in 1948, rock cairns recorded in 2000, a cave site recorded in 2001, a lithic scatter, and one lithic isolate. Historic sites within the area include the Lyons Ferry Boat Crossing, Trestle City, Joso viaduct, and one additional historic can scatter site. There are also two sites possessing both historic artifact scatters and a precontact component.

Numerous cultural resources investigations have been carried out within a mile of the Joso HMU, beginning with the River Basin Surveys of 1940s and 1950s. Some were regional (lower Snake River) investigations; others were more focused on the Lyons Ferry area. The historic sites reflect transportation themes important to local and regional history.

The Lyons Ferry Boat Crossing (45-FR-313) was the location of an early cable-operated ferry that moved passengers and livestock across the Snake River just west of the Palouse River confluence. A ferry continuously operated at this spot from about 1860 until 1968. This was the river crossing along the military road that connected Fort Walla Walla with Fort Benton in Montana.

The Oregon-Washington Railroad and Transportation Company, controlled by the Union Pacific Railroad, built the Joso viaduct (45-WW-79) over the Snake River at Lyons Ferry in 1914 as part of its effort to connect its line between Portland and Spokane. The bridge was noted for its length (3,920 foot) and height (it originally rose 270 feet above the river), as well as problems related to

its construction in a swiftly moving current, constructed with pedestals located at variable depths in bedrock. The bridge was raised up in 1968 when the Lower Monumental Dam was constructed. Trestle City (45-FR51) is the former location of the workers camp associated with construction of the Joso viaduct.

Recent studies concluded that no additional archaeological survey work is required in the Joso site.

Ninety-three archaeological sites have been identified within the Little Goose study area. Two sites have been recommended potentially eligible for the NRHP and reevaluation of other sites is being initiated.

AA total of 159 archaeological sites have been identified within the Lower Granite study area. Seventy-six of these are inundated. Three sites have been determined eligible for NRHP listing and two have been recommended potentially eligible.

3.5 Socioeconomics

The study area includes parts of seven counties in Washington State and one county in Idaho State.

The study area and surrounding region have grown continually over the last 20 years, with a trend of migration from rural areas into urban centers. The study area population is predominantly white and educational levels generally match state averages. Area employment has been affected by the recent national recession in 2008-2010, but incomes have continued to increase throughout the region.

The following sections describe the current socioeconomic conditions of the communities in the study area. Socioeconomic conditions that are considered include population demographics, employment and income, and environmental justice concerns. This section also presents information on transportation, including commercial navigation, and its role in the regional economy.

3.5.1 Population and Demographics

Population for each county in the study area is presented in Table 3-6, below. The study area is generally rural in nature with generally low population densities. The main population centers in the study area and surrounding region are the Lewiston-Clarkston area, near the confluence of the Clearwater and Snake Rivers in Nez Perce County, Idaho and Asotin County, Washington, and the Tri-Cities area, near the confluence of the Snake and Columbia Rivers in Franklin County, Washington. The study area population generally increased between 1990 and 2010, with the exception of Garfield County, Washington.

Table 3-6. Study Area Population Projections by County (2010-2030)

State	County	2010	2015	2020	2025	2030	Change 2010 – 2030 (%)
Idaho	Nez Perce	39,265					
	State of Idaho	1,517,291	1,630,045	1,741,333	1,852,627	1,969,624	30
Washington	Asotin**	21,198	23,241	24,321	25,341	26,222	24
Washington	Columbia**	3,984	4,096	4,096	4,096	4,088	3
Washington	Franklin**	69,757	80,348	90,654	100,666	109,861	57
Washington	Garfield**	2,129	2,494	2,566	2,632	2,683	26
Washington	Walla Walla**	57,795	63,139	65,593	67,895	69,828	21
Washington	Whitman**	41,793	44,274	45,581	46,786	47,743	14
	State of Washington	6,541,963	6,950,610	7,432,136	7,996,400	8,624,801	32
	United States	308,935,581	322,365,787	335,804,546	349,439,199	363,584,435	18

Sources: U.S. Census Bureau: 2010 Decennial Census (USCB 2011a); Idaho Department of Labor (IDL 2011); Oregon Office of Economic Analysis (OOEA 2011); and Washington Office of Financial Management (WOFM 2011).
*Notes: * Projections not available for Idaho counties; * *2010 Census estimates unavailable; 2005-2009 5-year American Community Survey (USCB 2011b) estimates used instead.*

The majority of the population in the study area is white as shown in Table 3-7. The remainder of the population in the study area is primarily Hispanic and American Indian within the counties. Hispanics in the rural communities are primarily migrant farm workers located within the counties.

Table 3-7. Race and Hispanic Ethnicity of Population within Study Area (2000)

State	County	Hispanic Ethnicity	Race						
		Hispanic (%)	White (%)	Black or African American (%)	American Indian and Alaska Native (%)	Asian (%)	Native Hawaiian and Other Pacific Islander (%)	Some Other Race (%)	Population of Two or More Races (%)
Idaho	Nez Perce	2	92	0	5	1	0	1	2
	State of Idaho	8	91	0	1	1	0	4	2
Washington	Asotin	2	96	0	1	1	0	1	2
Washington	Columbia	6	94	0	1	0	0	3	2
Washington	Franklin	47	62	2	1	2	0	29	4
Washington	Garfield	2	96	0	0	1	0	1	1
Washington	Walla Walla	16	85	2	1	1	0	8	3
Washington	Whitman	3	88	2	1	6	0	1	3
	State of Washington	7	82	3	2	5	0	4	4

Source: U.S. Census Bureau: 2000 Decennial Census (USCB 2011a)

Per capita income, a measure of economic prosperity in the study area, has been increasing over the period 2000-2009 as shown in Table 3-8. Although the economy entered recession in 2008, the trend shows that incomes continue to increase.

Table 3-8. Study Area Income per Capita by County 2000-2009

State	County	2000	2005	2009	2000 - 2009 Change (%)
Idaho	Nez Perce	25,677	29,676	34,215	33.3
Washington	Asotin	24,331	29,066	34,077	40.1
Washington	Columbia	27,997	27,315	34,971	24.9
Washington	Franklin	19,901	22,188	26,342	32.4
Washington	Garfield	25,095	25,716	32,470	29.4
Washington	Walla Walla	23,680	26,484	33,059	39.6
Washington	Whitman	20,236	22,107	28,320	39.9

Source: U.S. Bureau of Economic Analysis (USBEA 2011, 2012)

3.5.2 Environmental Justice Communities

As outlined in Executive Order 12898, federal agencies must evaluate environmental justice issues related to any project proposed for implementation. This evaluation includes identification of minority and low-income populations, identification of any negative project impacts that would disproportionately affect these low-income or minority groups, and proposed mitigation to offset the projected negative impacts. The evaluation of environmental justice issues includes an identification of high minority and low-income populations in the study area. The identification of any negative project impacts that would potentially have disproportionately high and adverse effects on these low-income or minority groups is presented in Section 4.0.

Two study area Census tracts (9901 Nez Perce County, Idaho, and 201 Franklin County, Washington) have poverty percentages that are more than double the state level.

Only one of the study area census tracts for which minority data is reported had a minority population higher than the state average minority population percentage. Tract 201 in Franklin County, Washington has a minority population greater than the statewide average (69 percent for the tract compared to 24 percent for the state) due to the high Hispanic population in the area. All other tracts were below the statewide minority average.

3.5.3 Transportation

An overview of regional transportation systems is presented in this section. Commercial barge navigation on the lower Snake River is of key importance because navigation is one of the authorized project purposes of the LSRP and is a major element of the regional economy. The study area is served by a network of roads and railroads (as well as the commercial navigation system of the lower Snake River). Aviation is not addressed in this EIS as a programmatic sediment management plan is unlikely to affect aviation.

3.5.3.1 Commercial River Navigation

The Snake River navigation channel extends approximately 140 miles, from the confluence of the Columbia and Snake Rivers at Pasco, Washington, to the confluence of the Clearwater River with the Snake River at Lewiston, Idaho. The Snake River channel is the eastern end of the Columbia-Snake River shallow-draft channel, which extends 330 miles from Portland, Oregon and Vancouver, Washington to Lewiston, Idaho, and allows for commercial navigation between the Pacific Ocean and Lewiston, Idaho. Deep-water ports on the Lower Columbia River are major international export terminals and are the destination of most of the barge traffic originating on the Snake River.

Approximately 10 million tons of commercial cargo is transported on the lower Snake River each year with an annual value of between $1.5 and $2 billion. Downbound movements (i.e., movements from upstream ports toward the Columbia River) of grain account for most of this cargo, of which the largest share is wheat. Approximately half of all the wheat exported from export terminals on the Lower Columbia River arrives by barge.

The navigation channel in the LSRP is generally maintained at a minimum depth of 14 feet at minimum operating pool. The actual level of each pool varies depending on uncontrolled runoff, precipitation, wave action, and powerhouse operations. The facilities in each reservoir were designed to operate between minimum operating pool and maximum pool elevation (full pool; Table 3-9).

Table 3-9. Lower Snake Pool Levels

Reservoir	Minimum Pool Elevation	Maximum Pool Elevation
Ice Harbor	437	440
Lower Monumental	537	540
Little Goose	633	638
Lower Granite	733	738

Source: The Federal Caucus (Federal Caucus 2011)

The locks on the Snake River are located at Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. The navigation locks on the lower Snake River share similar dimensions, with a width of 86 feet and length of 665 to 675 feet and depth of 15 feet. The maximum lift of each of the locks is also similar, ranging between 101 and 105 feet.

Grain terminals account for the largest number of facilities. The Snake and Clearwater have a total of 14 grain terminals. Wood products are handled by eight facilities, all of which are on the Snake River. Other commodity types are handled by between one and four facilities on the Snake and Clearwater Rivers. Table 3-10 through Table 3-12 provides an overview of the facilities on the Clearwater River and lower Snake River.

Table 3-10. Lower Snake River Barge Facilities – Lower Granite Reservoir

River	Name	Mile	Bank (facing downstream)	Grain	Petroleum Products	Fertilizer	Chemicals	Wood Products	Pulp and Paper	Containers	General Cargo	Heavy Lift	Passenger Vessels	Vessel Services
Lower Granite Pool														
Snake	Tidewater Terminal Co, Wilma Dock	135.3	Right		X	X				X	X			X
Snake	Granger Co, Wilma Dock	135.5	Right					X						
Snake	Port of Whitman County, Site I Wharf	135.8	Right					X						
Snake	Foss Maritime Co, Wood Chip Dock	135.9	Right					X						
Snake	Mountain Fir Chip Co, Wilma Division Dock	136.1	Right					X						
Snake	Stegner Grain Terminal Dock	136.6	Right	X										
Snake	Port of Whitman County, Site A Dock	137	Right					X			X			X
Snake	Port of Clarkston Dock	137.8	Left					X		X	X	X		
Snake	Lewis-Clark Terminal, Clarkston Grain Terminal	138.3	Left	X										
Clearwater	Mountain Fir Chip Co, Lewiston Division Dock	0.5	Right					X						
Clearwater	Port of Lewiston, Container Terminal Dock	1.1	Right					X	X	X	X			
Clearwater	Continental Grain Co, Lewiston Elevator Dock	1.3	Right	X										
Clearwater	Lewis-Clark Terminal, Lewiston Dock	1.4	Right	X										

Source: Corps of Engineers Port Series No. 34

Table 3-11. Lower Snake River Barge Facilities – Little Goose, Lower Monumental and Ice Harbor Pools

River/Pool	Name	Mile	Bank	Grain	Petroleum Products	Fertilizer	Chemicals	Wood Products	Pulp and Paper	Containers	General Cargo	Heavy Lift	Passenger Vessels	Vessel Services
Little Goose Reservoir														
Snake	Pomeroy Grain Growers Dock	83	Left	X										
Snake	Columbia Grain International, Central Ferry Elevator	83.5	Right	X										
Snake	Central Ferry Terminal Association, Grain Dock	83.7	Right	X										
Snake	Port of Whitman, Boettcher Landing Dock	84	Right			X								X
Snake	Almota Elevator Co Dock	103.6	Right	X										
Snake	S & R Grain Co, Port of Almota Dock	103.7	Right	X										
Lower Monumental Reservoir														
Snake	Columbia County Grain Growers, Lyons Ferry Dock	61.1	Left	X										
Ice Harbor Reservoir														
Snake	Walla Walla Grain Growers, Sheffler Dock	29	Left	X										
Snake	Louis Dreyfus Corp, Windust Elevator Dock	38.5	Right	X										

Source: Corps of Engineers Port Series No. 34

Table 3-12. Lower Snake River Barge Facilities – McNary Pool (includes facilities on the Columbia River)

River/Pool	Name	Mile	Bank	Grain	Petroleum Products	Fertilizer	Chemicals	Wood Products	Pulp and Paper	Containers	General Cargo	Heavy Lift	Passenger Vessels	Vessel Services
McNary Reservoir														
Snake	Port of Walla Walla Dock	1.7	Left										X	
Snake	Co-Grain, Burbank Elevator Barge Slip	1.8	Left	X										
Snake	Cargill, Burbank Grain Elevator Dock	2	Left	X										
Snake	Northwest Terminalling Co, East Pasco Terminal	2	Right		X									
Snake	Tidewater Terminal Co, Pasco Mooring Docks	2.7	Right											X
Snake	Tidewater Terminal Co, Pasco Petroleum Dock	2.8	Right		X									
Snake	Tidewater Terminal Co, Pasco Fertilizer Dock	2.9	Right			X								

Source: Corps of Engineers Port Series No. 34

The total tonnage moved on the lower Snake River fluctuates from year to year, depending on crop production, the state of the U.S. economy, and trends in world trade. The U.S. and world economies suffered a deep recession in 2007, 2008, and 2009 (the most recent years for which data was available), and the volumes barged on the lower Snake River dropped as a result. In contrast, the Pacific Northwest wheat forecast for 2011 is strong and world demand is growing, which is likely to result in substantial cargo volume growth. Table 3-13 presents the total tonnages of cargo moved through the lower Snake River, and includes McNary Reservoir since cargo statistics do not differentiate between the Snake and Columbia River portions of McNary Reservoir.

Table 3-13. Lower Snake River Navigation Lock Detail (million tons)

Year	Lower Granite	Little Goose	Lower Monumental	Ice Harbor	McNary*
1994	2,314	3,542	3,678	4,278	7,976
1995	2,414	3,776	3,924	4,581	8,670
1996	1,771	2,912	3,098	3,564	7,886
1997	1,952	3,180	3,675	4,205	8,294
1998	2,221	3,554	4,018	4,571	8,591
1999	1,987	3,128	3,496	4,067	7,604
2000	2,264	3,103	4,110	4,560	8,461
2001	1,820	2,811	3,408	3,952	8,102
2002	1,349	2,427	2,687	3,086	6,372
2003	1,527	2,579	2,866	3,210	6,998
2004	1,749	2,951	3,267	4,119	7,508
2005	1,661	2,724	2,991	3,519	6,652
2006	1,570	2,717	2,915	3,371	6,950
2007	1,763	2,933	3,268	3,611	7,351
2008	1,164	1,840	2,119	2,161	5,301
2009	1,226	2,503	2,536	2,867	6,125

**Note: McNary Pool includes facilities on both the Snake and Columbia Rivers.*
Source: Corps of Engineers

Cargo volumes at the Lower Granite lock were reduced between 2007 and 2008, dropping from 1.76 million short tons[1] to 1.16 million short tons. In 2009, the last year for which data was available, Lower Granite volume increased somewhat over 2008, growing to 1.23 million short tons.

[1] Short ton is 2,000 pounds. It is specified here to distinguish from metric ton (1,000 kilograms, or 2,205 pounds), which is frequently used for world grain production statistics.

At the Little Goose Reservoir, the volume of cargo dropped from 2.93 million short tons in 2007 to 1.84 million short tons in 2008, but increased to 2.50 million short tons in 2009. The Lower Monumental and Ice Harbor locks experienced similar declines and increases in volumes.

Grain movements on the Snake River are all downbound, and are destined for export elevators or mills at deep-draft ports on the Lower Columbia River. Most of the grain moving on the Snake River originates in the upper two reservoirs (Lower Granite and Little Goose). Since 1994 the uppermost reservoir, Lower Granite, has accounted for an average of 37 percent of originating grain tonnage. The Little Goose Reservoir, immediately below Lower Granite, accounted for an average of 38 percent. The remaining tonnage is split between Lower Monumental (10 percent) and Ice Harbor (15 percent). Figure 3-2 illustrates trends in volumes of grain shipments by reservoir.

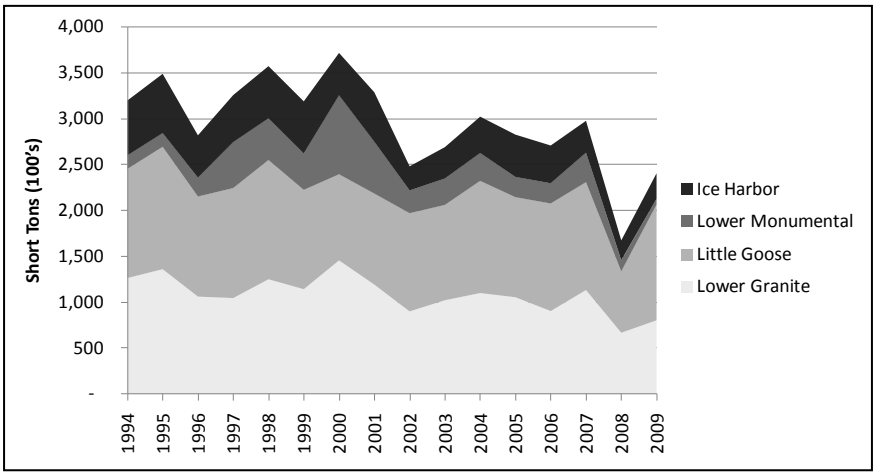

Figure 3-2. Snake River Grain Volume Originating by Reservoir (excluding McNary Pool)
Source: U.S. Army Corps of Engineers

Several grain elevators are located in the Snake River below Ice Harbor Dam. The McNary Reservoir includes these elevators as well as several others located on the Columbia River. Available statistics do not differentiate the volume of the grain traffic in the McNary Reservoir that is generated in the Snake River from that generated in the Columbia River.

The addition of McNary traffic to the volume generated on the rest of the Snake River does not change the general pattern of the past 16 years. The volume of grain shipped from the five reservoirs averaged approximately 5.0 million short tons per year between 1994 and 1998, but 4.2 million tons per year between 2003 and 2007 (Figure 3-3). In 2008 the volume fell to just 2.8 million tons before rebounding to 3.8 million tons in 2009. As discussed above, the recession in 2007 through 2009 depressed cargo volumes.

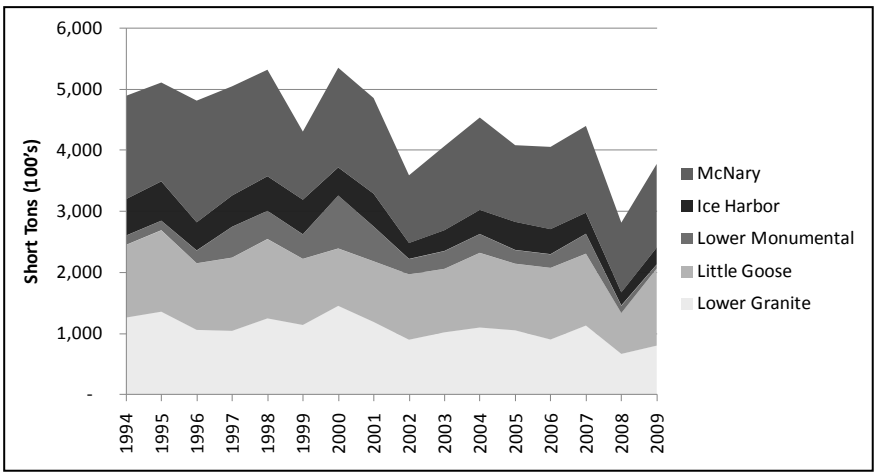

Figure 3-3. Snake River Grain Volume Originating by Pool (including McNary Reservoir)

Source: Corps of Engineers

Most of the grain shipped on the lower Snake River, nearly 69 percent, originates in Washington. Idaho accounts for 22 percent, and the remaining 9 percent originates in Montana, North Dakota, Utah, and Oregon (USACE 1999c).

Table 3-14. Origin of Grain Shipped on the Lower Snake River, by State

Origin	Bushels	Metric Tons	% of Total
Oregon	1,180,000	32,100	0.96
Idaho	27,260,000	741,900	22.10
Washington	84,730,000	2,306,000	68.69
Montana	6,780,000	184,500	5.50
North Dakota	3,270,000	89,000	2.65
Utah	140,000	3,800	0.11
Total	123,360,000	3,357,300	100.00

Source: Lower Snake River Juvenile Salmon Migration Feasibility Study, Transportation Appendix, September 1999

Essentially all of the pulp and paper on the Snake River moves downbound from Lewiston, Idaho. Between 2000 and 2010, the amount of pulp and paper shipped by barge dropped sharply, falling from approximately 175,000 short tons in 2000 to less than 30,000 tons in 2005. Volumes rebounded to 90,000 tons in 2006 and 2007, but then fell below 50,000 short tons in 2008 and below 20,000 tons in 2009.

Petroleum products are an upbound move, with most of the volume originating in Vancouver, Washington. Most petroleum products are offloaded above the McNary lock and below the Ice Harbor lock. The primary facilities for handling this type of product are located in Pasco, on the Snake River between RM 2 and 3. Above Ice Harbor there is one facility for petroleum products, located in the Lower Granite Reservoir at Wilma, approximately 3.5 miles below the Clearwater River.

All of the facilities in the Snake River used for handling wood products are located above the Lower Granite lock and dam. Most of these are located at Wilma, approximately 3.5 miles below the Clearwater River on the Snake River, while two docks in the Clearwater River also handle wood products.

The volume of wood products shipped by river dropped sharply during the recession of 2000, falling from nearly 400,000 short tons in 2000 to less than 140,000 tons in 2002. Volumes rebounded above 320,000 tons by 2004, but also declined during the recession of 2007-2009.

A variety of other products are transported by barge on the Snake River, including containers, fertilizer, and machinery.

3.5.3.2 Tour Boats

The lower Snake River is used by a variety of passenger vessels, including cruise ships, tour boats, and recreational vessels.

American Safari Cruises operate two vessels on the lower Snake River, the *Safari Explorer* and *Safari Spirit*. The *Explorer* is the larger of the two, at 145 feet in length and an 8.5-foot ***loaded draft***. The *Spirit* is 105 feet long and has a loaded draft of 6 feet. American Cruise Lines operates the *Queen of the West*, a 230-foot paddle wheeler with a loaded draft of 11 feet. Lindblad Expeditions operates two vessels on the lower Snake River, the *National Geographic Sea Bird* and the *National Geographic Sea Lion.* Each of the vessels is 152 feet long, with loaded drafts of 8 feet each.

The cruise business on the Snake River is highly seasonal, with most of the activity occurring during spring and fall. The peak month for Snake River cruises is October, which typically accounts for one quarter of annual cruise lockages.

The smaller cruise vessels have generally not been impacted by ***shoaling*** in the navigation channel. In contrast, the larger *Queen of the West* has had to shift its base of operations in Clarkston from the Port of Clarkston cruise boat dock to a cargo dock across the river due to sediment accumulation at the Port of Clarkston.

3.5.4 Rail

The study area railroad system is integrated with and competes with the barge transportation system described above, particularly with respect to shipments of grain. The rail system consists of two Class 1 railroads[2], as well as a number of regional railroads. The Class 1 railroads include the Burlington Northern Santa Fe (BNSF) and Union Pacific Railroad (UPRR). The BNSF operates two main rail lines through eastern Washington. The UP operates one main line in

[2] Class I railroads are large railroad companies that have annual operating revenues of $250 million or greater, as defined by the U.S. Surface Transportation Board. They generally have large regional networks that include many states.

eastern Washington and another that crosses Idaho and Oregon. Regional railroads in the vicinity of the lower Snake River include the Palouse River and Coulee City Railroad and the Great Northwest Railroad.

3.5.5 Roads and Highways

Several major roads and highways serve areas within the study area, including U.S. Highway 12 (generally runs east-west), 95 (north-south), Washington State Route 195 (north-south) and Idaho Highway 13.

Because of the flexibility of motor freight, road and highways have become the primary mode of transport in the region; several motor freight companies are based in the Lewiston area. Two major U.S. highways, 12 and 95, intersect at Lewiston, Idaho. Trucks carry a significant volume of grain in the region. These trucks are chiefly from eastern Washington and northern Idaho, with some from as far east as North Dakota and eastern Montana. However, the road infrastructure is not adequate in many areas to support the increased axle weights of trucks and year-round trucking (LCVMPO 2006). Roads and highways also provide the primary transportation facilities used for personal and recreational travel in the region.

3.6 Water Quality and Sediment Quality

3.6.1 Water Quality

The State of Washington has designated the lower Snake River and its tributaries to be protected for the following uses: salmon spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values (WAC 173-210A-600). The segment of the lower Snake River in Idaho has been designated for cold water aquatic life, primary contact recreation, special resource water, domestic water supply, wildlife habitats, and aesthetic beneficial uses (IDAPA 58.01.02.130). Tributaries to the lower Snake River in Idaho are designated for a variety of beneficial uses, as specified in IDAPA 58.01.02.

The Corps undertook an extensive study to characterize water and sediment quality in the Lower Snake River (generally in locations where sediment accumulation interferes with authorized project purposes). The study built upon years of previous monitoring of water and sediment quality. Turbidity values recorded were relatively low (generally less than 10 NTU), although measurements in the Snake River yielded higher values than the Clearwater River (USACE 2011d). General trends in median turbidity values show a slight increase as the river course increases downstream from the mouth of the Clearwater River to the mouth of the Snake River. Correlations between turbidity measurements and river discharge were high at the upstream monitoring station in the Snake River, implying that high flows lead to increased turbidity.

Larger particles transported by the lower Snake River settle out in the transition zone near Lewiston, Idaho and downstream in the Lower Granite Reservoir; finer particles can remain suspended downstream of the Lower Granite Reservoir. Total suspended solids (TSS) concentrations are typically higher at greater depths in the water column; however, concentrations can also be high near the water surface as a result of algal growth, port operations, and tributary inflows. The 2011 study found similar median TSS measurements throughout the Snake River, with the highest measurements detected during the spring thaw (USACE 2011d).

Dissolved Oxygen (DO) concentrations were found to be lower in the mainstem Snake River than in the Clearwater River. The median concentration measured from the Lower Granite Dam forebay was slightly lower than the other sites. The seasonal lows may be a result of algae descending in the water column (USACE 2011d). Similarly, super saturated conditions were associated with algal bloom. DO concentrations fluctuate with seasonal cycles in the lower Snake River system, likely due to the negative correlation between water temperature and DO.

Water temperature in the lower Snake River varies by time of year and location. Generally, water temperature is low in January and February, increasing slowly during spring runoff from March to May, then increasing more rapidly from June to early August. Temperatures plateau through mid-September, then decrease steadily through January. Trends in the mainstem Snake River measured at a USGS gauging station near Antone, Washington (RM 167) indicate that the average daily maximum water temperatures at this station are very similar for the periods 1975

through 1991 and 1992 through 2010. Maximum daily temperatures at this station exceeded 68°F (20°C) each year for 35 to 91 days between 1 June and 1 October (USACE 2011d).

Summertime releases of cold water in Dworshak Reservoir were initiated in 1992 with the goal of maintaining temperatures of 68°F (20°C) or lower in the Lower Granite Dam tailrace. The effect of these released cold water flows at Lower Granite Dam is apparent; measurements recorded from 1995 through 2010 show the average of the daily maximum temperatures recorded at the tailwater station were less than 68ºF (20ºC) (USACE 2011d).

The 2011 study found pH values in the mainstem lower Snake River to be more ***alkaline*** than the Clearwater River. Alkalinity showed a declining trend in the Snake River with downstream movement (USACE 2011d). Hourly data from the lower Snake River stations showed substantial differences in pH frequency from those of the Clearwater River station. About 90 percent of the hourly data recorded at the uppermost Snake River stations ranged from 7.5 to 8.5 units. Eighty four percent of the measurements recorded at the station near the mouth of the Snake River were between 7.5 and 8.5 units (USACE 2011d). Natural geological conditions, agricultural fertilizers, and aquatic primary productivity contribute to the elevated pH conditions.

Nutrients – particularly nitrogen and phosphorus – are of interest due to their effects on biological activities within aquatic systems. Forms of nitrogen of interest are ammonia and nitrate. Historically, ammonia concentrations in the Lower Snake River have close to or less than instrument detection (USACE 2005). Nitrate concentrations have ranged from 0.13 to 0.35 mg/l (USACE 2005). . The dominant forms of phosphorus are ortho-phosophorus (ortho-P) and total phosphorus (TP). Ortho-P concentrations in the lower Snake River are high in the fall and winter, and relatively low in the summer, likely due to biological uptake by aquatic plant and algal growth in the summer. In the fall, primary productivity decreases and phosphorus levels increase as there is reduced biological uptake and algal decay (USACE 2011d). The highest total phosphorus (TP) concentrations generally occurred during the fall and winter when the concentrations of most ions increases as a result of less dilution, and during runoff events when the suspended solids concentrations increase. Total phosphorus concentrations are often used as ***trophic state indicators***. ***Eutrophication*** of a lake, or in this case a reservoir, is a natural aging process that can be unnaturally accelerated by the presence of too many nutrients. In the eutrophication process, a lake will gradually appear cloudier due to the increased growth of microscopic plants and animals. Based on the measurements from the 2011 study, the lower Snake River reservoirs would be classified as lower eutrophic (USACE 2011d).

3.6.2 Sediment Quality

Agriculture and urban land cover accounts for the majority of the total study (TetraTech 2006). Agriculture within the study area and surroundings predominantly consists of dryland crop farming, for which fungicides, pesticides, and herbicides are typically used, consistent with regulatory standards. Sediments from agricultural and urban land could potentially carry chemical constituents into the lower Snake River.

Sediment samples were collected from the proposed maintenance sites in June 2000 and April 2003 (revised version published in 2004). The results of grain size analyses conducted on these samples are described in this section. Samples collected from the main navigation channel in the Snake and Clearwater Rivers' confluence area averaged 91 percent sand and 11 percent fines in 2000. The 2003 data encompassed larger variations in composition, but the averages were similar; 94 percent sand and 6 percent fines in the recovered samples. The downstream lock approach sites at Lower Granite and Lower Monumental consist of large rock substrate and 2- to 6-inch cobbles.

The Corps contracted to have a series of analyses performed on sediment samples collected in 2000 and 2003 to determine the chemical content of sediments at proposed channel maintenance sites in the lower Snake River and in the confluence area. All detected concentrations of contaminants were below the screening levels prescribed in the *Dredged Material Evaluation Framework: Lower Columbia River Management Area* (USACE 1998). Additional information regarding the chemical content sampling results is noted in Section 3.8.

An additional study evaluating the quality of sediment at the Ice Harbor Dam lock approach and at the confluence area of the Snake and Clearwater Rivers was performed by the Corps in 2011 (USACE 2011e) and are summarized in Appendix I.

Sediment samples were collected from the Port of Clarkston, Port of Lewiston, federal navigation channel in the vicinity of the Snake and Clearwater Rivers, and the Ice Harbor navigation lock approach in August 2011. The samples were analyzed for physical and chemical characteristics consistent with the Sediment Evaluation Framework for the Pacific Northwest (SEF), and the Washington State Department of Ecology (WADOE) 2012 sediment management standards (SMS). Elutriate analyses were also completed for some of samples to evaluate the potential release of constituents from disturbed sediments. The data was compared to criteria associated with the above referenced standards and guidance. Grain size data from the sampled sites characterized the majority of the material proposed for dredging as sand with smaller amounts of silts near the mooring areas. The majority of the individual organic parameters were nondetectable. Low level dichlorprop (10 ppb) was detected in one elutriate sample from the Port of Clarkston but did not trigger any of the criteria previously mentioned. Most of the metals data met the guidelines as well. One exception was the mercury concentration in one sediment sample from the Port of Clarkston, less than the SEF and SMS criteria. Dioxin and furan toxic equivalents (TEQs) were calculated for the sediment and elutriate and were consistent with the results of previous studies in agricultural soils in Washington and less than Puget Sound background levels. Based on the results from the study, the sediments at the Port of Clarkston, Port of Lewiston, and the navigation channel in the confluence area meet the chemical and physical criteria for open and unconfined in-water placement. Additionally, sediments within the LSRP are not expected to require special management prior to handling or placement and would not be considered as industrial or hazardous waste.

3.7 Hydrology and Sediment

The origination, movement, and accumulation of sediment within the lower Snake River reservoirs are complex processes and involve a variety of natural and human-caused factors. As such, this section provides information on sediment sources and transport from areas outside the study area (but within the sediment-contributing watershed). Sediment erosion is caused by processes such as wind, rainfall, snow-melt, runoff, and channel migration. These and other related processes transport eroded sediment to streams. Naturally occurring events such as wildfires, large storms, and landslides can increase the potential for these processes to contribute higher sediment loads to watershed streams. Human disturbance of the land through activities such as development, timber harvesting, mining, agricultural activities, and construction of roads can expose or loosen soil and also increase sediment loads.

Eroded sediment in a stream or reservoir moves when the moving water that contains it reaches a certain flow velocity. The flow velocity required to move sediment is higher for large particles (boulders and gravel), and lower for fine particles (fine sand and silt). A portion of the sediment that is eroded and enters streams within the watersheds of the lower Snake River is conveyed to Lower Granite Reservoir and the reservoirs downstream. The fraction of sediment that is composed of larger particles, or the coarser-grained sediment, move very slowly through the river system and are not a major component of sediment deposition in the reservoirs. The finer-grained sediment fraction, composed of clay, silt and sand, is the more mobile portion of the sediment load that enters the reservoirs.

Finer sand and silt sediment is deposited in the upper portion of the Lower Granite Reservoir in the vicinity of the confluence of the Clearwater and Snake River and moves downstream and eventually is buried deep in the reservoir. A small portion of the sediment load that is suspended in the reservoir water column (usually clay and silt) is transported over Lower Granite Dam and into Little Goose Reservoir and downstream. A study conducted by the University of Idaho and Washington State University found that sediments deposited in the upper areas of Lower Granite Reservoir and upstream of the confluence in the Snake and Clearwater Rivers came from nonagricultural lands in the upstream watershed, while sediments downstream of Silcott Island tended to come more frequently from agricultural sources (UI/WSU 2011).

Sediment deposited in deep areas of the reservoir or transported over the dam and out of the reservoir does not influence flow conveyance or the risk of flooding in the Lewiston, Idaho area, nor does it generally accumulate in the navigation channel or affect other authorized purposes in the lower Snake River. These problems arise only when sediment is transported to the relatively shallow upper portions of the reservoirs (Lower Granite Reservoir in particular), or deposited in slow-moving waters near ports, recreational facilities (such as boat basins), or HMU irrigation water intakes. Deposition of sediment in the upper portion of the reservoirs fills up the navigation channel (restricting barge traffic) and could potentially reduce the flow conveyance capacity of the Lewiston levee system and increase the risk of flooding during extreme high flow events. As noted in Section 1, dredging has historically been used by the Corps in the past to remove sediment from this part of the river to maintain the navigation channel and flow conveyance capacity. Figure 3-4 illustrates an area of sediment accumulation causing navigation issues near the confluence of the Snake and Clearwater Rivers.

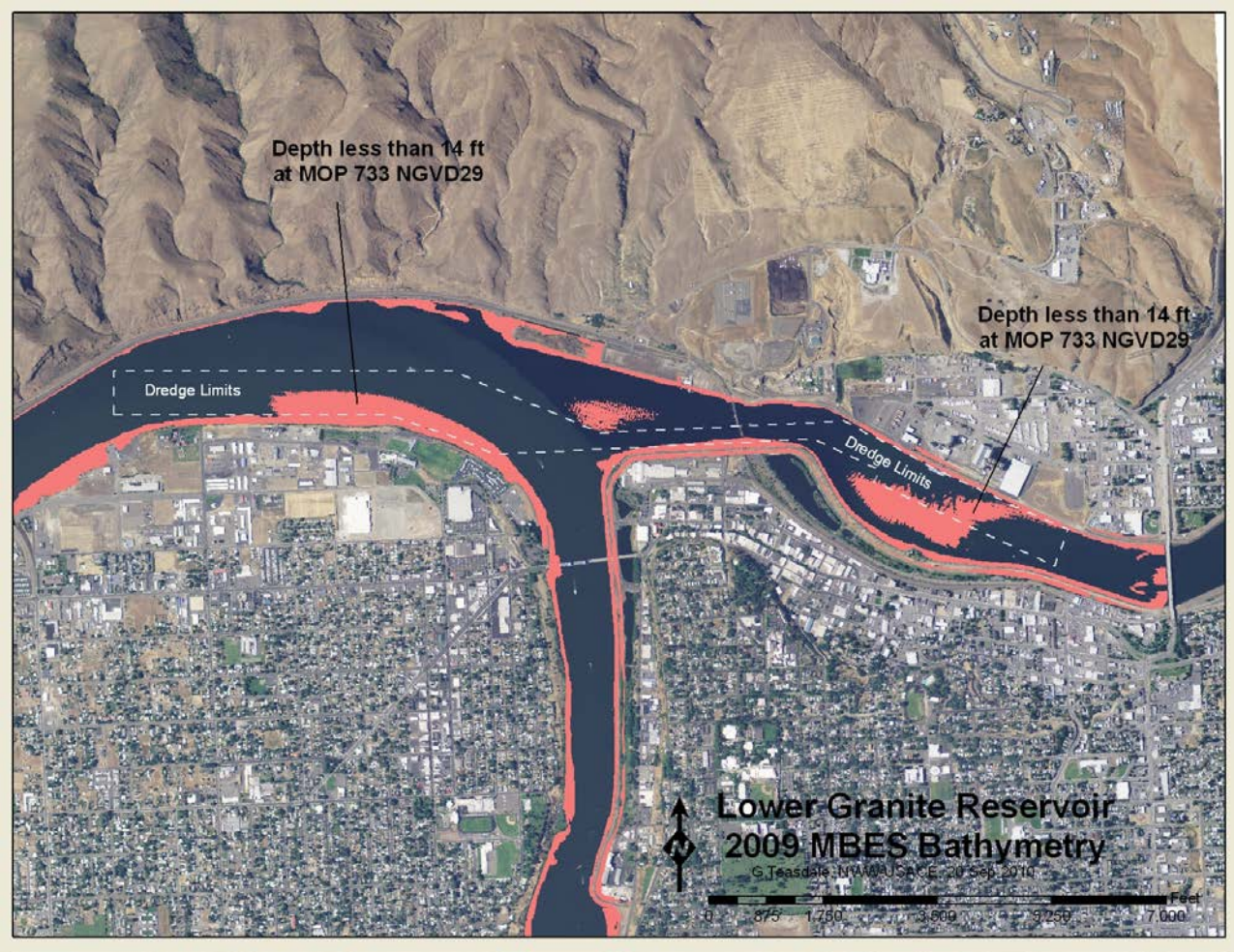

Figure 3-4. Sediment Encroachment in 2009 at the Confluence

This section evaluates the physical characteristics of watershed hydrology and of sediment transport and deposition in the LSRPLSRP. The Corps has studied extensively the processes that contribute to sedimentation in the lower Snake River, as described in Section 1.

3.7.1 Geomorphology and Sediment Transport in the Snake River Basin

The sediment-related processes leading to accumulation that affects authorized purposes are schematically shown in Figure 3-5. The following subsections provide a general description of sediment dynamics in a watershed to illustrate the types of processes that lead to sediment in the LSRP.

3.7.1.1 Sediment Generation in Upper Watershed

Sediment is produced by natural and human-influenced erosion in the watershed and transported into the tributary river channels. The tributary rivers drain mostly forested or agricultural lands. Sediment eroded from the upper watersheds is generally finer-grained (clays, silts, and sands). The fine sediment may be transported into smaller river channels and eventually down to the major tributaries. See (1) in Figure 3-5.

3.7.1.2 Sediment Transport to Snake River

The Clearwater, Salmon, and Grande Ronde Rivers have gradients steeper than that of the relatively flat lower Snake River. Because of their steeper gradients and the availability of coarse-grained sediment, the bed load of these rivers is typically gravel and cobble and is transported relatively slowly through the river systems. Most fine sediment (clay, silt, sand) that enters the tributaries of the Clearwater, Salmon, and Grande Ronde Rivers is ultimately transported into the Snake River.

The river channels themselves also erode and transport fine to coarse sediment by channel migration and by moving landslide and ***mass-wasting*** debris that makes its way into or near the channel. Most coarse sediment is derived from the actual erosive force of the river channels and their tributaries and from mass-wasting and landslides in the vicinity of the rivers. The mobile fine sediment bedload moves quickly through the river systems (days to months to years) while the coarse gravel/cobble bedload requires longer time frames to move through the system (years, decades, and centuries). See (2) in Figure 3-5.

3.7.1.3 Sediment Deposition in Upper End of Lower Granite Reservoir

Above the Clearwater/Snake River confluence the bedload is coarse gravel, and sand and silt are actively moved into the Lower Granite Reservoir in suspension. Beginning at the upper end of the Lower Granite Reservoir, sand is deposited in greater quantities into the Snake River system. Silt begins to be deposited approximately 10 miles downstream at RM 131. The amount of sediment entering the river at the confluence is approximately 2.2 million cubic yards per year (mcy/yr) (USACE 2011a). Sand and silt deposits in the upper end of the Lower Granite Reservoir can create a problem by filling up the navigation channel and reducing the capacity of the river to convey flows, thereby increasing the river stage (i.e., water surface elevation) and

flood risk. Approximately 2.0 mcy/yr of sediment has been deposited into the upper end of the Lower Granite Reservoir (USACE 2011a). Maintenance dredging has periodically occurred in Lower Granite Reservoir to remove accumulated sediments that interfere with authorized purposes of the LSRP (see Table 1-4),and (3) in Figure 3-5).

3.7.1.4 Sediment Accumulation in Deep Reservoir or Transport Downstream

Most fine-grained sediment is transported past the upper end of the reservoir and accumulates in the deeper portion of the reservoir. Some of the fine sediment is transported over Lower Granite Dam and downstream to the other reservoirs and lower reaches of the Snake River. Of the 2.2 mcy/yr of sediment entering the Snake River at the confluence of the Clearwater River, 0.2 mcy/yr is deposited in the deep water portions of the reservoir or moves downstream of the dam. See (4) in Figure 3-5.

This section describes the hydrology of the watershed, estimates the volume of sediment produced in the watershed, and describes the movement of sediment into and through the lower Snake River system. The information presented in this section is organized by geographic area, as described in the subsections below.

The Snake River extends approximately 140 river miles from the confluence of the lower Snake River with the Columbia River near Pasco, Washington, through the confluence of the Snake and Clearwater Rivers and up the Clearwater River to Lewiston, Idaho. The Snake River drainage area upstream of Lower Granite Dam is approximately 103,200 square miles (mi^2) (USACE 2011f). However, the watershed that contributes sediment to the LSRP is limited to the portion of Snake River drainage area that contributes sediment to the lower Snake River system. The size of the study area is approximately 32,500 mi^2 and includes thousands of miles of stream channels. There are five distinct subbasins within the watershed (Salmon, Clearwater, Grande Ronde, Snake River Hells Canyon Reach, and Lower Snake); characteristics of these subbasins are described in the following sections.

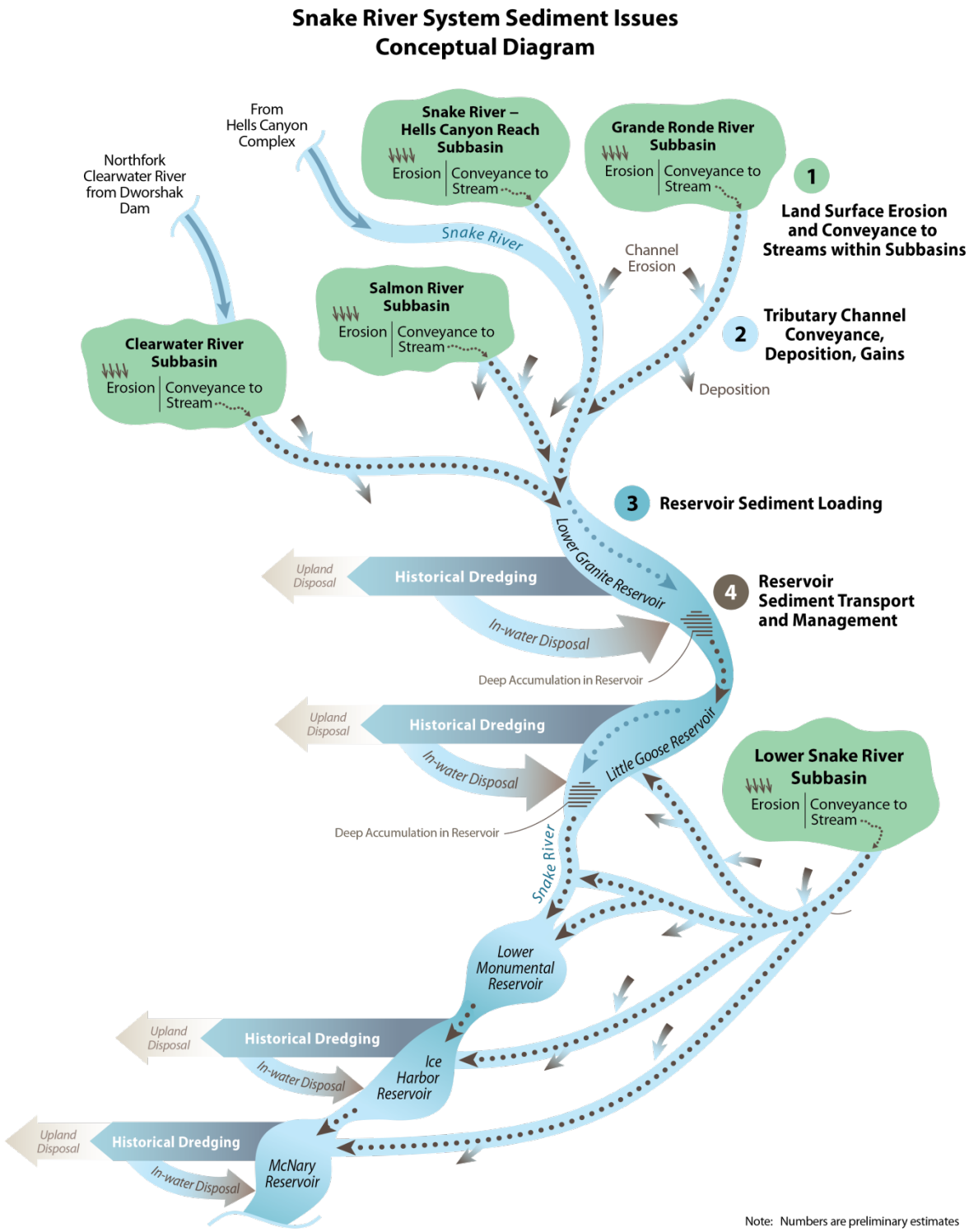

Figure 3-5. Lower Snake River System Sediment Issues – Conceptual Diagram

3.7.2 Watershed Sediment Production

Hydrologic processes drive the production of sediment, its conveyance to the reservoirs, and its transport within the reservoirs. This section presents available information on the production of sediment from each of the five subbasins that are tributary to the lower Snake River system. Table 3-15 provides a summary of the geographic areas of each of the subbasins in the watershed (Tetra Tech 2006). Figure 1-2 provides an overview of the subbasins. The hydrology and estimated sediment production associated with each subbasin are described in the subsections below.

Table 3-15. Watershed Subbasins

Subbasin	Area (mi^2)	Percent of Watershed
Salmon River Subbasin	13,994	43
Clearwater River Subbasin	6,907	21
Grande Ronde River Subbasin	4,101	13
Snake River – Hells Canyon Reach Subbasin	2,104	6
Lower Snake River Subbasin	5,471	17
Watershed Area Total	32,576	100

Source: Tetra Tech 2006

3.7.2.1 Sediment Contribution to Lower Snake System

As noted in Section 1, studies of sediment contribution from subbasins in the Lower Snake Basin have been conducted by the Corps based on monitoring and measurements of sediment contributions from major tributaries flowing into the lower Snake River. This approach uses measurements of the actual sediment load coming out of each subbasin and into the lower Snake River. From these measurements the Corps estimated that the Salmon River makes the largest annual sediment contribution to Lower Granite Reservoir (approximately 69 percent of the total sediment contribution) (USACE 2011a).

The sediment load estimates from monitoring are significantly more accurate than the sediment yield estimates based on land use and average erosion and yield and, as such, were used by the Corps as a basis of evaluating the existing environmental conditions and trends. Monitoring of sediment load was conducted on the Salmon, Grande Ronde and Clearwater Rivers, and on the Snake River below the Grande Ronde. Monitoring was also conducted in Lower Granite Reservoir, below the confluence of the Snake River and Clearwater River.

Salmon River Subbasin

The Salmon River subbasin covers nearly 14,000 mi^2 of land in Idaho and is composed of 10 major tributaries and their associated watersheds. The Salmon subbasin comprises 43 percent of the watershed area (Tetra Tech 2006). The Salmon River flows from its headwaters 410 miles north and west through central Idaho to its confluence with the Snake River in Lower Hells

Canyon. Tributaries to the Salmon River include the Lemhi, Pahsimeroi, Middle Fork Salmon, South Fork Salmon, and Little Salmon Rivers.

The western portion of the subbasin is Pacific ***maritime***-influenced with a majority of the precipitation falling as snow. In contrast, the eastern portion of the subbasin typically receives approximately 50 percent less precipitation than the western portion, due to the ***rain shadow*** effect of the Pahsimeroi Mountains (Tetra Tech 2006). Peak flows generally occur in May and June due to snowmelt.

Sediment transport is associated with streamflow – that is, higher flows generally transport more sediment. Peak streamflow events tend to produce higher flow velocities and result in movement of larger volumes of sediment downstream. The USGS measures streamflow on the Salmon River at White Bird, Idaho (USGS 2011). The mean annual discharge in 2010 was 10,330 cubic feet per second (cfs). The average monthly discharge between 1999 and 2009 ranged from 3,770 cfs in September to 31,900 cfs in May. Figure 3-6 shows annual average streamflow for the Salmon River at White Bird, Idaho.

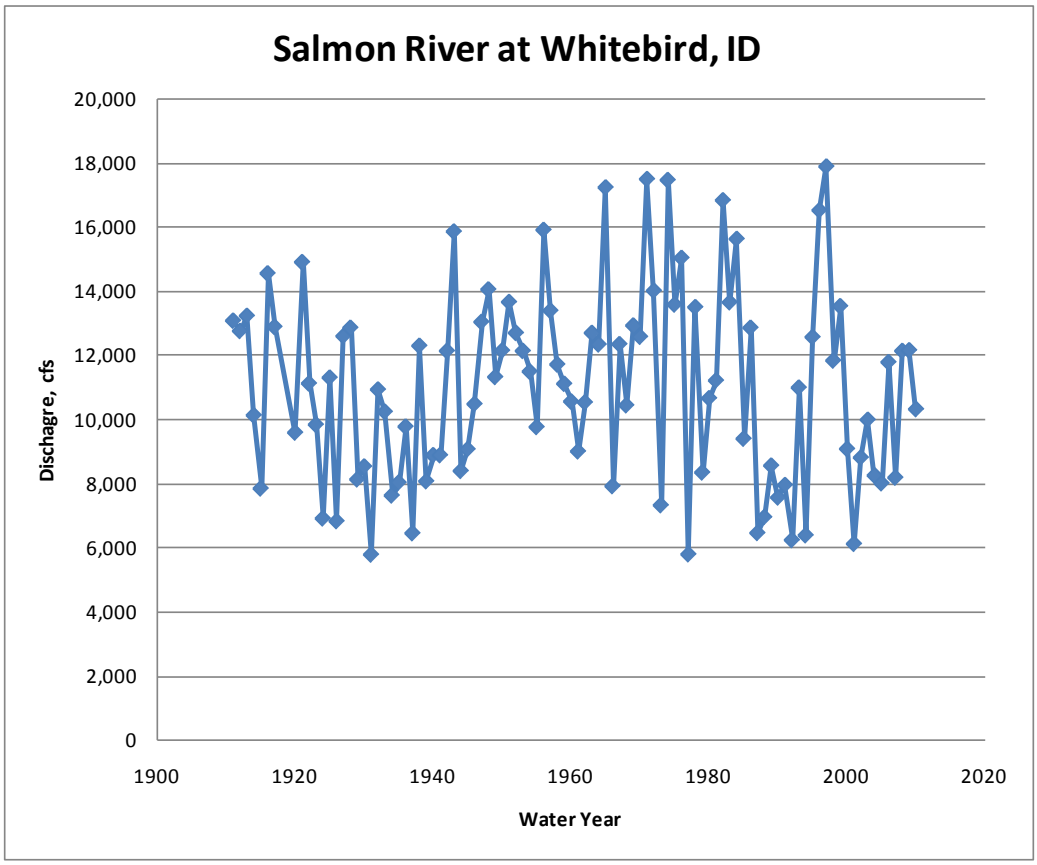

Figure 3-6. Annual Average Streamflow, Salmon River at White Bird, Idaho

Source: USGS

Landscape features and land uses found in a watershed can affect erosion and sediment delivery to waterbodies. In general, land that has been disturbed by humans for uses such as agriculture, logging, mining, road networks, or urban development has greater potential for erosion and delivery of sediment to waterbodies. Changes in land use, particularly the development or use of land for logging or agriculture, will tend to increase the amount of sediment generated. However, undisturbed land can also have high potential for sedimentation due to naturally-occurring factors such as soil type, topography, and frequency or magnitude of events that can cause erosion and sedimentation, such as landslides, forest fires, or storms. The USFS (Goode et al., 2011) predicts that future climate change, by increasing the risk of wildfire, may increase the amount of sediment produced by forested lands tributary to the Snake River system. All of these factors interact to affect the quantity of sediment produced within a subbasin; for example, land that is heavily forested may be less likely to erode than land with sparse vegetation; however, a forest fire or human-caused disturbance such as logging and roads can result in greater erosion in a forested area.

The land cover in the Salmon River subbasin is primarily forest; shrub and grasslands are also significant in the drier eastern watersheds of the subbasin. The subbasin is sparsely populated with low road densities. Agricultural and urban land cover is more prevalent in the Lower Salmon watershed, but still represents a small portion (3 percent) of the Salmon River subbasin. The large majority (approximately 90 percent) of the watershed is federally owned by the BLM and the USFS.

The Corps conducted a review of literature that evaluated the level of hydrologic and riparian disturbance found in the watershed, and compiled ratings of the relative level of disturbance found in each watershed (Tetra Tech 2006). The ratings related to the degree of disturbance found in a watershed are based on the level of human-caused disturbance (e.g., roads, mining, or agriculture) and the sensitivity of the landscape to disturbance. The overall level of land disturbance in the Salmon River subbasin is considered to be low; however, the Lemhi watershed has a high level of disturbance (Tetra Tech 2006). Highly erodible soils exist throughout the basin, particularly in the Lemhi, Pahsimeroi, and Lower Salmon watersheds. Historic activities associated with land disturbance such as timber harvesting and mining have declined in recent years, although past activities are still important sources of sediment in the subbasin (Tetra Tech 2006). Approximately 27 percent of the subbasin is federally protected and thus not subject to human-caused disturbance that could result in sediment production.

Disturbances, including forest fires and roads, are the primary source of sediment loading in the Salmon River subbasin (Goode et al. 2011). Studies conducted over several decades suggest that sediment yields within a subbasin are highly variable based on a wide variety of factors. For example, USFS studies report that estimated levels of sediment yield from forested roads and from forest fire damaged areas can range from 285 tons/mi^2 up to more than 5,000 tons/mi^2 (Elliot et al. 2010).

Like forested and range lands, estimating sediment load from agricultural areas is similarly dependant of a wide variety of factors; but more data is available on agricultural areas which allows for a planning level analysis and estimate of sediment eroded from agricultural lands. Annual erosion from agricultural areas in the Lower Salmon and Little Salmon River watersheds (approximately 3 percent of the subbasin acreage but where the majority of agricultural use in the subbasin is located) was estimated to be 0.05 million tons per year (UI/WSU 2010). This is roughly equivalent to 46,000 cy/yr.

Erosion is related to sediment deposition in streams and sediment accumulation in reservoirs; however, the relationship between these processes is complex and is influenced by a wide variety of factors. Stream systems, like the Salmon River and other tributaries, hold large quantities of sediment that are mobilized during high flow events. Further, all eroded material is not necessarily transported to a waterbody.

Analysis of measured suspended sediment loads indicates that the Salmon River contributes approximately 1.5 mcy, or approximately 69 percent, of the total sediment load entering Lower Granite Reservoir (USACE 2011a).

Snake River – Hells Canyon Reach Subbasin

The Snake River – Hells Canyon Reach subbasin includes all of the drainages upstream of the mouth of the Clearwater River and downstream of Hells Canyon Dam, exclusive of the Salmon and Grande Ronde River subbasins. This subbasin includes portions of Idaho, Oregon, and Washington and is approximately 2,100 mi^2 in size, which comprises 6 percent of the watershed. The subbasin excludes all of the Snake River Basin upstream of Hells Canyon Dam.

The climate in this region is generally temperate and dry, with most precipitation occurring during short intense summer storms and longer, milder winter storms. A large portion of the streamflow contributed by this area originates from snowpack or large rain-on-snow events that historically have resulted in major flooding on tributary streams (Tetra Tech 2006).

The USGS measures streamflow on the Snake River near Anatone, Washington, which includes streamflow coming from the Hells Canyon Dam and the Upper Snake River. (USGS 2011). The mean annual discharge in 2010 was 29,130 cfs. The average monthly discharge between 1999 and 2009 ranged from 15,300 cfs in November to 62,300 cfs in May. Figure 3-7 shows annual peak streamflow for the Snake River near Anatone, Washington.

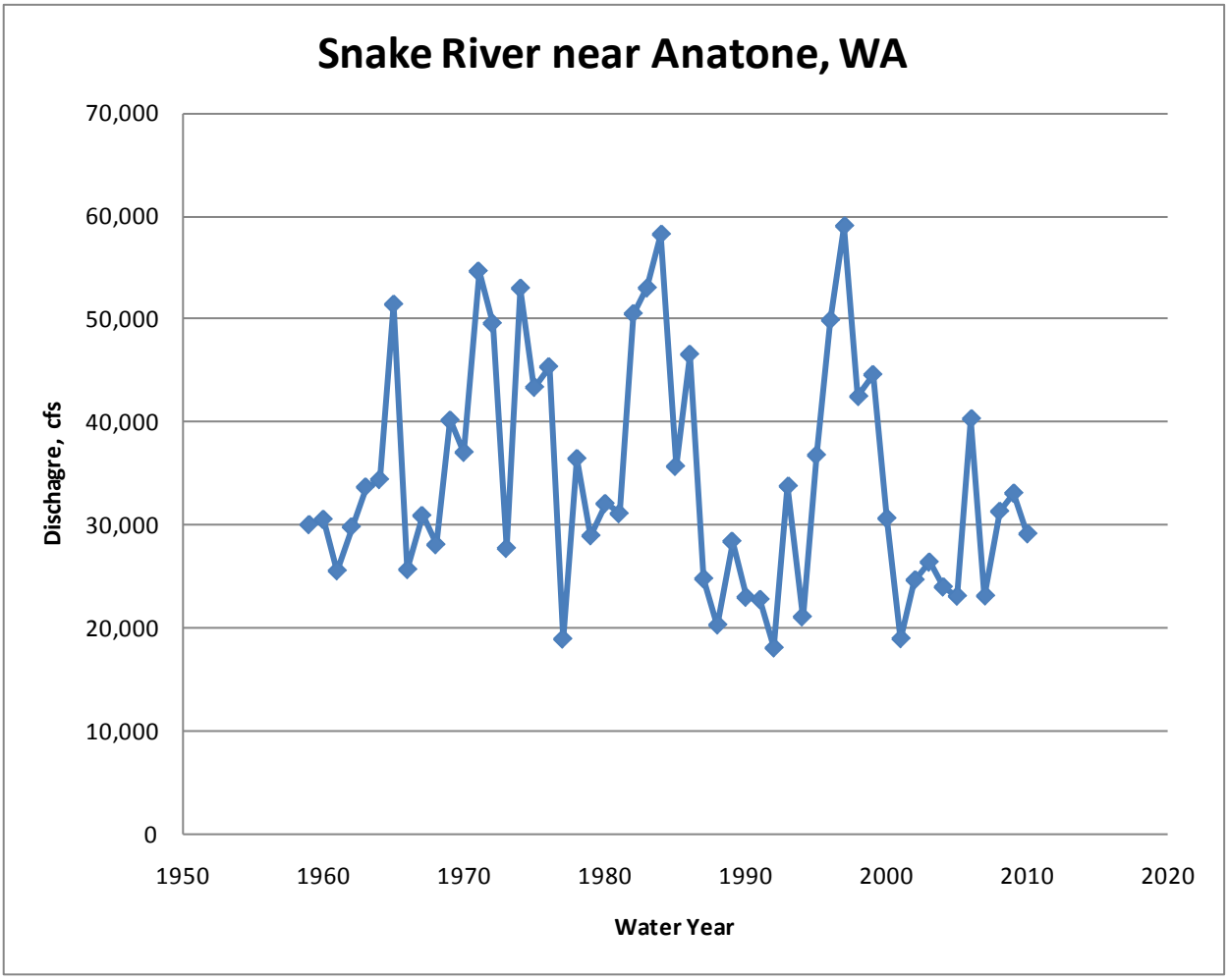

Figure 3-7. Annual Average and Annual Peak Streamflow, Snake River near Anatone, Washington
Source: USGS 2011

Land cover in the subbasin is comprised mostly of prairie and canyon grasslands and shrub-steppe vegetation. These types of land covers are generally in lower elevations and are mainly used for agriculture. As elevation increases, forests become more prominent. Similar to the other subbasins described above, the majority of this subbasin is federally owned. The majority of privately owned land is located within the Lower Snake-Asotin watershed. Similarly, road densities are low throughout the watershed with the exception of the Lower Snake-Asotin watershed, where agricultural/urban uses are more prevalent.

The level of land disturbance in the Snake River – Hells Canyon Reach subbasin is considered low to moderate, except in the Lower Snake-Asotin watershed, where disturbance levels range from moderate to high (Tetra Tech 2006). Erosion hazards are high throughout the subbasin (UI/WSU 2010).

The UI/WSU study reported average annual erosion from agricultural areas in the Hells Canyon and Asotin watersheds (approximately 22 percent of the subbasin acreage) is estimated to be 0.1 million tons per year (UI/WSU 2010). This is roughly equivalent to 93,000 cy/yr.

The Snake River – Hells Canyon Reach subbasin carries sediment contributions from both the Salmon River and Grande Ronde River subbasins to Lower Granite Reservoir. Studies conducted by the Corps suggest that these subbasins contribute the bulk of sediment delivered to Lower Granite Reservoir; little additional sediment is delivered directly from the Hells Canyon Reach (USACE 2011a).

Grande Ronde River Subbasin

The Grande Ronde River subbasin drains approximately 4,100 mi^2, which comprises 13 percent of the watershed, and spans regions in northeastern Oregon and southeastern Washington. Major tributaries include the Upper Grande Ronde, Wallowa, and Lower Grande Ronde Rivers.

The climate of the Grande Ronde River Basin is variable as a result of the high relief of the Blue and Wallowa Mountains; winters are generally cold and moist, while summers are warm and dry (Tetra Tech 2006). The Grande Ronde River and its tributaries are snowmelt runoff streams. Peak runoff occurs from April through June.

The USGS measures streamflow on the Grande Ronde River at Troy, Oregon (USGS 2011). The mean annual discharge in 2010 was 2,400 cfs. The average monthly discharge between 1999 and 2009 ranged from 622 cfs in September to 7,110 cfs in May. Figure 3-8 shows annual peak streamflow for the Grande Ronde River at Troy, Oregon.

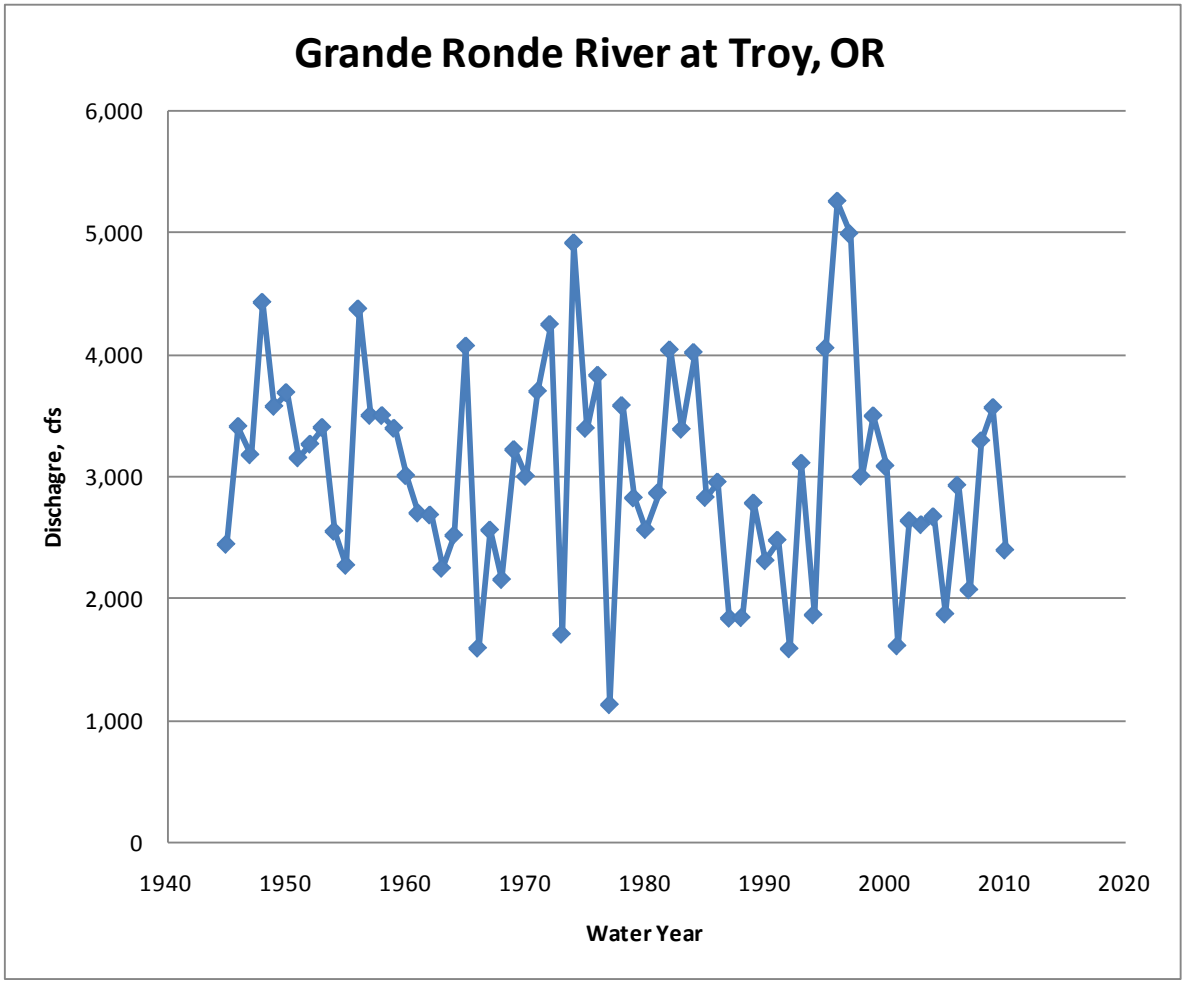

Figure 3-8. Annual Average and Annual Peak Streamflow, Grande Ronde River at Troy, Oregon
Source: USGS 2011

Land cover is predominantly forest in the higher elevations of the subbasin; in the lower elevations, grasslands are prevalent. Seventeen percent of the Grande Ronde River subbasin is covered by agricultural and urban land uses. Land ownership is roughly split between federal and private ownership.

In contrast to the subbasins described above, the level of land disturbance in the Grande Ronde River subbasin is considered high (Tetra Tech 2006). Road densities are moderate to high throughout the subbasin. Historical activities, including road construction, agriculture, timber harvest, and grazing have contributed to this condition (Tetra Tech 2006). High erosion hazards have been identified in all watersheds within the subbasin (UI/WSU 2010).

The UI/WSU study reported that average annual erosion from agricultural areas in the Upper Grande Ronde, Wallowa, and Lower Grande Ronde River watersheds (approximately 17 percent of the subbasin acreage) is estimated to be 0.08 million tons per year (UI/WSU 2010). This is roughly equivalent to 74,000 cy/yr.

The Corps studies of sediment contribution suggest that the Grande Ronde subbasin contributes approximately 9 percent of the total sediment contribution of the Snake River to Lower Granite Reservoir (USACE 2011a). This is roughly equivalent to 200,000 cy/yr.

Clearwater River Subbasin

The Clearwater River subbasin is primarily located in Idaho and is bordered by the Salmon River subbasin to the south. Within the watershed, the Clearwater River drains approximately 6,900 mi^2, or 21 percent of the watershed. Major tributaries within the subbasin include the South Fork of the Clearwater River and the Lochsa and Selway Rivers. As discussed previously, the North Fork of the Clearwater River is not included in the watershed because sediment from this portion of the subbasin is blocked by Dworshak Dam. The mainstem of the Clearwater River accounts for approximately a third of the flow contributed to the Snake River by the watershed.

The Clearwater River subbasin is maritime-influenced, similar to the western portion of the Salmon River subbasin (Tetra Tech 2006), with the majority of precipitation occurring as snow. Peak flows generally occur in May and June due to snowmelt.

The USGS measures streamflow on the Clearwater River at Spalding, Idaho (USGS 2011). The mean annual discharge in 2010 was 10,830 cfs. The average monthly discharge between 1999 and 2009 ranged from 3,540 cfs in October to 35,700 cfs in May. Figure 3-9 shows annual peak streamflow for the Clearwater River at Spalding, Idaho.

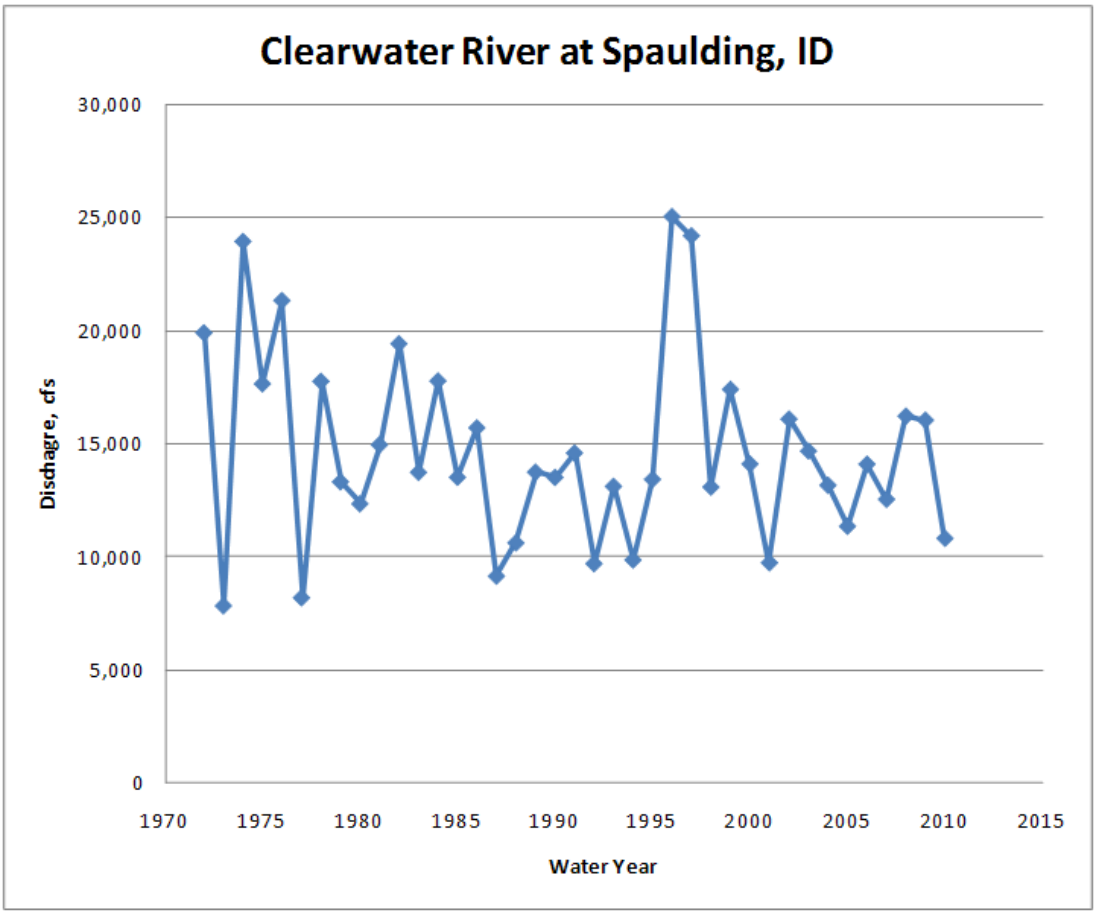

Figure 3-9. Annual Average Streamflow, Clearwater River at Spalding, Idaho

Similar to the Salmon River Basin, the land cover in the Clearwater River subbasin is primarily federally-owned forest, although privately-owned, agricultural/urban land cover is significant, and is more prevalent than in the Salmon River subbasin. See discussions of land use and socioeconomics elsewhere in this section for additional detail.

Approximately 45 percent of the subbasin is designated wilderness forest, protected from activities or disturbance that would result in human-caused erosion or sediment production. Aside from the protected lands, agriculture and grazing are common of the land uses in the western part of the subbasin. Mining historically occurred throughout the entire watershed, but has decreased dramatically in recent years. The level of land disturbance is considered low in the eastern portion of the watershed due to its protected status. In contrast, land disturbance in the western portion of the watershed ranges from moderate to high (Tetra Tech 2006). Highly erodible lands occur in the South Fork and Clearwater River watersheds; agricultural areas in the Potlatch River watershed are also at high risk for erosion (UI/WSU 2010).

Wildfires are a key source of sediment in the Clearwater River Basin (Elliot et al. 2010). The potential for reducing sediment deposition associated with wildfires is limited in the wilderness areas where forest land is protected and active management of the land, including fire

management, is limited. The forest road network is the second greatest source of sediment in the subbasin (Elliot et al. 2010).

The UI/WSU study reported that average annual erosion from agricultural areas in the South Fork, Middle Fork, and Clearwater River watersheds (approximately 24 percent of the subbasin acreage) is estimated to be 1.8 million tons per year (UI/WSU 2010). This is roughly equivalent to 1.7 mcy/yr.

As described above, only a small portion of this eroded material makes its way through the drainage system to accumulate within the rivers and reservoirs as sediment.

The Corps' analysis of sediment measurement indicates that the sediment contribution from the Clearwater River at Spalding comprises 22 percent of the total contribution to Lower Granite Reservoir (USACE 2011a). Converting this value to a volumetric estimate indicates that the load of sediment contributed to the reservoir by the Clearwater River subbasin is approximately 0.5 mcy/yr.

Lower Snake River Subbasin

The lower Snake River subbasin, from the mouth of the Clearwater River to the Snake River's confluence with the Columbia River, is located in the southeast corner of Washington and also includes areas in western Idaho. The subbasin is comprised of approximately 5,471 mi^2, or 17 percent of the watershed.

The climate in the Lower Snake subbasin is semi-arid; the western portion of the subbasin receives as little as 5 inches of mean annual precipitation, while the eastern part receives as much as 50 inches in the Palouse Mountains (Tetra Tech 2006).

Streamflow in the Lower Snake subbasin is regulated by the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams. The average annual discharge measured near Clarkston, Washington, just downstream of the confluence of the Snake and Clearwater Rivers, is 50,300 cfs (USACE 2011f). This essentially comprises the flow entering Lower Granite Reservoir.

The Palouse and Tucannon Rivers flow into the Snake River between Little Goose Dam and Lower Monumental Dam. The USGS measures streamflow on the Palouse River at Hooper, Washington (USGS 2011). The mean annual discharge in 2010 was 264 cfs. The average monthly discharge between 1999 and 2009 ranged from 31 cfs in August to 1,700 cfs in March. The mean annual discharge of the Tucannon River in 2010, measured near Starbuck, Washington, was 141 cfs (USGS 2011). The mean monthly discharge between 1999 and 2009 ranged from 59 cfs in August to 312 cfs in May.

While the discharges from the Palouse and Tucannon Rivers are small compared to the flow of the Snake River, the drainage areas of these watersheds are relatively large. The Palouse River watershed includes approximately 3,300 mi^2 and comprises 60 percent of the Lower Snake

subbasin drainage area. The Tucannon River watershed includes approximately 1,400 mi^2, or 27 percent of the total subbasin drainage area (Tetra Tech 2006). Together the Palouse and Tucannon River watersheds comprise 87 percent of the Lower Snake subbasin drainage area. Therefore, the majority of the Lower Snake subbasin drains into the Snake River, downstream of Little Goose Reservoir and upstream of Lower Monumental Reservoir.

Land cover in the subbasin is notably different than in the other watershed subbasins in that it is primarily agricultural and privately owned. Dryland agriculture and grazing are prevalent; urban areas include Clarkston and Pullman, Washington, and Lewiston and Moscow, Idaho. The dryland agricultural practices and geology of the area (loess deposits) are the primary source of sediment from this subbasin (UI/WSU 2010). Agricultural soils tend to be fine-grained and, as such, agricultural areas contribute mostly silts and clays to the lower Snake River (UI/WSU 2010); these fine materials typically remain in suspension through the reservoirs.

The level of land disturbance in the lower Snake River subbasin is considered high (Tetra Tech 2006). The land cover throughout the subbasin has been highly altered by conversion of grasslands primarily to agricultural use. Surface soil erosion hazard is high in all watersheds within the subbasin (UI/WSU 2010).

The Palouse River watershed is historically known as an area prone to high rates of erosion and sediment contribution to the Lower Snake system. The prevalence of loess soils, rolling hills, and high winds all contribute to highly erodible land in the Palouse region; disturbance of the soil for agricultural uses can exacerbate these issues. A study conducted by the Soil Conservation Service (now known as the Natural Resources Conservation Service, or NRCS) in the 1970s estimated erosion in Palouse River Basin to be approximately 19 million tons per year (SCS 1979); this is roughly equivalent to 18 mcy/yr. Sediment yield was estimated to be approximately 5.4 million tons per year; this is roughly equivalent to 5.0 mcy/yr (SCS 1979). In recent years, agricultural best management practices have been implemented in the Palouse River watershed and other agricultural areas throughout the Snake River basin, which have reduced sediment load to the Snake River system. The UI/WSU study reported average annual erosion from agricultural areas in the lower Snake River subbasin (approximately 79 percent of the total subbasin acreage) to be 4.12 million tons per year (UI/WSU 2010). This is roughly equivalent to 3.8 mcy/yr.

Due to the prevalence of agricultural land uses in the Palouse and Tucannon watersheds, agricultural lands represent the primary contributor of sediment within this subbasin. The total estimated yield from the forest and agricultural lands in the lower Snake River subbasin is approximately 187,000 cy/yr. This load contributes sediment to the Little Goose, Lower Monumental, and Ice Harbor Reservoirs, with the majority accruing to Lower Monumental due to its location at the confluence of the Palouse and Tucannon Rivers. Sediments entering from the Palouse and Tucannon Rivers are estimated to be predominantly of agricultural origin and therefore likely composed of finer (clay and silt) particle sizes. These are less likely to settle out in areas where they would interfere with authorized purposes of the lower Snake River. Further,

the location and quantities of sediments entering the lower Snake River below Lower Granite Dam are minor in comparison to the quantities entering Lower Granite Reservoir.

3.7.3 Lower Snake River System and Sediment Transport

This section provides an overview of the lower Snake River system and sediment transport and accumulation in the lower Snake River system. A portion of the accumulated sediment interferes with flow conveyance, navigation, HMU irrigation intakes, and recreation facilities.

Lower Granite Reservoir, also known as Lower Granite Lake, was created by the construction of Lower Granite Dam. The Salmon River, Clearwater River, Grande Ronde River, and Snake River – Hells Canyon Reach subbasins all drain into and contribute sediment to this reservoir. The Lower Granite Dam is located approximately 13 miles from Pullman, Washington, near Mayview, Washington. The towns of Lewiston, Idaho and Clarkston, Washington are located along the eastern (and upstream) end of the reservoir. The reservoir extends 39.3 miles east behind the dam, to Lewiston, Idaho (USACE 2010c). A 14-foot-deep, 250-foot-wide navigation channel is authorized through the length of Lower Granite Reservoir (and each of the other lower Snake River reservoirs).

The Lower Granite Lock and Dam Project is located on the Snake River near RM 107 (see Figure 3-10). The dam and reservoir provide hydroelectric power, a controlled channel for navigation, 13 developed recreation areas, a navigation lock, wildlife habitat areas, fish passage facilities, water for six municipal and industrial pump stations, and three port facilities on Lower Granite Lake (USACE 2010c). The reservoir has a capacity of 440,000 acre-feet and a surface area of 8,900 acres. The normal operating pool elevation for the Lower Granite Reservoir ranges from 733-738 feet above mean sea level (msl).

When the Lower Granite Dam was constructed, a backwater levee system was created to protect the business district of Lewiston (USACE 2002b). There are approximately 7.6 miles of levees that protect the city of Lewiston from reservoir backwaters. The levees are designed to have a minimum freeboard of 5 feet during the SPF event of 420,000 cfs on the Snake River below the confluence of the Clearwater River (USACE 2002b; USACE 2011f). The goal of the levee system is to allow the Lower Granite Reservoir to pass the SPF event while protecting Lewiston from inundation. However, sediment deposition has reduced the channel capacity. This reduction in capacity has caused the rise of water surface elevations, increasing the risk of flooding (USACE 2011a).

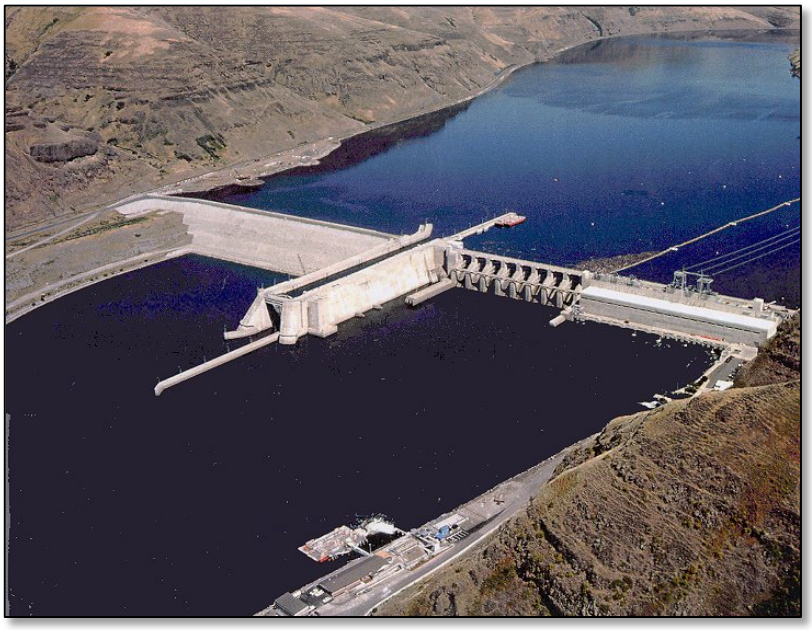

Figure 3-10. Lower Granite Dam

Source: USACE 2002b

The Corps has studied sediment inflow and accumulation by surveying sediment accumulation at a series of river sections along the Snake and Clearwater Rivers and within Lower Granite Reservoir (see Section 1 for a summary of the Corps' studies). These cross sections of the river bed channel show how the channel would look if sliced perpendicular to flow, and show where sediment has accumulated or has been eroded at a particular section. The sediment cross sections have been measured every 2 to 3 years since the creation of the Lower Granite Reservoir (USACE 2011a). The Corps has not conducted detailed sediment cross section surveys outside of Lower Granite Reservoir because the magnitude of sediment accumulation that affects authorized purposes is notably less in other reservoirs. Figure 3-11 and Figure 3-12 present examples of the cross sections analyzed in the Corps studies, and show the accumulated sediment between 1974 and 2009 as the difference between the two lines in each figure. Figure 3-11 is from RM 137.69, just below the Port of Clarkston, and shows little accumulation of sediment. Figure 3-12 is from RM 123.3 below Silcott Island, and shows significantly more accumulation of fine sediment in the deep water portion of the reservoir.

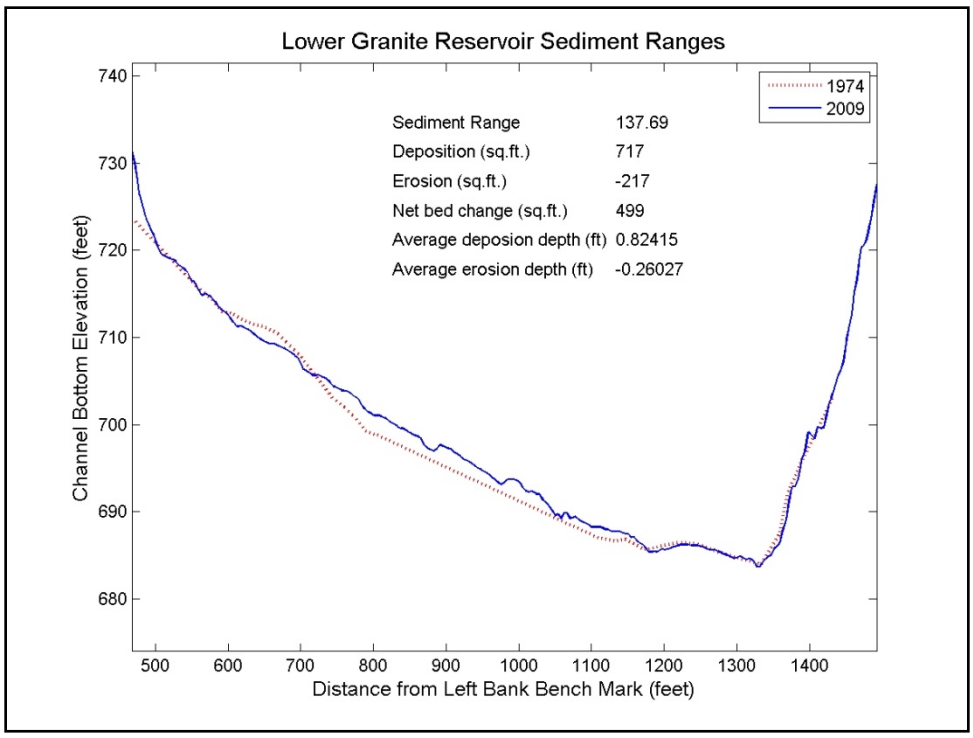

Figure 3-11. Comparison of 1974 and 2009 Sediment Ranges at Snake River Mile 137.69

Source: USACE 2011a, Figure 6, Comparison of 1974 and 2009 sediment ranges at Snake River mile 137.69.

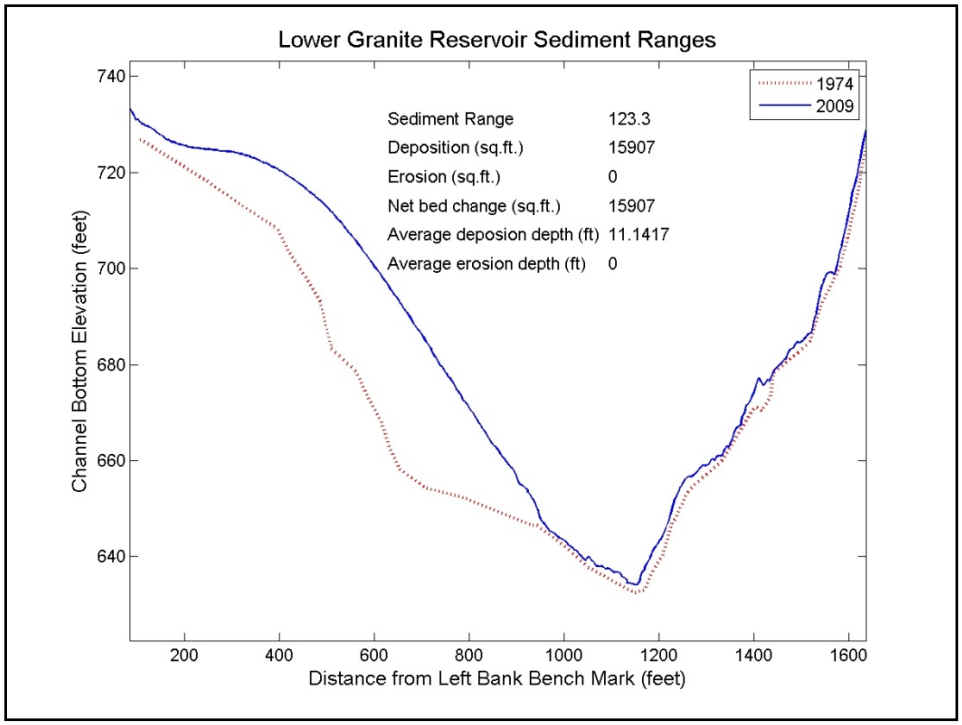

Figure 3-12. Comparison of 1974 and 2009 Sediment Ranges at Snake River Mile 123.30

Source: USACE 2011a, Figure 8, Comparison of 1974 and 2009 sediment ranges at Snake River mile 123.30.

The total estimated gross sediment accumulation in Lower Granite Reservoir from 1974 (when the dam construction was completed) to 2010 is 79.8 mcy (USACE 2011a). The average annual inflow of sediment to the reservoir is estimated to be 2.2 m cy/yr. The actual annual sediment loads vary significantly by year and between sediment range surveys (USACE 2011a).
Table 3-16 shows the estimated sediment accumulation in the Lower Granite Reservoir from the Snake and Clearwater Rivers, the accumulation above and below Silcott Island, and the total and average annual volume of sediment (USACE 2011a). Table 3-16 shows that most of the sediment is deposited deep into the reservoir below Silcott Island. Table 3-17 presents the relative contributions of sediment and sand from the tributaries to the Clearwater and Snake Rivers during water year 2009-2010. Sand is the largest component of sediment accumulating in the confluence area. Larger loads of sediment (particularly of sand) on the Snake River upstream of the confluence with the Clearwater River indicate that the load of sediment being contributed by the Salmon River may be increasing (USACE 2011a). The USFS (Goode et al., 2011) estimates that sediment loads into the Lower Snake system are likely to increase if the amount of wildfire activity increases in the future due predicted climate change.

Table 3-16. Sediment Accumulation in Lower Granite Reservoir, 1974 – 2010

	Sediment Volume (mcy)				
	Snake River Above Confluence with Clearwater River	Clearwater River Above Confluence with Snake River	Snake River Below Silcott	Dredged Sediment Volume	Period Total Volume
Total Volume (mcy)	1.30	1.03	74.74	2.76	79.83
Percent of Total	1.6%	1.3%	93.6%	3.5%	100.0%
Average Volume (mcy/yr)	0.04	0.03	2.08	0.08	2.22

Source: USACE 2011a, Table 7, Summary of Sediment Accumulation in Lower Granite Reservoir

Table 3-17. Relative Contributions of Subbasins to Sediment and Sand Load at Lower Granite Reservoir, 2009 – 2010

Tributary	Percent of Total Load at Lower Granite Reservoir	
	Percent of Total Suspended Sediment Load	Percent of Total Suspended Sand Load
Salmon River at Whitebird	69.9	75.3
Grande Ronde River at Mouth	8.7	3.3
Clearwater River at Spalding	21.4	21.4

Source: USACE 2011a, Table 27, Relative Contributions of Tributaries to Total Load at Lower Granite Reservoir

The sediment cross section surveys were also used to analyze the changing distribution of sediment in the Lower Granite Reservoir. This analysis shows that sediment has accumulated below Silcott Island at approximately RM 130, and that the upper reach of the Lower Granite Reservoir between Silcott Island and the confluence is gaining sediment at a reduced rate. The Corps studies indicate that the majority of the sediment load to Lower Granite Reservoir has

accumulated below Silcott Island, while the rate of accumulation above Silcott Island has diminished, and some areas above Silcott Island have lost sediment (USACE 2011a). These observations indicate that the confluence area of the reservoir is at or approaching equilibrium in terms of sediment accumulation (USACE 2011a). This means that sediment accumulating near the confluence of the Snake and Clearwater Rivers is generally being scoured out and transported downstream during high flow conditions, such that over time there is little change in the flow conveyance capacity of the Lewiston levee system.

Sediment core samples were examined to evaluate the composition of sediment found in Lower Granite Reservoir (USACE 2011a). The size and type of grains that make up sediment affect the way that sediment moves into and through the reservoir. The study found that core samples taken above Silcott Island were composed mostly of medium-grain sand, while core samples taken below Silcott Island were composed of finer-grained sand and silt (USACE 2011a). Above the confluence, the Snake River and the Clearwater River have gravel and cobble beds because flow velocities transport the finer sand and silt downstream into the backwater of the reservoir. In the confluence area, the bed material is almost entirely medium to coarse sand. These results are important indicators of what type of sediment would need to be controlled in order to potentially affect deposition in upstream versus downstream sediment problem areas. To reduce accumulation in the confluence area, it would be necessary to control the load of sand entering the reservoir. Reducing accumulation in the Silcott Island area would require controlling the load of silt and fine sand.

The Corps has also conducted detailed reservoir sediment transport modeling and flood hydrology and hydraulics studies (USACE 2011a). The primary purpose for these studies was to understand the level of existing and future risk of overtopping associated with the levees in the vicinity of the Clearwater River confluence area, and to what extent sediment management measures might alter the deposition and accumulation of sediment that creates issues that impede the Corps' ability to fulfill its mission and the PSMP EIS' purpose and need. Sediment deposition in this area has the potential to raise the maximum water surface level during extreme flood events such that it would result in the levees associated with the Lower Granite Dam being overtopped. The sediment transport modeling and flood hydraulics and hydrology studies indicate the following (USACE 2011a):

- The SPF [3] on the lower Snake River system has a peak flow of 420,000 cfs. The SPF is one measure of the adequacy of the levee system to provide sufficient flood protection, although Corps studies consider a range of probabilistic factors to estimate flood risk, in accordance with Corps policy[4].

[3] The SPF on the Lower Snake River System has a probability of occurrence of less than 0.1 percent in any given year.

[4] Corps ER 1105-2-101 requires that uncertainties in the key parts of the analysis must be quantified and combined to estimate the overall project performance and potential for loss-of-life or economic or environmental consequences. Elements included in the risk analysis are described in USACE 2011a.

- Model simulation of 50 years (i.e., through 2060) of accumulation and transport of sediment in the Lower Granite Reservoir estimates that the Lower Granite Reservoir bed level would vary from less than 1 foot to over 15 feet, with an average gain of between 6.0 and 7.3 feet. Total reservoir sediment accumulation over the 50 year period would be 83.9 mcy.
- Model simulation of 50 years of accumulation and transport of sediment in the Clearwater River above the confluence indicates that the increase in the bed level varies from 5 to 9 feet in the segment up to the Canadian Pacific Railroad bridge. Total predicted accumulated sediment volume in the 2 miles of the Clearwater River above the confluence is 1.9 mcy over 50 years.
- Model simulation of 50 years of accumulation and transport of sediment in the Snake River above the confluence indicates that the increase in the bed level could be between 1 foot and 5 feet in the segment between the confluence and Interstate Bridge. Total predicted accumulated sediment volume in the Snake River reach above the confluence is 2.9 mcy over 50 years.
- Based on the requirements of ER 1105-2-101, the existing levee systems appear adequate to provide protection from overtopping during the SPF and exceed the requirements for levee systems under the National Flood Insurance Program. After 50 years of simulated sediment accumulation, the model predicts that the levee systems would be adequate to provide protection from overtopping during the SPF.

The Corps' simulations of sediment accumulation used historically-based estimates of future sediment loading to Lower Granite Reservoir. Recognizing that future sediment loads may be greater or less than historic loading due to the effects of climate change, watershed erosion control measures, or other factors, a sensitivity analysis was conducted on the 50-year sediment transport modeling studies to estimate the Lower Granite Reservoir sediment accumulation associated with sediment loads of 125 percent and 75 percent of the historically predicted load. These simulations showed that the greater or lesser loads into the reservoir would produce proportionally greater or lesser accumulation volumes. However, in some locations, a greater load does not produce greater accumulation. Under these scenarios, the channel between RM 130 and 132 and in the vicinity of RM 136 would be stable and would not increase any more if a sediment load greater than 75 percent of the historically predicted load is assumed. In other areas of the reservoir, bed levels would increase or decrease (respectively) by between approximately 1 and 2 feet when sediment load is increased or decreased by 25 percent.

The historic accumulation of sediment in the Lower Granite Reservoir has affected authorized purposes of the lower Snake River, including navigation, fish and wildlife conservation, recreation, and flow conveyance at the confluence of the Snake and Clearwater Rivers. Historically, the Corps has used periodic dredging to manage sediment as part of operating and maintaining the reservoir. The Corps has dredged a portion of the accumulated sediment from specific problem areas and disposed of the material, either upland of the reservoir, or "in-water" within the reservoir in an area where additional sediment will not cause problems and require further dredging (see Table 3-18). Since the 1990s, the dredged sediment has been used for creating habitat for native fish species. Table 3-18 lists the past dredging activities conducted in the Lower Granite Reservoir. Dredging of sediment that interferes with authorized purposes has been conducted approximately every 3 to 5 years since the Lower Granite Dam was put into service. The primary reasons for this dredging are: 1) to maintain the required depth in the river

channel to allow for navigation; and 2) to maintain flow conveyance capacity to reduce the risk of flooding near the confluence of the Snake and Clearwater Rivers.

While dredging has addressed the problems associated with sediment deposits, it does not prevent more sediment from accumulating in the same or other problem areas. The Corps has identified several areas in the Lower Granite Reservoir where sediment accumulation has or, in the future, could potentially interfere with authorized purposes of the lower Snake River.

Table 3-19 lists the problem areas identified by the Corps for the Lower Granite Reservoir and adjacent areas, including the confluence of the Snake and Clearwater Rivers.

Table 3-18. Historic Dredging Activities in the Lower Granite Reservoir

Dredging Location	Year	Purpose	Amount Dredged Cubic Yards	Dredged Material Placement
Port of Clarkston – Lower Granite Reservoir	1982	Navigation	5,000	Upland site
Port of Lewiston – Lower Granite Reservoir	1982	Navigation/ maintain flow conveyance capacity	256,175	Upland sites
Confluence of Clearwater and Snake Rivers	1985	Maintain flow conveyance capacity	771,002	Wilma HMU
Port of Lewiston – Lower Granite Reservoir	1986	Navigation/ maintain flow conveyance capacity	378,000	Upland sites
Confluence of Clearwater and Snake Rivers	1988	Maintain flow conveyance capacity	915,970	In-water
Confluence of Clearwater and Snake Rivers	1989	Maintain flow conveyance capacity	993,445	In-water
Confluence of Clearwater and Snake Rivers	1992	Maintain flow conveyance capacity	520,695	In-water
Ports of Lewiston, Almota, and Walla Walla	1991/92	Navigation	90,741	Upland and In-water
Confluence of Clearwater and Snake Rivers	1996/97	Navigation	68,701	In-water
Port of Clarkston – Lower Granite Reservoir	1997/98	Navigation	12,154	In-water
Port of Lewiston – Lower Granite Reservoir	1997/98	Navigation	3,687	In-water
Greenbelt Boat Basin Clarkston – Lower Granite Reservoir	1997/98	Navigation	5,601	In-water
Confluence of Clearwater and Snake Rivers	1997/98	Navigation	215,205	In-water
Confluence of Clearwater and Snake Rivers	2005/2006	Navigation	420,000	In-water
Port of Clarkston – Lower Granite Reservoir	2005/2006	Navigation	11,000	In-water
Port of Lewiston – Lower Granite Reservoir	2005/2006	Navigation	5,000	In-water

Table 3-19. Corps Identified Potential Sediment Problem Areas in the Lower Granite Reservoir and Adjacent Areas

Reservoir	River	Approximate River Mile[1]	Site Name	Use
Lower Granite	Clearwater	1.0-2.0	Port of Lewiston	Navigation
		3.0	Clearwater Boat Ramp	Recreation
	Snake/ Clearwater	131.5-139.5/0.0-2.0	Snake River at Mouth of Clearwater River	Navigation, conveyance
	Snake	128-130	Silcott Island	Navigation
		137.0	Hells Canyon Resort	Recreation
		139.0	Port of Clarkston	Navigation
		139.5	Greenbelt Boat Basin	Recreation
		140.5	Southway Boat Ramp	Recreation
		141.5	Swallows Park Boat Basin and Swim Beach	Recreation
		142.5	Hells Gate State Park	Recreation
		146.0	Chief Looking Glass Park	Recreation

[1] River mile indicates the number of miles upstream of the mouth of the Snake River

3.7.3.1 Little Goose Reservoir

Little Goose Reservoir, also known as Lake Bryan, was created by the construction of the Little Goose Dam in 1970 (USACE 2002b). The tributaries to Little Goose Reservoir are Deadman Creek, Almota Creek, Penawawa Creek, New York Gulch, and Dry Gulch. The Little Goose Lock and Dam are located approximately 9 miles northeast of Starbuck, Washington. The reservoir extends approximately 37 miles from the Little Goose Dam east to the Lower Granite Dam (USACE 2002a).

Figure 3-13. Little Goose Dam
Source: USACE 2002a

The Little Goose Lock and Dam project is located near RM 70 on the Snake River (see Figure 3-13). The project was completed and began operating in 1970. The project provides

hydroelectric power generation, navigation lock, and fish passage facilities; in addition, recreation areas and wildlife habitat areas are located on the reservoir behind Lower Goose Dam. The reservoir has a capacity of 516,000 acre-feet and a surface area of 10,025 acres. The normal operating pool elevation for the Little Goose Reservoir ranges from 633-638 msl (USACE 2002a; 2002b; 2010c).

The only dredging that has occurred in Little Goose Reservoir was located in the area of Schultz Bar and the downstream lock approach at Lower Granite Dam. Other problem areas have been identified where dredging or other measures might be necessary in the future. Table 3-20 lists the past dredging activities conducted in Little Goose Reservoir. Table 3-21 lists the potential problem areas identified by the Corps for Little Goose Reservoir.

Table 3-20. Historic Dredging Activities in Little Goose Reservoir

Dredging Location	Year	Purpose	Amount Dredged Cubic Yards (m^3)	Dredged Material Placement
Schultz Bar – Little Goose Reservoir	1991	Navigation	27,335 (20,899.1)	Upland
Schultz Bar – Little Goose Reservoir	1995	Navigation	14,100 (10,780.2)	In-water
Lower Granite – Downstream Navigation Lock Approach	1997/98	Navigation	2,805 (2,144.6)	In-water
Lower Granite – Downstream Navigation Lock Approach	2005/2006	Navigation	2,000	In-water

m^3 = cubic meters

Table 3-21. Corps-Identified Potential Sediment Problem Areas in Little Goose Reservoir

Reservoir	River	Approximate River Mile[1]	Site Name	Use
Little Goose	Snake	82.5	Central Ferry State Park	Recreation
		83.0	Port of Garfield Access	Navigation
		83.5	Port of Central Ferry	Navigation
		88.0	Willow Landing HMU	Water intake/recreation
		100.0-102.0	Navigation Channel at Schultz Bar	Navigation
		103.5	Port of Almota	Navigation
		103.5	Illia Landing	Recreation
		105.5	Boyer Park and Marina	Recreation
		107.0	Lower Granite Lock Approach	Navigation

[1] River mile indicates the number of miles upstream of the mouth of the Snake River

3.7.3.2 Lower Monumental Reservoir

Lower Monumental Reservoir, also known as Lake Herbert G. West, was created by the construction of the Lower Monumental Dam in 1969 (USACE 2002b). The main drainages to Lower Monumental Reservoir are the Palouse/Rock Rivers and the Tucannon River, as well as smaller drainages, including Alkali Flats Creek, and Fields Gulch. The Lower Monumental Lock

and Dam is located approximately 6 miles south of the town of Kahlotus, Washington, which is approximately 43 miles north of Walla Walla, Washington. The reservoir extends approximately 29 miles from the Lower Monumental Dam east to the Little Goose Dam (USACE 2002a).

The Lower Monumental Lock and Dam project is located near RM 42 on the Snake River (see Figure 3-14). The project was completed and began operating in 1969. The dam provides hydroelectric power generation, a navigation lock, and fish passage facilities. In addition, the reservoir behind the dam includes six developed recreation areas, wildlife habitat areas, and one port facility. The reservoir has a capacity of 432,000 acre-feet and a surface area of 6,590 acres. The normal operating pool elevation for the Lower Monumental Reservoir ranges from 537-540 msl (2002a; 2002b; 2010c). No past dredging activities have been conducted in the Lower Monumental Reservoir.

Figure 3-14. Lower Monumental Dam
Source: USACE 2002a

Table 3-22 lists the potential problem areas identified by the Corps for the Lower Monumental Reservoir.

Table 3-22. Corps Identified Potential Sediment Problem Areas in the Lower Monumental Reservoir

Reservoir	River	Approximate River Mile[1]	Site Name	Use
Lower Monumental	Snake	48.0	Skookum HMU	Water intake/irrigation
		51.0	Ayer	Recreation
		55.0	55-Mile HMU	Water intake/irrigation
		56.5	Joso HMU	Navigation
		59.5	Lyons Ferry State Park	Recreation
		66.0	Texas Rapids Boat Basin	Recreation
		70.0	Little Goose Lock Approach	Navigation

[1] River mile indicates the number of miles upstream of the mouth of the Snake River

3.7.3.3 Ice Harbor Reservoir

Ice Harbor Reservoir, also known as Lake Sacajawea, was created by the construction of the Ice Harbor Dam in 1961. The dam is located approximately 8 miles east of Pasco, Washington. It was the first Corps dam constructed on the lower Snake River in Washington (USACE 2002b). There are only two streams that drain into the Ice Harbor Reservoir: Walker Canyon Creek and an unnamed tributary (Tetra Tech 2006). The reservoir extends approximately 32 miles from the Ice Harbor Dam upstream east to the Lower Monumental Dam (USACE 2002a).

The Ice Harbor Lock and Dam are located near RM 10 on the Snake River (see Figure 3-15). The dam provides hydroelectric power, a navigation lock, and fish passage facilities. The reservoir behind the dam includes six developed recreation areas, wildlife habitat areas, and one port facility. The reservoir has a capacity of 24,900 acre-feet (between elevations 437 and 440 msl) and a surface area of 8,375 acres. The normal operating pool elevation for the Ice Harbor Reservoir ranges from 437-440 msl (USACE 2002a; 2002b; 2010c).

Figure 3-15. Ice Harbor Dam

Source: USACE 2002a

Past dredging was conducted near the downstream approach to Lower Monumental Dam for the purpose of maintaining navigation. The Corps has identified potential problem areas where authorized purposes, including irrigation withdrawals and recreation, may be affected in the future. Table 3-23 lists the past dredging activities conducted in Ice Harbor Reservoir since the facilities were completed.

Table 3-24 lists the potential problem areas identified by the Corps for Ice Harbor Reservoir.

Table 3-23. Historic Dredging Activities in Ice Harbor Reservoir

Dredging Location	Year	Purpose	Amount Dredged Cubic Yards	Dredged Material Placement
Downstream Approach – Navigation Channel Lower Monumental Lock and Dam	1972	Navigation	25,000	Upland and in-water
Downstream Approach – Channel Construction Lower Monumental Lock	1977	Navigation	10,000	Upland
Lower Monumental – Navigation Lock Approach	1998/ 99	Navigation	5,483	In-water
Lower Monumental – Navigation Lock Approach	2005/2006	Navigation	12,000	In-water

Table 3-24. Corps-Identified Sediment Problem Areas in Ice Harbor Reservoir

Reservoir	River	Approximate River Mile1	Site Name	Use
Ice Harbor	Snake	10.0	North Shore Boat Ramp	Recreation
		11.5	Charbonneau Park	Recreation
		13.5	Levey Park	Recreation
		15.0	Big Flat HMU	Water intake/irrigation
		18.0	Fishhook Park	Recreation
		23.0	Lost Island HMU	Water intake/irrigation
		24.5	Hollebeke HMU	Water intake/irrigation
		29.0–33.3	Walker's Elevator	Navigation
		39.0	Windust Boat Ramp	Recreation
		41.0	Lower Monumental Lock Approach	Navigation

[1] River mile indicates the number of miles upstream of the mouth of the Snake River

3.7.3.4 Snake River Downstream of Ice Harbor Dam

The reach of the Snake River downstream of Ice Harbor Dam merges into the McNary Reservoir on the Columbia River near Pasco, Washington. The Columbia River then continues south and curves west to the McNary Dam, which is located outside of the study area approximately one mile east of the City of Umatilla, Oregon (USACE 2002b). The McNary Reservoir, also known as Lake Wallula, was created by the construction of the McNary Dam in 1957. The reservoir extends 64 miles upstream to the U.S. Department of Energy's Hanford Site on the Columbia River and approximately 10 miles up the Snake River to Ice Harbor Lock and Dam.

Table 3-34 lists the past dredging activities conducted in the Snake River portion of McNary Reservoir since the facilities were completed. Materials dredged from below Ice Harbor Lock and Dam project have been notably different from sediments dredged in the Snake River and a portion of the lower Snake River reservoirs. Dredged material from below Ice Harbor Lock and Dam has been predominantly larger cobbles and boulders that have accumulated in the navigation channel and lock approach following completion of the dam's construction.
Table 3-26 lists the potential problem areas identified by the Corps for McNary Reservoir. The potential issues identified in this reservoir include maintenance of navigation and continued opportunities for recreation.

Table 3-25. Historic Dredging Activities in McNary Reservoir (Snake River Portion)

Dredging Location	Year	Purpose	Amount Dredged Cubic Yards	Dredged Material Placement
Downstream Navigation Channel – Ice Harbor Lock and Dam	1972	Navigation	80,000	Upland and in-water
Navigation Channel – Downstream of Ice Harbor Lock and Dam	1973	Navigation	185,000	Upland and in-water
Downstream Approach – Channel Construction Ice Harbor Lock	1978	Navigation	110,000	Upland and in-water
Downstream Approach – Channel Construction Ice Harbor Lock	1985	Navigation	98,826	In-water
Downstream Approach – Channel Construction Ice Harbor Lock	1978/ 81/82	Navigation	816,814	Upland and in-water

Table 3-26. Corps Identified Potential Sediment Problem Areas in McNary Reservoir (Snake River Portion)

Reservoir	River	Approximate River Mile1	Site Name	Use
McNary	Snake	0.0	Sacajawea State Park	Recreation
		1.0	Burbank State Park	Navigation
		1.5	Hood Park Boat Ramp	Recreation
		9.2	Ice Harbor Lock Approach/Nav Coffer Cells	Navigation
		0.0–1.5	Snake River Entrance	Navigation
		2.0–10.0	Nav Channel Below Ice Harbor	Navigation

[1] *River mile indicates the number of miles upstream of the mouth of the Snake River*

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3.8 Hazardous, Toxic, and Radioactive Waste

This section focuses on qualitatively evaluating HTRW risks associated with land uses and materials that are manufactured, transported, or used within the study area. Potential HTRW concerns, in terms of historic and ongoing activities within study area are presented as a general discussion of potential sources of HTRW in the study area as a whole.

The Corps reviewed available information (such as state databases for storage and placement of hazardous material and waste), land use characteristics, and previous studies. Potential HTRW sources and concerns are discussed below.

In areas with agricultural uses, possible contaminants of concern for agricultural and urban land uses include a broad suite of pesticides, herbicides, fertilizers, petroleum and associated compounds, chlorinated solvents, degreasers, and various heavy metals. Agricultural chemicals have been used in areas surrounding the study area for decades. Each crop has specific chemical uses associated with it. Some agricultural chemicals have a longer residence time in soil and may break down into residual products that can accumulate to form toxic residue. Other agricultural chemicals, banned from use today, may be found in trace amounts in soils and sediments.

Urban land use areas have many facilities with the potential for hazardous material releases. Common facilities include gas stations, dry cleaners, automotive repair facilities, and in larger towns, manufacturing facilities. The most common contaminants of concern in soil and groundwater in urban areas are petroleum and associated compounds (typically gasoline and diesel releases from underground storage tanks (USTs) and spills), chlorinated solvents and degreasers (from dry cleaning and vehicle repair facilities), and various heavy metals, such as arsenic and lead. In addition, the transport of materials like petroleum and chemicals can raise HTRW concerns.

The Joso HMU is a 303- acre area located approximately 20 miles north of Prescott, Washington that the Corps has identified as the location of upland placement of dredged sediments, if that measure is selected. The proposed site had been used to excavate borrow material during the construction of the Lower Monumental Dam and associated facilities and large excavation areas within the proposed site remain visible. The proposed site has been used as an unauthorized shooting and debris dump site and several tire burn piles are located near the center of the site. An assessment of the site in 1999- 2000 indicated low level of concern about environmental contamination (USACE 2002b), and the site has remained essentially unchanged since that assessment.

Large amounts of oils, such as transformer oil, turbine oil, and lubricating oil, are stored at each of the LSRP lock and dam facilities. The majority of the oil is stored inside oil-filled operating equipment. Other hazardous material sources at the facilities include diesel, gasoline, propane gas tanks, carbon dioxide (for fire suppression), and various greases and refrigerants. The facilities also use a variety of solvents, paints, thinners, cleaners, aerosols, epoxy, enamel, and vinyl products stored in 55-gallon or smaller containers. Currently, each of the four dams

maintain Spill Prevention, Control, and Countermeasure (SPCC) Plans to describe the handling, storage, and inspection measures each facility takes to prevent discharges from occurring and emergency response procedures should there be an uncontrolled spill event.

Sediments within the LSRP are not expected to require special management prior to handling or placement and would not be considered as industrial or hazardous waste. Sediments below navigable waters qualify as HTRW only if they are within the boundaries of a site designated by the US EPA or state for a response action or are part of the National Priority List under the Comprehensive Environmental Response, Compensation, and Liability Act (U.S.C. Sections 9601 -9675), No HTRW sites have been identified in the Lower Snake River navigation channel (USACE 2005).

3.9 Air Quality

Air quality changes over time as economic development occurs and regulatory programs affect air emissions from sources. The following discussion provides a general summary of air quality in the study area.

This section also presents information on climate change and greenhouse gases (GHG). The study area for the discussion related to climate change and GHG is considered to be the entire planet as climate change issues are global in nature and incremental effects of GHG emissions may be felt in all parts of the planet.

3.9.1 Regional Climate Conditions

Historic meteorological data from the Western Regional Climate Center (WRCC) (WRCC 2010) for cities in the vicinity of the study area were reviewed and are shown in Table 3-27. The prevailing wind patterns in the study area are generally from the southwest. Storm activity in the summer and fall can lead to strong wind gusts making the arid parts of the study area prone to wind erosion and dust storms.

Table 3-27. Typical Range of Average Regional Climate Data Representative of the Study Area

Climate Metric	Lower Range Limit	Upper Range Limit
Oregon (Data from Enterprise, La Grande, and Baker City)		
Average Winter Temperature	30°F (-1.1˚C)	37°F (2.8˚C)
Average Summer Temperature	60°F (15.6˚C)	62°F (16.7˚C)
Average Annual Rainfall	11 inches	20 inches
Washington (Data from Kennewick, Ritzville, and Pullman)		
Average Winter Temperature	36°F (2.2˚C)	42°F (5.6˚C)
Average Summer Temperature	58°F (14.4˚C)	66°F (18.9˚C)
Average Annual Rainfall	7 inches	21 inches
Idaho (Data from Data from Mesa, Stanley, and Salmon)		
Average Winter Temperature	18°F (-7.8˚C)	36°F (2.2˚C)
Average Summer Temperature	52°F (11.1˚C)	61°F (16.1˚C)
Average Annual Rainfall	9 inches	21 inches

3.9.2 Regional Air Quality Conditions

The study area is generally rural with relatively few major sources of air pollution emissions. One of the largest sources of air pollutant emissions caused by human activities in the region is the Boardman coal-fired power plant, located just outside the study area in Boardman, Oregon, approximately 9 miles west of Hermiston, Oregon. The Boardman plant has estimated sulfur dioxide (SO_2) emissions of approximately 16,600 tons/year. However, Portland General Electric is implementing a new operating plan for the Boardman Plant, which includes installing new emissions controls at the plant to reduce emissions, and ending the burning of coal for electricity generation there by December 31, 2020. New emissions controls at Boardman are expected to

reduce nitrogen oxide emissions by approximately 50 percent and permitted levels of SO_2 emissions by 75 percent. State rules also require new controls to reduce the plant's mercury emissions by 90 percent. All coal-related emissions from the Boardman facility will be reduced to zero with the end of coal-fired operations in 2020 (PGE 2011). These operational changes will lead to a net reduction of regional air pollutant emissions in the vicinity of the study area over the next 10 years.

Other sources of regulated air pollutants in the study area include transportation sources (such as cars, buses, trucks, trains, ships and barges, and aircraft), urban sources (including wood smoke, emissions from commercial operations, and gas-powered residential equipment), reintrained dust (which is naturally occurring particulate matter (PM) that is resuspended into the atmosphere through natural processes such as wind), agricultural practices (including field burning, reintrainment of dust from practices such as plowing, and emissions from farm equipment), and wild fires. These types of sources occur, to varying degrees, throughout the study area.

3.9.3 Regional Greenhouse Gas Conditions

GHG are chemical compounds found in the earth's atmosphere that absorb and trap infrared radiation, or heat, re-radiated from the surface of the earth. The trapping and build-up of heat in the atmosphere increases the earth's temperature, warming the planet and creating a greenhouse-like effect (EIA 2009a). ***Anthropogenic*** activities (caused or produced by humans) are increasing atmospheric concentrations to levels that could increase the earth's temperature up to 7.2 F by the end of the twenty-first century (EPA 2010a).

The U.S. Global Climate Research Program (GCRP) summarizes the effects of global climate change to date in their report on *Global Climate Change Impacts in the United States* (GCRP 2009). The GCRP has found that, since the 1970s, average temperatures in the United States have risen, sea levels have risen, and precipitation patterns have changed. These findings are supported by the Intergovernmental Panel on Climate Change (IPCC) for the global climate (IPCC 2007).

The principle GHG emitted into the atmosphere through human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), and fluorinated gases (EPA 2010b). Of these four gases, CO_2 is the major GHG emitted (EPA 2010b; Houghton 2010). For example, CO_2 emissions from the combustion of coal, oil, and gas constitute 81 percent of all U.S. GHG emissions (EIA 2009b). Carbon dioxide enters the atmosphere primarily through the burning of fossil fuels such as coal, natural gas and oil, and wood products; as a result of land use changes; and the manufacturing of cement, among other industrial sources. Prior to the industrial revolution, concentrations were roughly stable at 280 parts per million (ppm), but have increased 36 percent to 379 ppm in 2005, all of which is attributed to human activities (IPCC 2007).

Of the remaining three principle GHGs, methane is emitted during the production and transport of fossil fuels, through intensive animal farming, and by the decay of organic waste in landfills. Methane concentrations have increased 148 percent above preindustrial levels (EPA 2010b).

Nitrous oxide is emitted during agricultural and industrial activities, and during the combustion of fossil fuels and solid waste. Nitrous oxide atmospheric levels have increased 18 percent since the beginning of industrial activities (EPA 2010b). Fluorinated gases, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, are synthetic compounds emitted through industrial processes and now are being used to replace ozone-depleting compounds such as chlorofluorocarbons in insulating foams, refrigeration, and air conditioning. Although they are emitted in small quantities, these gases have the ability to trap more heat than CO_2 and are considered high global-warming potential gases. Atmospheric concentrations of fluorinated gases have been increasing over the last two decades and are expected to continue to increase (EPA 2010b).

Global atmospheric GHG concentrations are a product of emissions and removal over time. Soils store carbon in the form of decomposing plant materials and constitute the largest carbon reservoir on land. Through the process of photosynthesis, atmospheric carbon is also captured and stored as biomass in vegetation, especially forests.

Stored carbon can be released back into the atmosphere when biomass is burned (ESA 2008). In addition, CO_2, N_20, and CH_4 emissions increase in areas where soil disturbance occurs (Kessavalou et al. 1998). Models predict atmospheric concentrations of all GHG will increase over the next century, but the extent and rate of change is difficult to predict, especially on a global scale.

In 2000, Oregon's GHG emissions were 67.7 million metric tons of carbon dioxide equivalent ($MMtCO_2e$), which was equal to approximately one percent of U.S. GHG emissions (more than 7 billion metric tons CO_2e). This represented a 15 percent increase over Oregon's 1990 GHG emissions of 58.7 $MMtCO_{2e}$. According to its worst case forecast, the Oregon Department of Energy estimates that GHG emissions from Oregon will be 61 percent higher by 2025 (Oregon Department of Energy 2004).

Of the GHG emissions from Oregon in 2000, 84 percent came from CO_2. The primary source of CO_2 pollution came from burning fossil fuels, such as coal at power plants serving the state, gasoline, diesel, and natural gas. There were also emissions from industrial processes, such as manufacture of cement and from combustion of fossil-fuel derived products in burning municipal and industrial wastes (Oregon Department of Energy 2004).

The Washington Department of Community, Trade, and Economic Development (WDCTED) and the Ecology published the current Washington GHG inventory in December 2007 (Ecology & WDCTED 2007). Their data shows that, in 1990, industrial sources in Washington State emitted 88.4 $MMtCO_2e$. Between 1990 and 2000, emissions grew steadily to over 100 $MMtCO_2e$. Emissions then dropped significantly over the next 2 years, largely because of the permanent shutdown of much of Washington's aluminum manufacturing industry, before resuming a steady increase between 2003 and 2005 (Ecology & WDCTED 2008).

During the 1990s and 2000s, Washington's GHG emissions were dominated by burning fossil fuels such as gasoline and natural gas. The main source of emissions in Washington is the transportation sector, which produces almost half of the state's GHG emissions. The next largest sector was emissions from electricity consumption, followed by combustion emissions in the industrial and residential/commercial sectors (Ecology & WDCTED 2008).

GHG analyses indicate that in 2005, activities in Idaho accounted for approximately 37 $MMtCO_2e$, an amount equal to approximately 0.5 percent of total U.S. GHG emissions (based on 2004 US emissions). Idaho's gross GHG emissions are rising faster than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Idaho's gross GHG emissions increased 31 percent from 1990 to 2005, while national emissions rose by only 16 percent from 1990 to 2004 (Center for Climate Strategies 2008).

Transportation and agriculture are Idaho's principle GHG emissions sources. Together, these two sectors accounted for 51 percent of Idaho's gross GHG emissions in 2000. The use of fossil fuels — natural gas, oil products, and coal — in the residential, commercial, and industrial sectors constituted another 19 percent of total Idaho emissions. The combustion of fossil fuels for electricity generation (including emissions associated with the generation of electricity imported from other states) constituted only 13 percent of total Idaho emissions, which is a little less than the nation as a whole (Center for Climate Strategies 2008).

3.10 Aesthetics

The study area is located in an arid region with surrounding open and agricultural landscapes and is predominantly rural in character except for the Tri-Cities area in Washington, and the Lewiston-Clarkston areas around Lower Granite Reservoir. The river passes through and is adjacent to the Blue Mountains and Columbia Basalt Plain physiographic provinces. The land surrounding the Snake River at its confluence with the Columbia is composed of low hills with steppe vegetation. Moving upstream, the valley walls become steeper, forming a canyon with sidewalls ranging from 200 to 2,000 feet high. The steep buttes and walls surrounding the river are the dominant features of this landscape. Throughout much of the study area, roadways (e.g., U.S. Highway 12) and railroad facilities are adjacent to the reservoirs.

The lower Snake River provides a water feature in an arid landscape with often dramatic, steep surrounding hillsides and canyons, making it an important aesthetic resource in the study area. Many of the recreational facilities developed along the lower Snake River take advantage of the scenic qualities of this landscape, as well as water-based recreation such as boating and fishing. In the urbanized areas, riverfront parkland has been developed and is heavily used.

People viewing the aesthetic resources of the study area include highway travelers, recreational users, and local residents. The aesthetic values of the river and surrounding landscapes vary based on the viewers' perspectives and values. Highway travelers tend to view the resources as they are traveling on roadways, such as along U.S. Highway 12, which parallels the Snake River over several stretches of its alignment; as such, these travelers tend to view the resources at a distance, generally at high rates of speed. Recreational users tend to view the resources for longer periods of time because they are involved in recreational activities that are dependent on the river setting. Local residents tend to view the resources as they go about their daily business, as well as when they use the river and surrounding lands for recreational purposes (Corps 1992).

The levees in Lewiston-Clarkston provide a visual, as well as recreational resource, with landscaping, walking paths, and points that provide views of the river. The levees do obscure views of the river from various locations in Lewiston, Idaho. Throughout the study area, viewing patterns vary seasonally in a manner similar to recreational uses of the river and surrounding lands, with more activities during the warm and sunny periods in late spring, summer, and early fall.

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SECTION 4.0 ENVIRONMENTAL EFFECTS OF ALTERNATIVES

The following sections describe the potential effects of the plan alternatives on the natural and human environment. The potential effects of measures included in each alternative – both the general effects of future actions and the effects of the proposed actions to address the immediate need are presented in this section.

Alternative 1 represents no change in recent management of the LSRP and addresses sediment accumulation that interferes with authorized purposes through operating the reservoirs for the navigation objective. Alternative 5 is a plan based primarily on dredging to address sediment accumulation that interferes with authorized purposes of the LSRP. Alternative 7 presents a variety of measures– dredging, system management, and structural sediment management – to evaluate and potentially implement within the LSRP to address sediment accumulation that interferes with authorized purposes. All three alternatives assume that sediment reduction measures will continue to be implemented in the Snake River watershed at current levels.

Implementation of Alternative 1 would be the same for the immediate need to reestablish the navigation channel to its authorized dimension and for future needs. The Corps would monitor conditions in the LSRP and manage the reservoir levels (consistent with applicable biological opinion and other requirements) to provide 14 foot water depth in the navigation channel and, to the extent possible, provide for other authorized purposes. They would employ the same approach to meet the immediate needs as well as future needs. The Corps can only raise reservoir levels to the maximum operating pool elevation for each reservoir, thereby limiting this alternative's effectiveness.

Alternative 5 would address future needs through dredging and dredged material management measures. The Corps would monitor sediment in the LSRP, and either in anticipation of (or response to) sediment accumulation that interferes with authorized purposes, the Corps would initiate planning, environmental compliance and implementation of dredging and dredged material management. For the resources discussed below, the general impacts of future implementation of dredging and dredged material management are described. As noted in Section 1, environmental compliance for future actions would include NEPA review and documentation tiered off of this EIS. The immediate needs would be addressed by navigation objective reservoir operation and dredging and dredged material management.

Alternative 7 would address future needs through dredging and dredged material management, system management, and structural sediment management. The Corps would monitor sediment in the LSRP, and either in anticipation of (or response to) sediment accumulation that interferes with authorized purposes, and in anticipation of sediment accumulation interfering with authorized purposes, the Corps would initiate planning, environmental compliance, design and implementation of cost effective and environmentally acceptable measures to address specific sediment problems. For the resources discussed below, the general effects of future

implementation of any of the measures are described. As noted in Section 1, environmental compliance for future actions would include NEPA review and documentation tiered off of this EIS. The immediate needs would be addressed by navigation objective reservoir operation and dredging and dredged material management.

Table 4-1. Alternatives and Associated Measures

Measures	Alternative 1 - No Action Alternative: Continue Current Practice	Alternative 5 - Dredging-Based Sediment Management	Alternative 7- Comprehensive (Full System and Sediment Management Measures)
Dredging and Dredged Material Management			
Navigation Channel and Other Dredging		●	●
Dredging to Improve Flow Conveyance Capacity		●	●
Beneficial Use of Sediment		●	●
In-water Disposal of Sediment		●	●
Upland Disposal of Sediment		●	●
Structural Sediment Management			
Trapping Upstream Sediments (in reservoir)			●
Agitation to Resuspend Sediment			●
Bendway Weirs			●
Dikes and Dike Fields			●
System Management			
Reservoir Drawdown to Add Conveyance Capacity			●
Modify Flows to Flush Sediment			●
Navigation Objective Reservoir Operation	●	●	●
Reconfigure Affected Facilities			●
Relocate Affected Facilities			●
Raise Lewiston Levee to Manage Flood Risk			●

4.1 Aquatic Resources

The project alternatives described in this EIS would each have some potential effects on aquatic resources within the study area. Effects are categorized within the same groups of plankton and benthic communities, aquatic plants, and fish (including threatened and endangered species) as presented in Section 3.1. Within the LSRP, the majority of research of aquatic resources has focused on Lower Granite Reservoir. Therefore, impact discussions will more frequently reference Lower Granite Reservoir, although in many cases the discussion is also applicable to the other reservoirs within the LSRP.

4.1.1 Alternative 1: No Action (Continue Current Practices)

The No Action Alternative represents a continuation of recent practices of managing the LSRP. Alternative 1 would consist of navigation objective reservoir operation provided for in RPA #5 of the 2008/2010 BiOp, to address both immediate and future needs.

Effects on Plankton and Benthic Community

Navigation objective reservoir operation would have no measureable effect on plankton and the benthic community within the LSRP. The abundance, distribution, and diversity of benthic and planktonic organisms would not change from the current condition under the No Action Alternative. Plankton communities would not be negatively affected by raising pool levels, and in some locations additional watered habitat would be formed and population size could grow slightly. Some minor effects to the benthic community that inhabits shallow water areas dependent on primary production within the photic zone may occur where increased water depths no longer allow enough light penetration. However, repopulation in new shallow water habitat would likely occur over the long term.

Effects on Aquatic Plants

Aquatic plants could be negatively affected by navigation objective reservoir operation. During a pool raise, shallow water habitat on the margins of reservoirs would likely become too deep in some locations to support the necessary photic activities to maintain a sustainable population. However, repopulation in new shallow water habitat would likely occur long term.

Effects on Fish (Including Threatened and Endangered Species)

Navigation objective reservoir operation could result in minor adverse effects on listed salmonid species due to loss or alteration of shallow water rearing habitat, and modified juvenile passage survival through reservoirs due to increased water levels. Raising the operating pool will have a greater effect in the areas near the dams than it will further upriver due to the normal change in elevation moving upstream.

The increased pool levels would result in a small decrease in velocities through the dam reservoirs. This has the potential to reduce out-migrant travel time through the Snake River

system. Migration delays may result in increased exposure of juvenile migrants to sources of mortality (e.g., predation, disease, thermal stress, metabolic stress), thereby decreasing survival. However, to provide higher passage survival and to reduce migration delay, surface passage structures (and related project operations) have been installed and implemented at many of the mainstem dams. These surface flow routes are expected to provide the majority of in-river juvenile migrants a safe and quick passage route through the lower Snake River dams and have the potential to be as or more effective during a pool raise action.

Another effect on fish due to pool raise action could be the loss of shallow water habitat. In the Lower Granite Reservoir, shallow water habitat currently comprises less than 10 percent of the total surface area within the reservoir (Tiffan and Hatten 2012). Dredged material placement (beneficial use) over the past 10 years has increased availability of preferred salmonid rearing habitat and habitat diversity (Tiffan and Connor 2012). The pool raise action may result in making this small amount of shallow water habitat slightly less beneficial. In the long term, it is possible that the resulting increase in water elevation may also result in creation of new shallow water habitat due to inundation of current low slope shoreline. However, the benthic and aquatic vegetation community would likely take more than a year to establish in these areas contributing to quality habitat for fish.

Depending on the timing of the pool raise, it is also possible that flow reductions during filling of the reservoirs could result in slightly decreased juvenile Snake River fall Chinook survival due to water temperature increases.

Increased reservoir depth and the potential loss of shallow water habitat could also affect resident fish species that inhabit the reservoirs in much the same manner, by potentially reducing shallow water spawning and rearing habitat.

4.1.2 Alternative 5 (Dredging-Based Sediment Management)

4.1.2.1 Future Actions

The direct effects to aquatic resources of Alternative 5 would be from periodic dredging operations and in-water placement of sediment. In-water work associated with dredging would have temporary, localized effects on turbidity and increased suspended sediment, as well as noise and possible ***entrainment*** of fish. The navigation channel and other areas where dredging would take place would be deepened and the areas where the material is deposited would become more shallow. These changes would cause temporary loss of benthic habitat and organisms at the dredged material placement sites. However, depending on the placement site, these management activities may create new, more productive shallow water habitat at the placement sites. Direct effects of future actions of Alternative 5 are described in detail below. Raising pool levels above MOP as part of this alternative would have the same effects on plankton and benthic community, aquatic plants, and fish (including threatened and endangered species) as those described for Alternative 1.

In-water disposal of dredged material (that is, deep water dumping of dredged materials as opposed to in-water placement for beneficial use discussed above) would modify deepwater habitat and bury immobile benthic organisms. It could also potentially bury fishes, cause turbidity-related effects, and create noise disturbances. Some of these effects can be minimized by adhering to the winter in-water work window when many of the fish species are not present, and primary productivity is lower.

Effects on Plankton and Benthic Community

Plankton communities would not be negatively affected by raising pool levels and dredging, and in some locations additional watered habitat would be formed and population size would likely grow. Benthic and ***epibenthic*** organisms at a dredge site would likely suffer complete mortality because of dredging. Recovery of the benthic invertebrates which form the majority of the food consumed by bottom-feeding fish would occur within a few months.

Benthic organisms immediately downstream of a dredging site would also be adversely affected due to increases in local turbidity from suspended sediment. Increased suspended sediment can affect feeding of benthic and ***pelagic*** (open river) filter feeding organisms (Parr et al., 1998), and the settling of the suspended particles can cause local burial, affect egg attachment, and modify benthic substrate. Some minor changes in the species composition and relative abundance of the benthic fauna are likely, because of combined effects of changes in substrate conditions as well as water currents from increasing the depth in the dredged area.

In-water placement of dredged material as beneficial use can increase the abundance and availability of benthic macroinvertebrates. With the exception of oligochaete worms, density of benthic organisms decreases with depth (Pool and Ledgerwood 1997). Currently, greater than 90 percent of the habitat in Lower Granite Reservoir is considered either mid-depth (20 to 60 feet) or deep water (greater than 60 feet) (Tiffan and Hatten 2012). Therefore, by raising the river bottom in some places through placement of dredged material, macroinvertebrate abundance could be enhanced in similar areas within the LSRP.

Benthic species with planktonic larval stages or species that move into the water column are expected to rapidly recolonize a dredged material placement site within a few weeks for species with planktonic larval stages or species that move out of the substrate such as *Corophium* sp and chironomids, and a few months for the less mobile species such as oligochaete worms (Seybold and Bennett 2010; Bennett et al., 1990, 1993a, 1993b). Studies have determined that the dredged material placement site at Knoxway Bench (RM 116) has been quickly colonized by benthic macroinvertebrates, and the total density of invertebrates was consistently high during both fall and spring (Seybold and Bennett 2010). Thus placement of dredged material for beneficial use would have no lasting adverse effects on benthic species.

For in-water disposal of dredged material that is not for beneficial use, benthic invertebrates inhabiting the placement area would be displaced and/or overlain by sediment during the dredged material placement. Monitoring of previous dredged material placement in Lower

Granite Reservoir, under similar sediment conditions, showed that benthic invertebrates rapidly recolonized areas where dredged material was deposited within a few weeks for species with planktonic larval stages or species that move out of the substrate such as *Corophium* sp and chironomids, and a few months for the less mobile species such as oligochaete worms (Seybold and Bennett 2010; Bennett et al., 1990, 1993a, 1993b). Turbidity generated by the proposed action would be diluted within a relatively short period of space and time and should have little effect on primary production. Due to the low ambient water temperatures experienced during the in-water winter work window and localized nature of the plumes, no impacts to beneficial primary productivity are expected. Because the work would be accomplished during the winter and the turbidity plume would be regulated; no detectable effects to phyto- or zooplankton are expected. Mobile aquatic organisms would likely move out of the immediate area of the proposed dredging and placement actions, but would return upon completion of the proposed actions.

Effects on Aquatic Plants

Aquatic plants are generally not present in the navigation channel. Therefore dredging activities would not affect aquatic plants. Dredging would remove plants in shallow areas, such as boat basins, placement of dredged material would bury plants within shallow water areas could adversely affect aquatic plants if they are present. The continuation of in-water dredged material placement, on the other hand, would enlarge shallow water areas that could be colonized by aquatic plants.

The effect of dredging operations outside the navigation channel on aquatic plants would result from ***entrainment*** at the dredge site, as well as temporary and localized impacts by increasing turbidity and suspended solids during dredging operations. A large quantity of suspended sediment can reduce light penetration, which in turn reduces primary production of both pelagic and benthic algae and rooted plants (macrophytes). Although dredging operations may create a detectable plume extending 1,000 feet downstream, if operations cause a 5 ***nephalometric turbidity units*** (NTUs) increase over background (10 percent increase when background is over 50 NTUs) at a point 300 feet downstream, the Corps will modify the dredging operation until turbidity levels become lower and within the acceptable range (USACE 2002b; USACE 2005; Appendix J).

Aquatic macrophytes are large plants that typically grow in shallow water along the shorelines of lakes or in the slow-moving reaches of rivers such as the lower Snake River reservoirs. Dredging would occur primarily in the deeper areas, such as the navigation channel where these plants are not present. Therefore Alternative 5 would have a minimal impact on aquatic plants that inhabit shallower waters.

Any macrophytes present at the beneficial use material placement site would be buried and die. Impacts from dredged material placement for beneficial use would be short term, minor, and localized with no long-lasting effects to the populations of benthic plants. These populations are capable of replacement and recolonization of lost abundance by a large source of adjacent and

upriver drifting segments of populations. Most research and monitoring on large river systems has shown that disturbance to habitat is a natural process and can be beneficial (USACE 2002b).

Any macrophytes and periphyton present at the dredged material placement sites would become buried and die. Deep-water placement would have minimal effect on existing aquatic plants, as it is outside of the photic zone. As the depth of the placement site decreases over time, increased light penetration would promote the colonization of the site by aquatic plants.

Effects on Fish (Including Threatened and Endangered Species)

Dredging effects on fish are generally localized and involve possible entrainment, increased turbidity, noise, and changes to habitat such as substrate and depth.

Most dredging activities would use a barge-mounted clamshell bucket to excavate and remove sediment. Due to the characteristics of this equipment, it is generally accepted that clamshell buckets have a low potential to entrain fish in comparison to other dredging methods (USACE 2002b). Specifically, the clamshell bucket descends to the substrate in an open position. During the descent, the bucket cannot trap or contain a mobile organism because it is open on top and bottom. The force generated by the descent drives the jaws of the bucket into the substrate, which “bites” the sediment upon retrieval, thus filling the empty bucket with sediment. The bucket bottom then closes as it is retracted from the dredged area. Clamshell dredging operations would proceed slowly, and would present reasonable opportunity for fish, including adult and juvenile salmonids to escape from a dredge area prior to commencement of the actual dredging operation.

In addition to the type of equipment used for navigation dredging, the time of year would also reduce the possibility of impacting endangered ESA-listed salmon and steelhead. The winter in-water work period (December 15 through March 1) is the time of year when the fewest ESA-listed salmonids are found in the reservoir (Tiffan and Connor 2012). Salmonids are pelagic oriented fish that do not typically occur in the benthic environment. The subyearling Chinook that rear and overwinter in the lower Snake River and associated reservoirs also prefer shallow water habitat over deeper water habitats during the spring and summer (USACE 2010a, Tiffan and Connor 2012) and are generally pelagically oriented near the surface during the winter (Tiffan and Connor 2012). These characteristics greatly reduce the risk of entrainment of either juvenile or adult salmonids. Furthermore, the disturbance from dredging activities is likely to encourage fall Chinook salmon and steelhead to avoid the vicinity of the dredging operations altogether. Juvenile or adult coho, spring and summer Chinook, and sockeye salmon are not likely to be present in the reservoirs during the in-water work period for the dredging operations.

While there is potential spawning habitat in the tailraces of the lower Snake River projects, no redds have been identified within the navigation lock approaches of any of the lower Snake River projects since surveys began in 1993. Therefore dredging activities in the lock approach areas would be unlikely to affect redds.. Dredging in this area may have the potential to disturb

or harm eggs and alevins in redds if found to be present. The Corps would survey this area prior to any dredging activity (Appendix J).

Dredging and dredged material placement would not cause effects on water temperature or dissolved oxygen because activity would typically take place in cold weather during the in-water work window. Dredging activities are temporary, and would cause short-term and localized impacts by increasing turbidity and suspended solids. Although dredging operations may create a detectable plume extending 1,000 feet downstream, operations causing a 5-NTU increase over background (10 percent increase when background is over 50 NTUs) at a point 300 feet downstream, would result in immediate actions to reduce the plume. Based on the disparity between the turbidity increases anticipated as part of the dredging and dredged material placement operation and the levels reported to be harmful to fish, dredging and dredged material placement operations would not adversely affect salmon and steelhead as a result of increased turbidity. In addition, although turbidity may cause stress, Gregory and Northcote (1993) have shown that moderate levels of turbidity (35 to 150 NTU) accelerate foraging rates among juvenile Chinook salmon, likely because of reduced vulnerability to predators (camouflaging effect).

Although low-to-moderate turbidity levels can enhance survival by providing cover from predation (Gregory and Levings 1998), excessive levels of turbidity can reduce feeding efficiency and food availability, and damage fish's gills (Bruton 1985; Gregory 1993). In the immediate vicinity of the proposed action, short-term turbidity could be high enough to interfere with predation success of vertebrate sight feeders, including juvenile salmonids. The disturbance would be limited to the duration of the project. Although the sight feeders may move out of the disturbed area during the proposed event, it is expected they would return on completion of the project. These interferences, if they occur, would be of limited duration, and would not coincide with any major migration of anadromous fish during the allowed in-water work period. Adequate area exists to allow sight feeders to move out of the turbid zone for feeding purposes.

Dredging activities would also generate underwater sound pressure levels that could elicit responses in some fish and other aquatic organisms (Hastings and Popper 2005). The intensity of the sound pressure levels from dredging activities can be quite variable. However, sound pressure levels are generally in the range of 112 to 160 dB. These sound intensities may influence organism behaviors or perceptions, but would be unlikely to cause physiological damage (Hanson et al. 2003).

Navigation dredging activities would be conducted within the winter in-water work window that extends from December 15th to March 1st. This time period would avoid the presence of many salmon species in the area (see Table 3-1 on migration timing). The timing of dredging operations does pose potential impacts for steelhead adults that may be migrating in the early winter, kelts that may be moving through the confluence area in early spring, or juveniles that may be overwintering. In addition, a small population of juvenile fall Chinook salmon that tend to holdover in the lower Snake River (i.e., have not outmigrated as subyearlings) and spring/summer Chinook may also be overwintering in the vicinity of some of the proposed

dredging and placement areas as indicated by habitat sampling (Tiffan and Connor 2012, Arntzen et al. 2012), PIT-tag data back to 1995, spring seining data back to 1991 (Bennett et al. 1998), and surveys in backwaters of the McNary Reservoir (Easterbrooks 1995, 1996, 1997, 1998).

The habitats directly affected by dredging, principally the navigation channel, are generally deeper than the shallow habitats preferred by fall Chinook (depths less than 10 feet) and would occur for a relatively short period of time. These sandy and silty portions of the riverbed would retain essentially their same characteristics after dredging. Because the area is used as a migratory corridor for ESA-listed anadromous salmon species, there is potential to modify designated critical habitat. However, dredging would not substantially change the cross-sectional areas of the river and, therefore, velocities would not change in areas used for salmon migration or degrade salmon migratory habitat. In addition, dredging would occur for a relatively short period of time during the period of lowest salmonid abundance (Tiffan and Conor 2012). The most substantial effect would be a short term (1 year or less) reduction in available food items. Based on previous investigations, it is expected that disturbed substrates will be rapidly recolonized by macroinvertebrates (Mackay 1992). Additionally, most of the dredging will occur in mid-channel areas during the winter that are used much less extensively by juvenile salmon than shallower, near shore areas (Bennett et al. 1997, Gottfried et al. 2011).

Dredging activities in backwater areas, such as boat basins, could affect fish that may be present in these areas. For example, in the McNary Reservoir, Easterbrooks (1996) reported that during the winter, when dredging would occur, both resident and overwintering anadromous species have been identified as using the backwater areas. Most of the predatory resident fish component was composed of introduced species, and salmonids were composed of both yearling and subyearling Chinook (Easterbrooks 1996). The location of the ports in Clarkston and Lewiston are not off-channel or protected backwater habitats, but are mainstem areas that continually collect both sand and silt. Dredging the navigation channel and berthing areas at these two port facilities in the Snake River is not expected to have short- or long-term deleterious consequences to fish populations or their existing backwater habitat used during winter, spring, and summer rearing. Adult steelhead and juvenile fall Chinook salmon are likely to be disturbed as a result of dredging operations, since it is expected that noise and activity will encourage fish to move to other areas. However, given the relatively small footprint of the operation at any given time, this disturbance is not expected to reach levels that would temporarily or permanently disrupt essential behaviors of fall Chinook or steelhead.

Areas that are suitable for juvenile rearing represent another element of critical habitat for ESA-listed anadromous species in the LSRP. In the past, the Corps has developed shallow water benches in the mainstem lower Snake River by depositing dredged material along the shoreline. The intent of developing these habitats is to increase the availability of shallow water rearing areas and associated invertebrate food sources. Because a large proportion of the shoreline on the lower Snake River is armored or otherwise unsuitable for subyearling fall Chinook, these

shallow water areas represent rearing oases in a relatively homogeneous environment dominated by riprap and steep banks.

Subyearling Chinook that rear and overwinter in the lower Snake River and associated reservoirs appear to prefer deeper water habitat away from the shoreline over shallow water habitats (Tiffan and Connor 2012), As an example, fall Chinook salmon used the shallow water habitat (i.e., submerged bars less than 20 feet deep) created with in-water placement of dredged material that surrounds Centennial Island (Lower Granite Reservoir, near RM 120) (Seybold and Bennett 2010). Subsequent sampling has indicated that in some years, as many as 10 percent of the total sample of subyearling Chinook salmon from the Lower Granite Reservoir originated from the habitat created by in-water placement of dredged materials and that fall Chinook salmon were most commonly collected over lower gradient shorelines that have low velocities and sandy substrate (Seybold and Bennett 2010; Tiffan and Connor 2012; Tiffan and Hatten 2012).

A recent analysis of juvenile fall Chinook salmon use of shallow water habitats in the lower Snake River reservoirs found that fall Chinook used these habitats, including the Corps' shallow water dredged material placement site at Knoxway Bench (located on the lower Snake River between RM 116.5 and 117.5), which was created using dredged materials in 2006 (Naughton et al. 2009). The Knoxway Bench site has been quickly colonized by benthic macroinvertebrates, and the total density of invertebrates was consistently high during both fall and spring (Seybold and Bennett 2010). Creation of shallow-water habitat is expected to enhance fall Chinook rearing areas by providing shallow water habitats with increased macroinvertebrate food sources. The placement of dredged material could have a negative effect on Pacific lamprey ammocoetes by burying them if they are present. However, in the long-term, habitat conditions in the area could be improved for lamprey.

Substrate material and depth are important to the use of habitat created with dredged material. Traditionally, a depth of 20 feet was determined as the boundary between mid-elevation depth and shallower water, based on typical limits of the photic zone conducive for primary and secondary productivity of food web constituents. The 20-foot demarcation was also selected because the shallower zone represents preferred depths of open sandy bench habitat important for juvenile fall Chinook salmon rearing (Bennett et al. 1993a, 1993b, 1995b, 1997; Curet 1994; Connor et al. 1994; Rondorf and Miller 1994). Studies within the Lower Granite Reservoir captured subyearling Chinook salmon over low gradient, low velocity, sandy substrates in the shallow zone indicating their preference for this habitat (Bennett and Shrier, 1986; Bennett et al. 1988, 1990, 1991, 1993a, 1993b). In addition, subyearling Chinook salmon rearing along the shoreline of Lower Granite Reservoir during the spring exhibit a strong selection for substrata consisting of primarily sand and a moderate avoidance of cobble/sand and talus/sand (Curet 1994).

Tiffan and Connor noted that while a sizeable portion of juvenile fall Chinook salmon remained in the lower Snake River after the spring and summer migrations, use of shallow water habitat during fall and winter 2010 was limited. Furthermore, radio-tagged fish located were pelagically oriented, and generally not found over shallow water or close to shore during winter months.

This provides evidence for shallow water habitat use by natural subyearlings during spring and summer, and evidence against large-scale use of shallow water habitat by salmonids during fall and winter. It also provides a biological basis for creating shallow water habitat less than 6.5 feet deep when depositing dredged materials (Tiffan and Conner 2012).

Disposal of dredged material (that is, deep water dumping of dredged material as opposed to beneficial use) would cause temporary localized increases in turbidity and suspended solids, as well as noise disturbance. These factors can affect fish in the immediate area, but their mobility would allow them to temporarily escape the disturbance and return later after the effects of the dredged material placement have dissipated. Both resident and anadromous fish could use the area upstream and downstream of the sites for refuge when dredging and placement activities would occur. The dredging and placement activities would not be a continuous activity confined to a single location and fish would return to the activity areas shortly after completion of the project. Increases in turbidity and effects on other potential water quality parameters are expected to be minimal and short-lived. Potential effects of the dredged material placement operation on downstream migrating salmonids would be expected to vary depending on timing of the downstream migrations, amount of time the migrants spend in the affected areas, and use of the affected areas. Subyearling Chinook that are rearing in the reservoirs tend to inhabit the shallow areas and would not likely be in the vicinity of deep water dredged material placement areas, and would be able to actively avoid the affected area. Both adults and juveniles of other salmon species will most likely not be present within the lower Snake River reservoirs during the in-water work window and therefore would not be affected by the temporary increases in turbidity, suspended solids, and noise. If any are present in the area, the stream-type juvenile out migrants (spring Chinook, most coho, sockeye, and steelhead) are generally relatively larger smolts that move rapidly downstream to the ocean upon entering the LSRP. Therefore, these species are likely to move past the potential dredged material placement sites in a short period of time, and therefore, would have limited exposure to any changes in water quality or food production associated with dredged material placement.

Bull trout adults only intermittently inhabit areas of the lower mainstem of the Snake River where dredging would occur. These fish may enter the reservoirs and mainstem areas during overwintering migrations from the tributaries that they inhabit during the remainder of the year (Faler et al. 2008). These are pelagic adult fish that can actively avoid the dredging operations when noise and other disturbances associated with dredging operations. Spawning and juvenile rearing occurs in the upstream reaches of tributaries and therefore dredging in the mainstem of the Snake River would not affect these life stages for bull trout.

The mainstem of the Snake River is part of the designated critical habitat for bull trout. Dredging operations may cause temporary avoidance of the area by bull trout, but would not permanently alter the ability of the river to provide adult rearing and migration habitat. The spawning, and rearing habitat of bull trout occurs in upper reaches of tributaries and therefore would not be affected by dredging operations.

White sturgeon juveniles and adults would not be affected by dredging operations since they could actively avoid the temporary disturbance. However, there is potential for dredging to disturb some spawning areas which can occur within the navigation channel in areas below the tailrace of dams (Parsley and Kappenman 2000). However, the timing of the in-water work window (December - March)should prevent dredging effects to the sturgeon eggs since spawning occurs during mid May through mid July after the dredging operations would have ceased. White sturgeon spawning occurs in fast flowing sections of the Snake River below dam tailraces (Parsley and Kappenman 2000) and at the upstream reach of Lower Granite Reservoir, so dredged material placement in the deeper, slower flowing reservoirs would not affect white sturgeon spawning habitat.

Pacific lamprey may potentially be present during dredging operations. Although ammocoetes settle out downstream from spawning riffles, the distance downstream that ammocoetes would drift before settling out and burying into the substrate has not been determined. If drift potential includes a substantial distance and ammocoetes migrate slowly downstream with flow, rearing Pacific lamprey could potentially be present in some of the areas proposed for dredging. Because the ammocoetes settle out in backwater areas, most areas that would be dredged or where dredged material may be placed are not likely to be heavily populated. Ammocoetes metamorphose into juveniles and migrate out to the ocean during March through July of the year following their metamorphosis (Wydoski and Whitney 2003). Pacific lamprey lack a swim bladder and are believed to typically occupy the lower portion of the water column and tend to drift downstream with the current during migrations (Luzier et al. 2011; Wydoski and Whitney 2003). This behavior makes them susceptible to entrainment or burial by dredging activities. However, both the juveniles and adults are mobile and could actively avoid dredging activities and the winter in-water work window occurs outside the time frame when the majority of adult and juvenile migration occurs. Furthermore, recent sampling efforts did not positively locate any juvenile lamprey in the types of areas being proposed for dredging or disposal of materials (Arntzen et al. 2012).

4.1.2.2 Immediate Action

Effects on Plankton and Benthic Community

The effects on the plankton and benthic community as a result of the immediate action of Alternative 5 (dredging, dredged material management, and navigation objective reservoir operation) would be the same as the effects described above under future actions.

Effects on Aquatic Plants

The effects on aquatic plants as a result of the immediate action of Alternative 5 (dredging, beneficial use of dredged material, and navigation objective reservoir operation) would be the same as the effects described above under future actions.

Effects on Fish (Including Threatened and Endangered Species)

The effects on fish as a result of the immediate action of Alternative 5 (dredging, beneficial use of dredged material, and navigation objective reservoir operation) would be the same as the effects described above under future actions. Redd surveys would be conducted in the tailrace of Ice Harbor Dam where potential fall Chinook spawning habitat occurs prior to initiation of the proposed action in accordance with the monitoring plan (Appendix J). No known spawning habitat is present in the Lower Granite pool portions of the proposed immediate action.

Alternative 5 dredging sites and disposal site would be monitored to ensure the operation complied with state turbidity standards and would provide a relatively minimal risk to salmonid adults. The effect was considered minimal because the location and footprint of the dredging sites would be well mixed within adequate background TSS or turbidity waters for which both juvenile and adult salmonids could readily escape or avoid the exposure to the elevated plume dissipating from the dredge.

If turbidity should reach unacceptable levels, the Corps would alter its operations (i.e., modify dredging timing, speed, and/or location) until the turbidity returns to background levels. A biological assessment was prepared for the immediate action and documents the effects on listed fish species. The immediate action “may affect” and would “likely adversely affect” Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon, and bull trout; and “may affect” but “not likely to adversely affect” Upper Columbia spring Chinook salmon, steelhead and sockeye salmon (Appendix K).

4.1.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

As described in Section 2, this alternative focuses on the use of structural sediment management and system management measures in the lower Snake River by the Corps. All sediment and system management actions under this alternative would occur within the lower Snake River reservoirs. In comparison to Alternative 1 and Alternative 5, Alternative 7 provides a broader array of sediment management tools for the Corps to consider and potentially implement, including measures that involve in-water work, permanent in-water structures, and operational changes to the LSRP. Direct effects of dredging and dredged material management under Alternative 7 are the same as those discussed under Alternative 5.

4.1.3.1 Future Actions

Structural sediment and system management measures are generally within the Corps’ authority to analyze, design, and implement, and include installation of bendway weirs and dikes, mechanical agitation to resuspend material, trapping sediments in the reservoirs, dredging to improve flow conveyance, navigation channel dredging and in-water or upland placement of dredged material. Effects of dredging and dredged material management are described above in Section 4.1.1, and are not repeated in this section. Because actions associated with structural

sediment management measures and some system management measures involve many of the same impacts such as in-water work, use construction equipment, and localized substrate disturbance and increased turbidity, they will be discussed together in the following section.

Direct effects to aquatic resources from structural sediment management measures would largely result from in-water construction, and possibly from dewatering and fish salvage (where fish are collected from the area to be dewatered and relocated outside the dewatered area), and dredge entrainment, increased turbidity, and noise, if those actions are required for construction. Fish salvage would be conducted under the supervision of a qualified Corps biologist and in accordance with NMFS and applicable state guidelines. Addition of structures within the river channel would alter flow patterns, sediment, and disrupt or remove local benthic communities. Both dredging and installation of structures would alter local aquatic habitat by changing depths and flow patterns.

The construction process for adding in-stream structures (bendway weirs, dike fields, or in-reservoir sediment trapping systems) would adversely affect water quality by increasing in-stream turbidity during construction and for a short period following construction. Agitation to suspend sediment would also create in-stream turbidity during implementation. With increased turbidity, increased substrate embeddedness and pool filling are possible during and after construction, at least until equilibrium in and around the new structure is established.

For most structural sediment management measures, construction and other heavy equipment such as dredges and barges would be used during implementation. Accidental releases of diesel fuel, lubricants, hydraulic fluid, and other contaminants contained in heavy equipment could potentially result in acute negative impacts to fish, invertebrates, and aquatic habitat. In addition, long-term effects could also result if a spill was not properly remediated. All over-water construction vessels would be fueled at existing commercial fuel docks. Such facilities have existing spill prevention systems in place that would be adequate to avoid spills or immediately address any accidental spills that do occur. The only potential sources of contaminants at the construction sites would be the construction equipment itself (lubricating oils and fuel).

A variety of system management measures in addition to navigation objective reservoir operation, as described in Section 2, could be implemented within the LSRP. These measures include flow modification to flush sediments, reconfiguring or relocating affected facilities to avoid problems with sediment deposition, and raising levees to provide for added flow conveyance capacity.

The main effects of flow modification measures to the aquatic environment would be from changes in flow conditions, water levels, and sediment dispersion patterns. Reconfiguring or relocating facilities would involve some in-water construction, such as at water intake structures, mooring facilities, and docks. In those instances, effects to the aquatic environment would be similar to those described for the in-water construction activities of the structural sediment management actions, and would include noise, local turbidity, and potential chemical spills from equipment.

Effects on Plankton and Benthic Community

Construction of bendway weirs or dikes would adversely affect benthic organisms that inhabited the site prior to the beginning of construction. After construction, as sediment accumulates between the weirs, recolonization is likely to occur as discussed with dredging and dredged material placement operations. However, changes in the hydrology and sediment accretion could preclude the site from returning to its preconstruction benthic community. This could be beneficial in cases where the preconstruction conditions held poorly populated benthic communities. The accumulation of new sediment could allow the colonization of these areas and therefore benefit primary productivity and the food web.

Construction of bendway weirs or dikes would have little discernible effect on plankton in the reservoirs. Localized effects could include temporary displacement from the construction sites and potential reduced feeding ability from increased suspended sediment from construction and in water disposal.

During construction activities, benthic invertebrates within the construction zones would either be displaced or suffer mortality. Mobile organisms such as crayfish could escape construction activities, while immobile organisms living in the substrate would be killed. Their loss would be of a short term nature because the area of impact would be repopulated rapidly by organisms such as larvae of mayflies, caddisflies, and midge larvae that drift with the stream current and readily recolonize disturbed areas.

The construction of the dikes themselves would have less impact on the benthic community than the scouring of the river channel that would occur after the dikes are in place. These effects would be localized in navigation channel areas where few benthic organisms reside. Changes in flow patterns for both bendway weirs and dikes could redistribute planktonic organisms to other areas, but little effect on abundance would occur. For nonmobile organisms such as benthic invertebrates and plants, the process would result in their dispersal with the agitated sediment, and deposition downstream. If the sediment contains organic materials in an anaerobic state, resuspension will increase the ***biological oxygen demand*** and depress dissolved oxygen (Johnson 1976).

Plankton communities would not be affected by reconfiguring facilities, but could be affected by flow modifications used to flush sediments downstream. Increasing flows to flush and transport sediment downstream and out of the reservoirs would also carry some of the plankton community out of the reservoir as well. This loss would be temporary as flows would return to previous rates after the flushing operation has occurred and plankton growth would resume in the slower waters of the reservoirs.

While benthic macroinvertebrate biomass shows a large amount of natural fluctuation in the Lower Granite Reservoir (Benett et al. 1993a), the effects of system management measures would be relatively predictable. In the case of the drawdown action, macroinvertebrates exposed to dewatering would likely not survive. Recolonization would likely take several weeks to

several months. Consequently, if multiple drawdown actions occur within that time frame, the invertebrate populations may not recover adequately between events. For the measures that include reconfiguring or relocating affected facilities, localized effects to the macroinvertebrate community would result in displacement or mortality during in-water construction as described previously; however, post-construction recolonization would likely result in recovery within several months.

Effects on Aquatic Plants

Aquatic plants within the construction site would be lost due to excavation and installation of the in-water structures (weirs, dikes, traps, or relocated/modified facilities). Once construction is completed, the bottom habitat and substrate composition would be changed and, in the case of weirs or dikes, the accretion of fine sediments around the dikes could preclude recolonization by aquatic plants.

Agitation to suspend sediment would create turbidity and agitated sediments would be transported away from the agitation site, potentially settling on aquatic plants in another location, and adversely affecting them.

System management actions would have differing effects on aquatic plants. During drawdown activities, submerged aquatic vegetation would be negatively affected in dewatered areas. However, repopulation in new shallow water habitat would likely occur long term. During construction activities associated with reconfiguring or relocating facilities, localized areas may experience submerged aquatic vegetation losses, but would not affect overall population assemblages.

Aquatic macrophyte densities are generally low throughout the Lower Granite Reservoir, occurring only in shallow waters. In 1993, no macrophytes were found in water greater than 3 feet in depth (Bennett et al. 1995b). Species composition of macrophytes was dominated by pondweed in 1992 and 1993 (Bennett et al. 1995a; Bennett et al. 1995b). Because of their occurrence in shallow waters, reservoir-wide abundance of aquatic macrophytes varies with water level, greatly decreasing during periods of reservoir drawdown (Bennett et al. 1995a). Despite their low abundance, aquatic macrophytes can have strong effects on variables important to juvenile salmonids. Bennett et al. (1995a) documented highest abundance and standing crop of macroinvertebrates, especially Dipterans, in areas of high macrophyte abundance.

Effects on Fish (Including Threatened and Endangered Species)

Construction of bendway weirs or dike fields would have effects on fish that inhabit the area during the construction of the structures. Construction during the in-water work window would minimize the number of species and individuals temporarily displaced by the dewatering of the construction site. However, as described in Section 3.1, steelhead and fall Chinook may be present throughout much of the year and could be in the areas proposed for in-water work or dredging during the construction and dredging periods.

Structures may be constructed out of riprap or sheet pile. If sheet pile is used, pile driving would have temporary, direct adverse impacts on fish in the vicinity of the project due to increased noise and vibration in the aquatic environment. Effects on salmonids would be minimized by conducting work during the approved in-water work period when fish are not likely to be present. Noise and vibration would adversely affect resident fish. Adverse effects of pile driving may be mitigated through various construction practices such as measures that include bubble curtains, pile hammer cushions, and coffer dams. If pile driving is involved with implementation of a measure, the Corps will assess and develop measures to reduce the noise and vibration effects on fish.

The changes in channel morphology concentrate a more diverse bottom structure and hydraulic response within the weir fields than what was present in the unaltered bend. This increase in diversity in the environment has attracted greater numbers of fish and greater diversity in a study on the Mississippi River (Wilson 1997). Deep holes and sand bars are generated in the course of operation of the weir fields, which provides a diverse environment for various aquatic species. This can also have the effect of increasing habitat for ambush predator species such as smallmouth bass, especially if the weirs are constructed of material such as riprap.

Because these features would be located along the navigation channel, most construction activities would take place in deeper water where impacts to rearing and spawning habitat would be minimal. However, these structures would slightly alter the flow characteristics of the river channel and thus have a localized effect on critical habitat for the ESA-listed salmon species that use the lower Snake River as a migratory corridor. Addition of structures within the river channel would alter localized flow patterns, depths, sediment, and disrupt or remove local benthic communities. These changes would be within the vicinity of the constructed structures and may alter some of the specific routes within the river for migrating adult and juvenile salmon but would not impede their migrations.

Direct effects of agitation on fish would be very similar to those from dredging described below. These include temporary increased turbidity, displacement of fish from the location where agitation is occurring, and disturbance from noise during the operation. These impacts would be temporary, and mobile organisms can escape and return to the area when turbidity and disturbance levels return to ambient.

These measures would not affect bull trout which rear and spawn far upstream in the tributaries. Adults are only occasionally present in the mainstem and reservoirs and they could actively avoid the localized construction effects such as noise and turbidity. Because bull trout primarily inhabit the cooler waters upstream in tributaries, the temporary effects to the food web in the construction areas would have a negligible effect on food resources for bull trout.

Construction of weirs and deposition of dredged material to create shallow water habitat would potentially reduce the amount of mid-water bench habitat used by white sturgeon. Loss of food resources in the localized area of disturbance could cause some white sturgeon to relocate to undisturbed areas where the benthic macroinvertebrate community remained intact. As described

earlier in section 4.1.1 with regard to dredging, this effect would be temporary. Avoidance of the construction areas by sturgeon due to the disruptive activities would allow sturgeon to limit or eliminate their exposure to the effects of noise and increased turbidity.

Adult upstream migration of Pacific lamprey occurs in September and October and juvenile downstream migration occurs in May and June. Because the timing of movements would not overlap with the in-water work window, no direct effects on Pacific lamprey are anticipated. Disposal of the dredged material would not impact food resources for Pacific lamprey because neither the adults nor juveniles feed while moving through the Lower Snake River.

A drawdown/flushing operation of the Lower Granite Reservoir is likely to adversely affect listed salmonid species due to increased turbidity, loss or alteration of shallow water rearing habitat, modified juvenile passage survivals through the routes at Lower Granite, and loss or alteration of spawning habitat due to sediment transport. These impacts would be lessened to some degree if the measure was implemented during the winter in-water work window. Temporary disturbance (dewatering for up to a month during the early outmigration of subyearling fall Chinook salmon) of suitable critical rearing habitat along the shorelines would also occur.

The drawdown measure would result in suspension of sand and silt in the water column and deposition further downstream, resulting in increased turbidity within the reservoir. This may result in exceeding natural background levels, potentially affecting ESA-listed fish species. For salmonids, turbidity elicits a number of behavioral and physiological responses (i.e., gill flaring, coughing, avoidance, and increase in blood sugar levels), which indicate some level of stress (Bisson and Bilby 1982; Berg and Northcote 1985; Servizi and Martens 1992). The magnitude of these stress responses is generally higher when turbidity is increased and particle size decreased (Bisson and Bilby 1982; Gregory and Northcote 1993). Although turbidity may cause stress, studies have shown that moderate levels of turbidity (35-150 NTU) accelerate foraging rates among juvenile Chinook salmon, likely because of reduced vulnerability to predators (camouflaging effect) (Gregory and Northcote 1993). In lamprey the increased turbidity has been associated with a trigger to begin juvenile outmigration and, depending on the timing, may result in premature arrival to the ocean. When the particles causing turbidity settle from the water column, they contribute to sedimentation. Sedimentation can cause the following effects: (1) buried salmonid eggs or embryos may be smothered and suffocated; (2) prey habitat may be displaced; and (3) future spawning habitat may be displaced (Spence et al. 1996).

The magnitude of flows in the mainstem Snake River influences water velocity, fish travel time, project operations, the amount of spawning habitat and shallow-water rearing habitat. These effects primarily influence juvenile migrant survival, which generally improves as flows increase (Cook et al. 2007). Dam and reservoir management to improve flow-related fish survival has been a major aspect of fish protection efforts since the late 1970s. Storage reservoir operations were further revised in successive consultations (1995, 2000, and 2004). In total, 5 to 6 million acre-feet of stored water are annually devoted to enhancing flow conditions in the Snake and

Columbia Rivers during juvenile migrations. Winter drafts are also limited to minimize the reduction of flows that occur each spring while the storage reservoirs are being refilled.

Snake River ESUs of Chinook, sockeye, and steelhead have juveniles that undertake outmigrations in the spring. Through the drawdown action it is possible that flows could be increased during outmigration periods and may slightly improve the functioning of the migration corridor and mainstem juvenile rearing habitat during those months.

However, depending on the timing of the drawdown, it is possible that flow reductions during refill following drawdown could result in slightly decreased juvenile Snake River fall Chinook survival due to water temperature increases. Recent research has shown that the proclivity of juvenile Snake River fall Chinook to continue migrating as subyearlings diminishes during July (Cook et al. 2007). Through the summer an increasing fraction of Snake River fall Chinook entering Lower Granite Reservoir remain in the reservoir and migrate during the following year as yearlings. Thus, higher water temperatures in summer (which negatively affects the survival of both migrating and resident salmonids) become increasingly important. During the hot summer months of July and August, operations at Dworshak Dam, designed to release sufficient cold water to maintain Lower Granite Dam tailrace water temperatures at or below 68°F, likely become the most important factor affecting juvenile Snake River fall Chinook survival through the Lower Granite Reservoir in the event of drawdown.

Another effect of the drawdown action is the potential adverse influence on spawning habitat. Since the construction of the lower Snake River dams, spawning habitat has been reduced for Snake River fall Chinook. If drawdown were to occur during spawning season it could result in redd stranding.

The actions to reconfigure or relocate affected facilities would include the use of mechanized construction equipment, in-water work, and fill and/or removal. Construction during the in-water work window would minimize the number of species and individuals temporarily displaced by the dewatering of the construction site. However, as described in Section 3.1, steelhead may be present throughout much of the year and could be in the areas proposed for in-water work during the construction periods. Overwintering juvenile fall Chinook could be present during construction, as well as both juvenile and adult steelhead. Worksite isolation would be used as a minimization practice, consisting of several measures meant to decrease fish exposure to the effects of construction activities. Despite this, it is likely a small number of juvenile salmonids could be injured or killed during construction of relocated or reconfigured facilities.

Levee raise construction activities would be on and around levees adjacent to Lower Granite Reservoir. Minor impacts to fish during construction due to noise and vibration. Ground disturbance would likely be minor and confined to the top of the existing levee. No long-term or indirect effects to fish or other aquatic resources would occur from raising levees.

The indirect effects of structural sediment management measures would largely result from the redispersal of sediment from the construction of in-water structures. The benthic invertebrate and

plant community, however, would be altered over the long term. Flow and sediment deposition patterns altered from the in-water structures would likely preclude recolonization by benthic organisms and the aquatic plants that previously inhabited those sites.

Weirs and dike fields could create habitat conditions that are favorable to smallmouth bass and other species that are juvenile salmonid predators, which would be an adverse effect on salmonids. Weirs and dike fields would provide substrate for some invertebrate species.

Changes in flows and sediment flushing would redistribute sediments downriver, which would accumulate over time. This could have long-term affects on benthic communities and fish habitat where the sediment accumulates. These effects would be similar to those described for the direct effects of sedimentation, but would occur later in time and in areas downstream of the action.

4.1.3.2 Immediate Action

Effects on Plankton and Benthic Community

The effects on the plankton and benthic community as a result of the immediate action of Alternative 7 would the same as the effects described above under immediate action for Alternative 5.

Effects on Aquatic Plants

The effects on aquatic plants as a result of the immediate action of Alternative 7 would be the same as the effects described above under immediate action for Alternative 5.

Effects on Fish (Including Threatened and Endangered Species)

The effects on fish, including threatened and endangered species, as a result of the immediate action of Alternative 7 would the same as the effects described above under immediate action for Alternative 5.

4.2 Terrestrial Resources

4.2.1 Alternative 1: No Action (Continue Current Practice)

Navigation objective reservoir operation would result in a minor adverse effect to terrestrial wildlife habitat located on the margins of reservoirs where pool levels are raised by drowning out habitat types that cannot handle inundation, thereby decreasing the amount of available wildlife habitat. Raising pool levels would have direct effects on wildlife species through the direct take of individuals or a high level of harassment. The impact is expected to cause minor to moderate short-term impacts, with minor, long-term impacts.

Shoreline wetlands could be temporarily affected by operating pool levels for the navigation objective and within the preset operating range for each reservoir. Under this measure, wetlands would either be exposed (i.e., dried out) due to lower water levels, or inundated due to higher water levels, resulting in changes to wetland water quality, hydrologic, or habitat function. Under this measure the Corps would continue to manage pool levels within the present operating range for each reservoir. Since shoreline wetlands are dynamic systems that are currently adapted to this type of fluctuation, this measure is expected to result in minimal, temporary adverse effects and no long-term direct effects to wetlands.

4.2.2 Alternative 5: Dredging-Based Sediment Management

4.2.2.1 Future Actions

Dredging and beneficial use of sediment could result in intermittent and temporary displacement of wildlife species from the operation of construction equipment. These activities are not expected to prevent wildlife from obtaining food or otherwise using the areas adjacent to the dredging and beneficial use of sediment sites. Riparian habitat, as well as shoreline perch trees for raptors and other birds, would not be affected. Waterfowl, birds, aquatic furbearers, and other wildlife could be temporarily displaced by activities; however, they would likely use areas upstream and downstream of the sites where dredging and beneficial use of sediment activities occur.

Most activities associated with dredging would be performed in deeper water, away from wetlands and are not anticipated to effect wetlands. It is assumed that existing entry and exit points and staging areas for work would be used and would not result in impacts to wetlands. Beneficial use of sediment, if used for enhancement or creation of aquatic and wildlife habitat, could positively affect wetlands. The dredged material would provide an ideal source of substrate material for near shore habitat and wetlands restoration, which could potentially improve the size, function, and quality of nearby wetlands.

Dredging and beneficial use of sediment would be a temporary activity and would not be continuous. Effects would be minor, short-term, and localized, as adjacent areas would be available for foraging, feeding, and perching. Waterfowl and other wildlife would return to the areas shortly after completion of the dredging and beneficial use of sediment. Mammals such as

mule deer would not be impacted as there would be no upland areas affected. Dredging and beneficial use of sediment are expected to cause temporary localized adverse effects to terrestrial wildlife species. No long-term effects are anticipated to occur to vegetation, wetlands, or wildlife species.

As discussed in Section 3.2 (Terrestrial Resources), federally listed or other protected wildlife species have the potential to be present near the dredged or beneficial use sites under this alternative. However, given the proposed dredging and beneficial use of sediment activities would occur within the river, the measures are not expected to cause any appreciable impact to ESA-listed or other protected terrestrial wildlife species or plants. Alternative 5 could cause temporary displacement of individuals on the water; however, species are expected to leave the area of impact as there are multiple alternate locations for species to locate.

The Joso HMU is a disturbed site that was historically used for gravel extraction and currently contains an exposed open gravel quarry. If used for upland sediment placement, the area would be stabilized following each dredging cycle and would be recontoured and restored with native plantings following completion of all dredging over the next 20 years. With completion of the placement and revegetation, the site would revert to wildlife habitat similar to the surrounding area. The effects to terrestrial resources, including wetlands and terrestrial wildlife, would result from dredged material storage activities at the site as well as construction-related activities and related direct effects. There would be a time lag of 5 to 7 years where habitat once available would be either unvegetated or in the early regrowth stages after restoration. As restoration progresses and as areas are filled, developed habitat would still be fragmented until all work ceases; however, an overall increase in wildlife habitat area and function is expected in the long term. These effects are expected to be localized with an overall long-term benefit by increasing wildlife habitat function through site restoration.

Currently there are no ESA-listed wildlife species known to use the Joso HMU, limiting any ESA direct impacts at this location at this time. Selection and further development of any measure would be subject to project-specific tiered environmental review and requirements, including the Endangered Species Act.

4.2.2.2 Immediate Action

The effects on vegetation, wetlands and terrestrial wildlife species as a result of dredging would be the same as effects described above under future actions.

No terrestrial ESA-listed or candidate species would be affected by the immediate action for this alternative (Appendix K).

4.2.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.2.3.1 Future Actions

Direct effects of dredging and dredged material management under Alternative 7 are the same as those discussed under Alternative 5.

In-water disposal of sediments would occur primarily in deep water and mid-depth areas of the Snake River where terrestrial species are not present. As a result, this measure would have no effect on terrestrial resources.

Construction activities associated with bendway weirs, dikes/dike fields and the relocation or reconfiguration of facilities may require some construction on the near shore, which could result in minor to moderate short-term direct effects to wildlife by the potential removal of their habitat. Construction of these facilities also has the potential to fill or clear shoreline wetland. Resulting in a long-term loss of some wetland area in bends where wetlands are present.

However, because the majority of the actions are to occur in the water, no long-term effects are expected due to the small areas of upland impact that are expected. The short-term loss of wildlife habitat type and function would be avoided to the extent feasible and would be limited due to the expected construction. These changes would be short term (where fast growing vegetation is affected) or long term in areas of woody vegetation, resulting in a minor, adverse direct effect to upland resources.

Construction activities would have minor, short-term effects within and immediately around location of levee raise. The Lewiston levees are in an urban area, so disturbance would affect developed, landscaped areas of the levees and would have little or no effect on wildlife, plants, or wetlands.

No short- or long-term direct effects are expected as a result of sediment trapping or agitation to upland wildlife habitat types, as the measures would occur in the water where terrestrial resources are not present.

Redirection of flows from bendway weirs, dikes/dike fields may result in loss (erosion) of wetland area on the inside of a stream bend (when wetlands are present in these locations).

The direct effects of operating pool levels for the navigation objective described under Alternative 1 would be the same under Alternative 7.

The reservoir drawdown component of this alternative would have an adverse effect on terrestrial wildlife habitat. Terrestrial wildlife such as beavers and muskrats would be displaced from their lodges and burrows during drawdown, exposing them to increased predation. Deer that walk onto the mudflats could sink into the mud and also be subject to increased predation. Birds and small mammals (i.e., mink, raccoons, otters, and skunks) would benefit from the

increased food source of aquatic organisms that would be stranded because of the drawdown. Reservoir drawdown or flushing would expose (i.e., dry out) wetlands due to lower water levels. This measure would be an infrequent event and water levels would return to normal operating levels following drawdown or flushing. Shoreline wetlands are dynamic systems that are well adapted to this type of fluctuation. As a result, these measures are expected to result in minimal, temporary adverse effects and no long-term direct effects to wetlands.

As discussed in Section 3.2 (Terrestrial Resources), federally protected wildlife species are listed in counties adjacent to the lower Snake River. However none occur in areas that would be affected by Alternative 7 measures. Selection and further development of any measure would be subject to project-specific tiered environmental review and requirements, including the Endangered Species Act.

4.2.3.2 Immediate Action

The effects on vegetation and terrestrial wildlife species as a result of dredging would be the same as effects described above under Alternative 5.

4.3 Recreation

4.3.1 Alternative 1: No Action (Continue Current Practices)

Navigation objective reservoir operation would provide some benefits to recreational boating by alleviating the difficult or hazardous access to boat basins that are experiencing sediment deposition. While the recreation sites were designed to operate within the full range of pool elevations, some boat basins/boat ramps are experiencing sedimentation problems that are limiting boat usage or are at least an inconvenience at MOP. The benefit from a pool level raise would cease once maximum pool level was reached. Swim beaches have been less usable at MOP and would also benefit from raising the pool levels. Maintaining the navigation objective would have little or no effect on land-based recreation or water-based recreation not associated with problem boat basins.

No changes to recreational patterns or visitation rates are expected from Alternative 1.

4.3.2 Alternative 5: Dredging-Based Sediment Management

4.3.2.1 Future Actions

Recreational users of park and recreation facilities along the lower Snake River may be disturbed by dredging activities and the presence and use of large mechanical equipment. Dredging activities would have minor, short-term, adverse effects on aquatic recreation, such as fishing and boating, in the vicinity of the dredging locations and material placement sites in the Lower Snake River. Minor temporary effects on land-based recreation would result from dredging in the lower Snake River adjacent to recreation areas. Dredging would likely occur during the approved in-water work period (December 15 through March 1) when recreation use is generally low, which would also minimize any effects on recreation.

Dredging intended specifically to remove accumulated sediment that interferes with recreational uses, such as at boat basins or marinas, would provide a direct, long-term beneficial effect to water-based recreation.

Upland placement of dredged sediments at the Joso HMU would have a minor, temporary adverse direct effect on recreational use at the HMU; however, very little recreational use takes place at this location. Upland placement would have temporary, direct effects on river users, hunters, and the nearby Lyon’s Ferry Park and Lyon’s Ferry Marina facilities during material placement. These effects are anticipated to be minor because the placement area is set back at least 600 feet from the river shoreline and is not directly visible from Lyon’s Ferry Park, located on the opposite side of the Snake River, or from Lyon’s Ferry Marina located about a mile upstream. Boaters using the marina would experience only a minor increase in barge traffic accessing the disposal site.

The dredging based sediment management measures are not expected to result in changes to recreational patterns or visitation rates.

The effects on recreation from maintaining pool levels at the navigation objective would be the same as described above for Alternative 1.

4.3.2.2 Immediate Action

The effects to recreational resources as a result of the immediate action of Alternative 5 would be the same as effects described above under future actions. Specific immediate action effects are described below.

The proposed maintenance dredging and disposal at RM 116 are expected to have some effects on recreational users of the river where the dredging and disposal is taking place. However, the effects would be minor due to the low levels of recreational activities that occur during the winter months. The Corps plans to publicize the dates of the proposed dredging operations to alert anglers and boaters. The proposed action does not include dredging any recreation sites, boat basins, and boat launches, therefore these areas would see continued access problems.

One type of recreational activity, steelhead fishing, could be affected by the proposed dredging actions. Steelhead fishing is a popular recreational activity in the confluence area. The steelhead season in this area extends from June through March in Washington and from September 15 to April 15 in Idaho. There is some concern that the turbidity plume caused by the dredging may discourage steelhead from moving upriver or may discourage fishermen from trying to catch steelhead. However, the number of steelhead passing over Lower Granite usually decreases by the third week of November. In recent years, the steelhead season has been winding down by the first of January. Because dredging would not start until December 15, the peak of the steelhead season should have passed prior to the start of dredging. Also, the allowable increase in turbidity close to the dredge operation would be low relative to the natural variations in background turbidity. Therefore, the dredging operation should have a minor negative impact on recreational steelhead fishing.

The dredging based sediment management measures are not expected to result in changes to recreational patterns or visitation rates.

4.3.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.3.3.1 Future Actions

Direct effects on recreation from structural sediment management measures under Alternative 7 in the lower Snake River would include the same activities and effects associated with dredging and beneficial use of dredged sediments as described under Alternative 5 above. Temporary, adverse direct effects on recreation from the construction of bendway weirs, dike fields, or reconfiguring and relocating affected facilities (such as water intake structures, commercial navigation facilities, or recreational boating facilities), would include potential effects on users' experiences near the construction area. For example, if bendway weirs or dike fields were constructed in an area of the river near an existing recreation area (land- or river-

based), recreation activities would be disturbed, and perhaps eliminated temporarily, during construction. Long-term, adverse direct effects would include potential navigation hazards to recreational watercraft posed by weirs and dike fields, and potential long-term disruption of fishing locations.

Short-term, adverse direct effects on recreation from agitation to resuspend sediment would include effects on river recreation in the immediate area of implementation due to noise, presence of equipment, and increased turbidity. Long-term, beneficial direct effects would include continued recreational use of aquatic facilities, specifically if agitation is addressing sediment accumulation that impedes recreation.

Short-term and moderate, adverse direct effects on recreation would result from activities associated with modifying flows to flush sediment. This measure would result in substantial changes in water levels and flow conditions, likely interrupting water-based recreation during the flushing event (likely several weeks in duration). No long-term direct effects on recreation would result from modifying flows to flush sediment as water levels would be returned to within normal operating ranges.

Trapping upstream sediments by excavating an area within the reservoir would have long-term, adverse direct effects on users and activities at any recreational facilities near the point of excavation. Long-term placement and operation of mechanical dredges and in-water work would preclude aquatic recreation in the sediment trapping area and would affect users' experience at adjacent facilities, if any, due to noise and presence of equipment.

Reconfiguring and/or relocating affected recreational facilities in the lower Snake River would result in long-term, beneficial direct effects on the affected facilities, improving the facilities' accessibility and function for boating, fishing, or other recreational activities.

Construction would have a temporary adverse effect on recreation activities that occur on the Lewiston Levee system if levee raises were proposed in portions of the levees used for recreation. Visitation to the recreation facilities that include the Lewiston Levees would be reduced and recreational activities (primarily trails) would be interrupted during construction. Recreational use would be restored following construction, and there would be no long-term or indirect effects on recreation.

Alternative 7 would not have indirect effects on land-based recreation. Measures that direct sediment away from locations where it could affect recreational use (such as the entrance to a boat basin), would have a beneficial long-term effect on water-based recreation. Adaptive management through sediment and system management measures are not expected to result in changes to recreational patterns or visitation rates.

4.3.3.2 Immediate Action

The effects on recreational resources as a result of the immediate action of Alternative 7 would be the same as effects described above under immediate action for Alternative 5.

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4.4 Cultural Resources

4.4.1 Alternative 1: No Action (Continue Current Practices)

Maintaining pool levels at the navigation objective may cause shoreline archaeological sites or portions of sites to be inundated for longer periods of time. This can provide some protection for sites; however, the more likely outcome is that longer exposure to high water levels could lead to increased erosion and loss of portions of archaeological sites. Long-term effects can include loss of a site and/or contributing elements of archaeological districts. Changes in water levels would not be substantial, but do have the potential to adversely affect archaeological sites when higher water levels are maintained. The change in flows and velocity also has the potential to introduce adverse effects to historic properties of religious and cultural significance to Indian tribes by altering landforms and impeding access to sites. Historic buildings, including the dams, would not be affected by maintaining pool levels at the navigation objective.

4.4.2 Alternative 5: Dredging Based Sediment Management

4.4.2.1 Future Actions

Early archaeological surveys conducted under the auspices of the Smithsonian Institution's River Basin Survey Program, along with on-going management of archaeological resources by the Corps of Engineers, has identified numerous archaeological sites. Sites include those that are on the lands adjacent to the rivers, as well as a number of sites that were subsequently inundated after construction of the LSRP. Dredging and disposal activities carried out near shorelines, confluences, alluvial fans, islands or channel bars, and in the area of recorded archaeological sites has the potential for ground disturbance that can bury, damage or destroy archaeological sites.

Dredging and the disposal of dredged material also have the potential to disturb values associated with historic properties of religious and cultural significance to Indian tribes. The Corps recognizes a number of these types of sites, many of which were inundated when the reservoirs associated with the LSRP were filled.

One other aspect of dredging that has the potential to affect historic properties is the disturbance of secondary deposits of archaeological material that may occur within sediments identified for dredging; including, potentially, human remains. Although the secondary deposition of the archaeological material likely means it retains no archaeological value, it may have traditional religious and cultural significance, especially in the case of human remains. For this reason, in-water disposal of dredged material is preferred as it ensures that the material remains in the river, in a secondary depositional environment. However, in shallow areas where dredged material may be placed for beneficial use, material placement and contouring and anchor lines also have the potential to disturb or bury inundated sites. Depending on where work takes place, construction activities may introduce disturbances to historic properties of religious and cultural significance to Indian tribes.

Use of mechanized equipment for upland placement of dredged material for beneficial use has the potential for ground disturbance that could adversely affect archaeological sites or cause damage to subsurface artifact site integrity. Placement of fill has the potential to bury archaeological sites. This may entail some beneficial protection; however, the chemical effect of burying sites is not well understood. Reuse of fill in conjunction with habitat enhancement may have beneficial effects for historic properties of religious and cultural significance to Indian Tribes.

Over the long-term, dredging and dredged material management activities associated with this alternative have the potential to adversely affect archaeological sites that are contributing elements of an archaeological district. These activities also have the long-term potential to adversely affect values of historic properties of religious and cultural significance to Indian tribes.

Selection and further development of any measure would be subject to project-specific tiered environmental review and requirements, including the National Historic Preservation Act.

4.4.2.2 Immediate Action

Potential effects to cultural resources as a result of the immediate action of Alternative 5 would be the same as effects described above under future actions. Specific immediate action effects are described below.

Dredging would be done in both Washington and Idaho. In the Washington locations, some dredging would be done in close proximity to archaeological sites, but should not directly impact any of them. This is because all identified locations have been previously dredged to the same depths planned for the near-term maintenance dredging actions (Table 1-3). In addition, the selected dredging method would not go below accumulated sediments into riverbed material.

In Idaho, two locations would be dredged. Each location has a portion of an archaeological site included within the study area but, again, it is not anticipated that dredging activity would impact cultural properties because both locations have been previously dredged several times to the same depths proposed for the near-term maintenance dredging actions (Table 1-3). In addition, the selected dredging method would not go below accumulated sediments into original riverbed material.

In-water placement of dredged material has the potential to bury inundated archaeological sites. Upland disposal of dredged material may entail some beneficial protection; however, the chemical effect of burying sites is not well understood. Reuse of fill in conjunction with habitat enhancement may have beneficial effects for historic properties of religious and cultural significance to Indian Tribes. However, construction of site access (e.g., roads), if required, would potentially increase access and traffic in the vicinity of the placement site, leading to an increased risk for damage to archaeological sites and adverse effects to historic properties of religious and cultural significance to Indian tribes.

Upland placement of dredged material could displace or destroy surface sites; in addition, heavy equipment can compact the soil, causing damage to subsurface site integrity. Concerns for constriction activities include activities in associated staging and lay-down sites. In shallow areas, barge and/or draglines and anchor lines also have the potential to disturb sites.

Disposal of the material at approximately RM 116 is also consistent with previous disposal actions. Although the immediately planned dredged material in-water disposal would extend to the west of the previously used areas, it would remain east of known, inundated archaeological sites. In-water disposal would also not affect any values associated with sites of religious and cultural significance to Indian tribes known for the vicinity.

The immediate action is not anticipated to have adverse effects to any archaeological material located within a secondary context, as that material would be relocated into a similar environment within the Lower Granite Reservoir. Similarly the immediate action is not anticipated to have any effects to historic properties of religious and cultural significance to Indian tribes.

4.4.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.4.3.1 Future Actions

Any dredging and dredged material management performed under Alternative 7 would have the same effects as Alternative 5.

Construction of bendway weirs, dikes/dike fields, and reconfiguration and relocation of affected facilities would involve upland and in-water construction that could adversely impact archaeology sites. Use of mechanized equipment has the potential for ground disturbance that can displace or destroy surface sites; in addition, heavy equipment can compact the soil, causing damage to subsurface site integrity. Construction also will create ground disturbance, a threat to archaeological sites. Placement of fill has the potential to bury archaeological sites. This may entail some beneficial protection; however, the chemical effect of burying sites is not well understood. Removal of riverbed or shoreline material, if required, has the potential to expose sites if removal reaches below the level of the fill, subjecting the site to potential vandalism and to wind and wave action that leads to erosion.

Agitation to resuspend sediment has the potential to move fine sediments that are capping inundated sites, compromising spatial integrity, and removing artifacts. Removal of fine sediments over time has the potential for long-term effects by moving artifacts from their original location and removing underlying fine sediments, allowing artifacts to lag unto the surface below, and even to create false sites by moving lighter artifacts and grouping them artificially.

These measures may adversely affect values associated with sites of religious and cultural significance to Indian tribes.

Changes in water level and flow velocity have the potential to harm archaeological resources through scouring of point bars, changes in the timing and duration of site exposure, and increased erosion in sites on shorelines, islands, and bars. Depending on the level of changes in water level and flow velocity, there is a potential for some sites that are currently inundated to become exposed. While this may provide an opportunity for investigation, it also risks casual discovery and potential looting or vandalizing of the site. If water levels are sufficient to continually or seasonally expose new portions of lands, traffic may be attracted to the area, further risking the integrity of sites.

Levee raise would be confined to the top of portions of the existing levee system. The levee system is not presently eligible for listing in the National Register of Historic Places and is a disturbed site containing no native material, so raising the levee would not affect historic properties or archaeological sites. Construction areas would be surveyed prior to any potential levee raise and the Corps would evaluate whether historic properties are present and potentially affected in compliance with the requirements of the National Historic Preservation Act.

Increased erosion has the long-term potential to adversely affect sites, some of which may be components of archaeological districts and whose removal will constitute a loss of contributing elements to the district.

4.4.3.2 Immediate Action

The effects to cultural resources as a result of the immediate action of Alternative 7 would be the same as effects described above under immediate action for Alternative 5.

4.5 Socioeconomics

4.5.1 Alternative 1: No Action (Continue Current Practices)

Navigation objective reservoir operation lessens the effect on commercial navigation of sediment accumulation. By maintaining pool levels to provide 14 feet of water in the navigation channel, commercial navigation would be unimpeded. However, navigation objective reservoir operation would be effective for only a limited time as continued sediment accumulation ultimately will impede navigation because pool levels cannot be raised beyond maximum operating pool.

Sediment has currently accumulated in the navigation channel and port berthing areas such that water depth at MOP is below the authorized 14 feet in several locations, and as shallow as seven to nine feet in some locations. The sediment accumulation interferes with commercial navigation and creates the potential for navigation hazards and property damage. The local ports have already reported that fixed-keel sailboats have struck ground at some locations, and barges have grounded. Grounding can cause damage to vessels, which can lead to sinking or capsizing due to holes or rips in hulls, and puts crews and passengers at risk. On commercial barges, grounding also can result in leakage or loss of cargo into the river. Navigation objective reservoir operation would provide a temporary solution to sedimentation that impedes commercial navigation. However, since pool levels can only be raised to a maximum operating pool elevation, capacity to raise pool levels could ultimately be used up and commercial navigation would be impeded, having an adverse effect on commercial navigation, as well as cruise ship operations. Alternative 1 would not affect railroad or highways in the short term. However, when commercial navigation is impeded, commodities would likely shift to other modes (truck, train) having an adverse effect on roads and railroads.

Navigation objective reservoir operation would help maintain economic activity in the region and would not change employment, income, or other socio-economic conditions in the study area. When the effectiveness of navigation objective reservoir operation decreases and commercial navigation is affected, regional employment and income could be adversely affected.

4.5.2 Alternative 5: Dredging-Based Sediment Management

4.5.2.1 Future Actions

Alternative 5 would have minor, short-term, beneficial direct effects on income and employment through construction activities associated with dredging and dredged material placement for beneficial use. Alternative 5 would have no long-term impacts to population, employment, and income. Dredging or raising pool levels would maintain current navigation operations (and associated economic activities); therefore no adverse impacts would result to the transportation and related sectors. Additionally, no direct socioeconomic or other effects would be disproportionately borne by high minority or high low-income populations; therefore, no environmental justice issues would result from this alternative.

Beneficial use of dredged material for fish habitat creation or ecosystem restoration projects would have indirect benefits, including potential recreation benefits (such as fishing and bird watching). Recreation activities lead to increased economic consumption on travel expenditures for fuel, food, and lodging, which could be incurred while visiting a recreational site. The net economic effect would be positive.

Recent evaluation of sediment dynamics and accumulation indicates that the sediment accumulation at the confluence of the Snake and Clearwater Rivers appears to have reached a state of equilibrium and future reduction of flow conveyance capacity within in Lower Granite Reservoir is not anticipated. Section 3.10 and Appendix F present detailed information on sediment accumulation and transport in the Lower Granite Reservoir, and the results of hydraulic and hydrologic analysis of flood risks in Lewiston, Idaho. This analysis has demonstrated that the risk of levee overtopping and associated flooding remains very low and is within acceptable levels of current Corps policy stated in ER 1105-2-101. Under Alternative 5, the Corps would continue to monitor and assess sediment in the Lower Granite Reservoir and any changes in flood risk.

Alternative 5 would have a long-term beneficial impact on river navigation by ensuring adequate depths in the navigation channels and access channels to ports, moorages, and public recreation areas. The short-term impact of dredging could include minor disruption of barge, cruise, or recreational traffic as dredge equipment works in the navigation channel or at ports and moorages. Disruptions at port facilities would potentially also affect highway and railroad connections to the ports. Beneficial use of dredged material would not affect river navigation.

Alternative 5 would maintain the authorized purposes of the LSRP, including commercial navigation. Farms and businesses that ship products by barge on the lower Snake River would continue to have access to markets and transportation options provided by the inland navigation system, which would be a positive economic effect.

4.5.2.2 Immediate Action

The effects to socioeconomic resources as a result of the immediate action of Alternative 5 would be the same as effects described above under future actions. The immediate action of Alternative 5 would address the dredging activities identified to be an immediate need for maintaining authorized channel depths for commercial navigation. It would address the areas where industry users have had the most difficulty navigating. Navigation interests would not need to light load and would not have to take the extra measures they now take to position and move tugs and barges. These factors would result in a positive economic impact to the navigation and related industries in the region.

4.5.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

Alternative 7 would have socio-economics effects similar to Alternative 5. Maintaining the navigation channel would maintain the flow of commodities thereby maintaining existing related conditions in employment and income in related economic sectors.

4.5.3.1 Future Actions

In addition to dredging and beneficial use of dredged material, other structural and system sediment management measures included in Alternative 7 would have minor, short-term, beneficial direct effects on income and employment through construction activities associated with the measures implementation. Alternative 7 would have no long term impacts to population, employment and income. Since, Alternative7 includes actions to maintain current navigation operations (and associated economic activities) no adverse impacts would result to the transportation and related sectors. This alternative would have a long-term beneficial direct effect on river navigation of dredging, providing adequate depths in the navigation channels and access channels to ports, moorages, and public recreation areas. Additionally, no direct socio-economic or other effects would be disproportionately borne by high minority or high low income populations; therefore, no environmental justice issues would result from this alternative.

System management measures that involve construction (bendway weirs, dikes/dike fields, relocation or reconfiguration of affected facilities, or levee raise) could have short-term direct effects on socioeconomics. Reservoir drawdown and modification of flows to flush sediment would cause temporary interruptions in commercial navigation in a portion of the lower Snake River system, which would also affect port operations while navigation is interrupted. Similarly, relocation or reconfiguring affected facilities would temporarily interrupt economic activity associated with the reconfiguration or relocation of the affected facility, although construction activity associated with the relocation or reconfiguration would create a temporary local economic benefit.

Modifying flows to flush sediments (drawdown) would require substantial changes in reservoir operations that would temporarily preclude most barge navigation in the reservoirs where and while drawdown was occurring. This would be a temporary adverse impact on commercial and recreational navigation. Normal operating water levels would be restored following the implementation of the drawdown or flushing measure, which would allow navigation to resume. Some shipments would likely shift to other modes (rail, truck), which could adversely affect the capacity of the rail or highway system. However, these measures would have a long-term beneficial effect on navigation, by improving the navigation channel. Changes to the ways in which barge tows are operated could affect the costs of barge shipping, as well as recreational vessels operating in the vicinity of the tows.

Because there may be time to plan for a drawdown and the expected timing would not correspond with grain harvest season, the effect on shippers would be minimal due to the short

duration of the drawdown. There may be some loss of grain sales if enough grain cannot be shipped out of the affected pool, but use of downstream storage facilities and shipping of grain prior to drawdown would minimize economic effects. Other commodities such as fuel oil, gasoline, chemicals, and wood products would need to be stock piled ahead of time. Trucks or rail could be used to transport these commodities for short-term supply. This will temporarily increase costs to those who usually use the river system for the transportation of commodities, but the increases should be small.

The loss of head and the ability to use Lower Granite to produce power would mean loss of power sales for the region. These costs would be borne by BPA (i.e., ratepayers) and are a National Economic Development cost. Reduced hydraulic head on the turbines due to a lower reservoir elevation at Lower Granite reduces the amount of power that can be generated. Lower-head elevation during flushing would result in lower power generation.

A drawdown could have an impact on the cruise ship industry. If the drawdown is implemented at a time when the cruise ships plan to use the river it will halt their trips to the Lewiston/Clarkston area during that time. This will cause economic loss for the cruise industry and the local supporting industries in the affected area. After this drawdown activity, cruise ships may be able to access docking facilities depending on the effectiveness of the flushing event.

Drawdown could have adverse effects on infrastructure adjacent and crossing Lower Granite Reservoir. During the 1992 drawdown test, several structural problems at ports and private facilities were observed (Corps 1993[drawdown report]). Levee raise would provide a minor temporary increase in local employment and economic activities associated with construction. The levee raise would provide long-term management of flood risk consistent with Corps of Engineers policies and guidelines, thus maintaining an acceptable level of flood protection for a portion of downtown Lewiston.

Sediment and system management measures noted above would generally have a long-term indirect positive effect on regional economies by providing for continuing commercial navigation and movement of commodities, providing options for commodity shippers, and maintaining acceptable levels of flood protection in Lewiston, the result would be positive long-term benefits to the communities protected by the levees.

4.5.3.2 Immediate Action

The effects to socioeconomic resources as a result of the immediate action of Alternative 7 would be the same as effects described above under immediate action for Alternative 5.

4.6 Water Quality and Sediment Quality

4.6.1 Alternative 1: No Action (Continue Current Practices)

Implementation of the navigation objective reservoir operation measure would not require construction or noticeably affect sediments in the target areas. The increased volume in reservoirs where pool levels are raised is unlikely to affect temperatures and thermal stratification in the reservoirs, or otherwise affect water or sediment quality.

4.6.2 Alternative 5: Dredging-Based Sediment Management

4.6.2.1 Future Actions

This alternative could have an intermittent, negative effect on water quality in both the Snake and Clearwater Rivers, primarily due to mobilizing sediments that could increase turbidity levels during dredging and in-water placement. At dredging sites water quality impacts would occur for a short distance downstream while the dredge is operating. At in-water placement sites, minor, adverse effects would occur while dredged material is placed and up to a few hours afterwards. At dredging and placement locations, only a small portion of the river would be affected.

Dredging is not anticipated to affect water temperatures. However, water temperatures at in-river placement sites may slightly increase from current conditions in the summer. Water overlying the shallow habitat would likely exceed 68°F (20°C) during summer days, but may also cool off more at night relative to the open-water. Predicting the thermal effects of these opposing actions in the long term is hampered by uncertainty related to issues of vegetation that could become established nearby and create shading, global warming, and runoff volume. However, considering the small incremental change in volume of shallow water, greater cooling of shallow water at night, effects of wind and wave action on mixing near shore, and advection of water through these areas, the overall changes to the thermal budget of the reservoir are not anticipated to be significant.

Dredging and placement activities would be temporary and would cause minor, localized effects by increasing turbidity and suspended solids. Background turbidities in the lower Snake River generally do not exceed 10 NTUs. As early as the 1940s, Van Oosten (1945) concluded from a literature survey that average turbidities as high as 200 NTUs are harmless to fish. Newcombe and Jensen (1996) provide a more robust risk analysis of the effects of turbidity upon salmonids, and show that prolonged exposure to turbidity levels greater than 100 NTU can affect long-term feeding success and hatching rates. .

Dredging in areas with finer sediments, such as the Ports of Lewiston and Clarkston, is likely to have the greatest effect on water quality. Dredging and in-water placement operations that include this type of material create a turbidity plume that extends downstream from the location of that activity. Based on past activities, turbidity levels would be expected to meet state water quality standards 300 feet downstream from dredging and placement actions, and to have returned to background levels 600 feet downstream from the activity. If conditions exceeding

these limits are observed, the dredging operation would be modified until levels become lower and within the acceptable range.

Based on the results from the recent round of sampling in 2011 (Section 3.6), the sediments that would be dredged met the chemical and physical criteria for open and unconfined in-water placement and are suitable for in-water placement. The guidelines provided by the 2009 SEF, the 2012 freshwater SMS in WAC Chapter 173-204, and the 2011 NOAA SQRT tables indicate that there would be no biochemical effects to listed fish species, pelagic zooplankton, or benthic macro invertebrates from the proposed action (Appendix I). Dredging would not affect the quality of sediments in the Lower Snake River.

For any future dredging action the Corps would complete sediment sampling consistent with the SEF and other applicable guidelines and plans.

Dredging to improve flow conveyance would be a much larger dredging operation than the navigation channel maintenance dredging operation. As a result, the temporal and spatial effects on water quality would likely be greater due to the additional area disturbed and time spent dredging.

Use of mechanized equipment in the river would increase the potential for a spill or release of hazardous materials such as oil, grease, fuels, or hydraulic fluids into the aquatic environment. Certain chemicals may have serious toxic effects on water quality and aquatic organisms. Avoidance and minimization measures would be implemented to prevent spills and releases. Spills would be controlled by measures outlined in the SPCC Plan.

The Corps would prepare a monitoring plan for dredging and disposal activities to be undertaken as part of future actions.

Beneficial use for riparian enhancement may involve plantings along the riverbanks. Plantings would shade portions of the active channel, blocking direct sunlight and cooling water temperatures. Cooler water temperatures could improve water quality, resulting in a beneficial effect.

4.6.2.2 Immediate Action

The immediate effects of the proposed immediate action on water quality would be the same as those described above under future actions.

Based on the results from the recent round of sampling (Section 3.6), the sediments proposed for the immediate action dredging met the chemical and physical criteria for open and unconfined in-water placement.

Dredging of the navigation channel downstream of Ice Harbor dam would have minimal effects on water quality. The material to be removed from these areas would be river cobble 2 to 6 inches in diameter with few fines, and possibly some larger rock up to 18 inches in diameter.

Other areas where dredging is proposed are predominantly sand, and dredging of these sediments would also only have minor effects on water quality.

Disposal of the dredged material at the beneficial use site at RM 116 to create shallow-water fish habitat also would be expected to cause turbidity plumes. The plumes would be of short duration, as the evacuation of a barge is a singular event as opposed to the continuous operation of the dredge, and material is generally coarse and not subject to much resuspension and transport. Previous disposal actions have shown that the material tends to stay in a clump as it drops from the barge to the riverbed, further minimizing the size of the plume (USACE 2005).

The Corps has prepared a monitoring plan for dredging and disposal activities that would be undertaken as part of the immediate action (Appendix H). A Section 404(b)(1) Evaluation was prepared for the immediate action and is included in Appendix L.

4.6.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.6.3.1 Future Actions

Effects to water quality and sediment quality would be the same to those described for dredging and dredged material management as described under Alternative 5. Therefore, all of the direct effects of the measures evaluated for Alternative 5 apply to this alternative. Effects to water quality and sediment quality from maintain pool levels at the navigation objective under Alternative 7 would be the same as those described under Alternative 1.

Mechanized construction equipment and in-water work would be required to construct bendway weirs, dikes, sediment traps, and the reconfiguration or relocation of existing facilities. In-water work has the potential to increase turbidity and TSS. These effects would be localized and temporary, and could be reduced with the implementation of protective measures. Ground disturbance outside of the active channel, such as removal of vegetation, soil disturbance, and compression and exposure of bare ground, could also increase the erosion risk in the vicinity of the river. Facility relocation would likely involve more substantial earthwork due to larger construction efforts. Soil loss from erosion could adversely affect surface water quality by increasing suspended solids and turbidity in receiving waters. Erosion control measures would be implemented to minimize these risks.

Use of mechanized equipment in the vicinity of the river would increase the potential for a spill or release of hazardous materials such as oil, grease, fuels, or hydraulic fluids into the aquatic environment. Avoidance and minimization measures would be implemented to prevent spills and releases. Spills would be controlled by measures outlined in the SPCC Plan.

Bendway weirs operate by redirecting flow around river bends to prevent bank erosion on the outside bend and deepening of the channel. The weirs can be directed to flow toward the opposite, inside bend causing scouring in order to straighten and widen the channel. Bank scour from bendway weirs may cause sediments to become suspended during operation and increase local turbidity. These effects would occur until the scouring reaches equilibrium.

Sediment traps work by collecting sediment and preventing downstream movement of trapped sediments. Some compounds, particularly nutrients, bind to suspended particles in the water column; settling of these particles could also reduce forms of phosphorus and nitrogen in the system. Sediments collected in the traps would need to be removed as they reach capacity and deposited as a beneficial use, or in an upland or in-water location. Effects of these deposition measures on water quality are described under Alternative 5.

The agitation to resuspend measure involves periodic agitation of deposited sediment to suspend these particles into the water column, which are then conveyed downriver with flows. Agitation would result in temporary increased localized turbidity. Other effects of agitation on water quality would be the same to the effects of dredging, as discussed under Alternative 5.

In-water disposal would affect water quality similarly to in-water beneficial use, as discussed under Alternative 5. Upland placement would not directly affect water quality, but could have minor indirect effects from the discharge of effluent from dewatering of dredged sediments placed in an upland disposal area. Given the general quality of sediments in the Lower Snake River, adverse effects from dewatering dredged sediments would not be anticipated.

Flow modifications to flush settled sediments would not require construction. Flow modifications to flush sediments would involve a drawdown of water levels in the reservoirs during high spring flows. Since drawdown would occur for a relatively short duration during high spring flows when water temperatures are typically cooler, it is unlikely that water temperature or DO concentrations in the reservoir would be affected. Modification to flows for purposes of flushing settled sediments would result in increased turbidity because increased flows would resuspend sediments in the reservoir being drawn down. Flushed coarser sediments would have a less severe and smaller areal extent of effects on turbidity than finer sediments. Increased flows would transport sediments from certain areas of the river, increasing turbidity throughout the area influenced by the drawdown. During the 1992 drawdown test of Lower Granite Reservoir turbidity increases were the greatest at the head (most upstream end) of the reservoir where riverine conditions were restored in areas that, under normal reservoir operations, experience slower flow velocities (USACE 1993). These turbidity effects would occur for a relatively short period of time following the drawdown, but before the reservoir levels are restored to the normal operating ranges.

Levee raise would be adjacent to Lower Granite Reservoir. Soil loss from erosion during construction could adversely affect surface water quality by increasing suspended solids and turbidity in receiving waters. Erosion control measures would be implemented to minimize these risks. Raising levees would not measurably increase impervious surfaces or change land uses, so it would not have a long-term effect on water quality. Levee raise would not affect sediment quality.

4.6.3.2 Immediate Action

The effects to water quality as a result of immediate action under Alternative 7 would be the same as the effects described above under immediate action for Alternative 5.

4.7 Hydrology and Sediment

4.7.1 Alternative 1: No Action (Continue Current Practices)

Navigation objective reservoir operation would not measurably affect sedimentation in the LSRP. Pool levels would be raised to counter the displacement of the settled sediments to aid in navigation and other uses of the river. Increased water surface levels in reservoirs where pool levels are raised would not directly affect the volume of sediment transported or accumulating in the LSRP.

Alternative 1 would have no indirect effects on sediment and hydrology. Sediment would continue to enter into the LSRP system and would likely accumulate in the reservoirs, including areas where sediment would interfere with authorized purposes.

4.7.2 Alternative 5: Dredging-Based Sediment Management

4.7.2.1 Future Actions

Under this alternative, the Corps would conduct dredging to remove accumulated sediments that interfere with navigation and other authorized purposes of the LSRP. Changes in the volume or frequency of dredging (increases or decreases) are possible, in response to changes in sediment loading to the reservoirs due to climate change, changes in the frequency of wildfire, land use changes, or other causes.

Dredging would temporarily change the channel cross section in the dredged area. Water depth would be increased and channel width would be increased (as needed) in certain areas. Over time, dredged areas may continue to fill in and may need to be dredged again. Historic data on past dredging provides the best available information on the frequency and volume of required future dredging under Alternative 5.

Beneficial use of dredged sediments for in-water habitat creation would result in a small, localized change in the location of the sediment in the reservoirs, but no change in the total volume of sediment. Beneficial use of dredged sediments outside of the reservoir (e.g., upland placement for beneficial use) would result in a very small change in the total volume of sediment in the reservoir. Beneficial use of dredged sediments would have no effect on the accumulation of sediment that interferes with the authorized purposes of the LSRP.

Alternative 5 would have no indirect effects on sediment and hydrology. Sediment would continue to enter into the LSRP system and would likely accumulate in the reservoirs, including areas where sediment would interfere with authorized purposes. Dredging and dredged material management would need to occur periodically to address sediment accumulation. Raising pool levels would not indirectly affect sediment transport or accumulation in the LSRP.

4.7.2.2 Immediate Action

The general effects on hydrology and sediment as a result of the immediate action of Alternative 5 would be the same as the effects described above under future implementation. The immediate action under Alternative 5 would move the sediment currently interfering with the authorized purposes of the LSRP and reestablish the navigation channel at its authorized dimensions.

4.7.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.7.3.1 Future Actions

Direct effects from dredging and dredged material management and the Navigation objective reservoir operation would be the same as described for Alternative 5, above. Additional structural sediment management measures would include the construction of in-reservoir facilities intended to enhance the movement of sediment through problem areas and into deep water areas or areas where deposition would not interfere with authorized purposes, and also reservoir water level management operations to similarly enhance the movement of sediment out of problem areas. These measures would change the velocity of flow through certain areas within the reservoir in which they are applied, either long term (for the constructed facilities), or temporarily, in the case of the water level changes. The sediment that is resuspended by the transport enhancement measures would produce a localized increase in turbidity and suspended sediment.

The Corps studied reservoir sediment transport and hydraulics (USACE 2011a). The studies indicate that in-water structures, such as weirs and dike fields, can be effective in moving coarse sediment out of the confluence area and farther down into the Lower Granite Reservoir. This would result in a beneficial long-term effect as it would reduce sediment accumulating in areas where it would interfere with authorized purposes of the LSRP, and the volume of required dredging in the Snake River and Clearwater River above the reservoir, and in the upper end of Lower Granite Reservoir. In-water structures would reduce the cross sectional area of the channel, which may initially result in an increase in flood flow water levels (a direct adverse effect). Over time, as sediment in the channel erodes, this effect on flood flow water levels decreases. The 50-year-long simulations by the Corps indicate that the relative increase in water surface elevation at the confluence area is less than half a foot for the SPF.

In-water work associated with the installation of structures such as weirs and dikes could have temporary, localized effects on turbidity and increased suspended sediment. The structures would have long-term, positive effects by increasing the movement of sediment and thereby reducing sediment accumulation in problem areas. Sediment that is moved out of problem areas would settle out in nonproblem areas. The total amount of sediment in the reservoirs would not change, just the amount occurring in problem areas.

The results from the simulation of seasonal drawdown indicate that drawdown of the reservoir during high flow periods would move a significant amount of sediment out of the confluence area (a direct benefit), but that the material tends to be redeposited near Silcott Island (downstream of RM 130). Dredging may be required in this area to maintain the authorized dimension of the navigation channel, if sediment is redeposited in the navigation channel. Drawdown during the low flow period tends to move much less material and thus has a minor beneficial effect. The Corps concludes that reservoir drawdown may have to be greater than the 1992 test drawdown to transport sediment further into Lower Granite Reservoir and produce a measureable reduction in flood water surface elevations at the confluence. Results also suggest that drawdowns would have to occur frequently in order to be an effective system sediment management technique.

Measures modifying flows to increase the movement of sediment out of problem areas could have temporary, localized effects on turbidity and increased suspended sediment. In addition, the resulting flushing of sediment could cause short-term, localized erosion and/or bank destabilization. Sediment would be temporarily resuspended in the water column, rather than being concentrated in problem areas, thereby having a long-term, positive effect on sediment accumulation. Modified flows would also result in a long-term, positive effect on sediment quantity in certain problem areas. The system management measures would be expected to reduce the need to dredge in certain, specific areas, although measures would need to be reimplemented on a regular basis as sediment refills the problem areas. Also, the results of Corps modeling studies indicate that reservoir drawdown in the Lower Granite Reservoir would reduce problem sediment in the navigation channel near the confluence, but would not move sediment far enough into the reservoir to provide flood risk benefits.

In-water work associated with reconfiguration or relocation of affected facilities could have temporary, localized effects on turbidity and increased suspended sediment. Assuming the modified operations function as anticipated, they could have long-term positive effects by reducing the impact of sediment accumulation on authorized purposes.

Raising the Lewiston Levee would have a long-term benefit for flood risk management in the City of Lewiston, Idaho. Any future levee raise would be implemented to achieve flood risk protection levels consistent with Corps of Engineers policies and guidelines. This would provide a consistent level of flood risk protection for the areas of downtown Lewiston currently protected from inundation by the levees.

Uncontrolled redistribution of sediment associated with flushing and drawdown measures designed to move sediment from problem areas could result in indirect, adverse effects by creating problem sediment accumulation areas in other locations, for which further action, such as dredging, may be required. Sediment transport associated with in-water structures as well as flushing or drawdown would be modeled in greater detail as part of any proposal to implement such measures pursuant to the PSMP.

Uncontrolled redistribution of sediment associated with measures designed to move sediment from problem areas could result in indirect, negative effects by creating different problem areas in other locations. It is assumed that projects would be designed to avoid or minimize this unintended effect.

4.7.3.2 Immediate Action

The effects to hydrology and sediment as a result of immediate action under Alternative 7 would be the same as the effects described above under immediate action for Alternative 5.

4.8 Hazardous, Toxic, and Radioactive Waste

4.8.1 Alternative 1: No Action (Continue Current Practices)

The No Action Alternative would not have an effect on HTRW because there is no HTRW within the Lower Snake River navigation channel.

4.8.2 Alternative 5: Dredging-Based Sediment Management

4.8.2.1 Future Actions

Dredging of the navigational channel and the beneficial use of sediment could result in the release of hazardous materials, such as fuels and lubricants, from the storage of such materials or the use of mechanical equipment either into the water or on shore. However, the potential risk of release of fuels or other materials from mechanical equipment or storage is considered minor and temporary because it is assumed that releases would be controlled by implementation of best management practices required under Construction Stormwater Pollution Prevention Plans. Any releases would be mitigated through standard remediation activities under existing regulations.

Although the Joso HMU site has no documented history of HTRW releases, a low relative risk exists that HTRW may be encountered and released during construction because undocumented activities at the site may have contaminated soils. The Corps would complete a site assessment of Joso or any other area proposed for upland disposal as part of planning for site-specific action. If contamination were encountered during construction, there would be a risk of exposure of the workers to contamination. If encountered, materials sampling and analysis would be required to determine the proper management and placement of such materials to prevent the spread of contamination to soils and surface water at other locations. Construction delays and increased construction cost may result if HTRW is encountered during construction.

If any HTRW were discovered during implementation of proposed measures under this alternative, appropriate actions would be taken based on regulations in effect at that time. These actions could involve leaving those hazardous substances undisturbed or removing them from the site and disposing of them at an approved landfill thus reflecting a positive indirect effect. Uncontrolled releases would be minimal and mitigated according to applicable regulations and therefore not cause an indirect effect.

4.8.2.2 Immediate Action

There would be no HTRW effects from the immediate action. There is no HTRW in areas of proposed sediment management.

4.8.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.8.3.1 Future Actions

For any construction activities, the Corps would conduct a site assessment as needed prior to final planning and implementation. Construction associated with structural sediment management measures, such as bendway weirs, dikes and dike fields, and structures to agitate water would include the use of mechanical equipment and storage of hazardous materials. The use of mechanical equipment could result in the release of hazardous materials, such as fuels and lubricants, into the water or on shore. However, the potential risk of release of fuels or other materials from mechanical equipment or storage is considered minor and temporary because it is assumed that releases would be controlled by existing regulations and prevented by implementation of best management practices required under Construction Stormwater Pollution Prevention Plans. Any releases would be mitigated through standard remediation activities under existing regulations.

The reconfiguration or relocation of facilities could generate HTRW through two possible mechanisms: demolition of all or portions of facilities, and construction of new facilities or expanded facilities. The impacts of construction activities (including the increased risk of release of HTRW from mechanized equipment and storage) discussed above in structural sediment management measures would be applicable to system management measures involving construction activities (reconfiguring affected facilities, relocating affected facilities, and upstream sediment traps). The Corps or other responsible entity would conduct site assessment as needed prior to completion of planning for a reconfiguration or relocation of an affected facility.

Demolition activities associated with reconfiguring or relocating facilities could include the removal of lead-based paint and asbestos containing materials. Demolition may result in releases of these constituents to the air in the vicinity of the demolition, to soils onsite, and potential subsequent release to surface water and sediments. There would be a risk of exposure to the demolition workers from these hazardous materials. However, demolition work associated with lead and asbestos is assumed to be implemented using best management practices under existing regulations. Materials sampling and analysis prior to demolition would be required to determine the proper management and placement of such materials to prevent the spread of contamination to air, soils, or surface water. Delays and increased demolition cost may result if HTRW is encountered. The relative risk of release of HTRW from demolition is considered minor and temporary, with potential impacts only during demolition and relocation activities.

Other system management measures, including modifying flows to flush sediment or reservoir drawdown to add conveyance are not anticipated to affect HTRW as the two locations with elevated levels of contaminants in the sediments are located high enough on the shoreline that the sediment would not be mobilized during a flushing or drawdown action.

Levee raise construction activities would use fuels and other materials that, if released into the environment, could contaminate soil or ground water in the area of the release, or surface water in Lower Granite reservoir. The Corps would require construction best management practices to prevent and control any accidental release of fuels or other materials during construction. Therefore, a levee raise would likely have no effects with regarding to hazardous, toxic or radioactive waste.

If any HTRW were discovered during implementation of proposed measures under this alternative, those hazardous substances would either be left undisturbed or would be removed from the site, disposed of at an approved landfill, and any uncontrolled releases would be minimal and mitigated according to applicable regulations.

4.8.3.2 Immediate Action

The effects to HTRW as a result of immediate action under Alternative 7 would be the same as the effects described above under immediate action for Alternative 5.

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4.9 Air Quality

4.9.1 Alternative 1: No Action (Continue Current Practices)

Under this alternative, air quality would be expected to remain similar to existing conditions. Navigation objective reservoir operation would have no effect on air quality. However, if there is some shifting of transportation from barge to truck or rail as sediment deposition interferes with commercial navigation, there may be some increased emissions into the air shed from the increased truck or train traffic. In the short term, this would be expected to be a de minimus impact on ambient air quality.

4.9.2 Alternative 5: Dredging-Based Sediment Management

4.9.2.1 Future Actions

Temporary (construction-related) air quality effects under Alternative 5 would result from emissions from equipment used for navigation channel dredging and dredged material placement activities.

Air pollutant emissions associated with beneficial use of sediment would result from the use of tug boats and sediment transport barges, mechanized construction equipment (such as cranes, backhoes, and other earth moving equipment) to place dredged material and construct containment berms where necessary for placement of dredged material. Emissions would also result from the use of nonelectric pumps; mechanized construction equipment needed for the construction of any access roads and boat ramps; and from fugitive dust emissions during sediment transport and placement.

The amount of fugitive dust emissions from construction activities and movement of dredged material would depend on meteorological conditions (particularly wind speeds), soil types and moisture content, and the surface area of soils or sediments exposed.

Under Alternative 5, emissions of GHGs would result from the use of internal combustion engines in dredges, tug boats, barges, and other types of construction equipment associated with navigation channel dredging activities. Emissions would be temporary, as well as minor, likely falling well short of the annual emissions thresholds in EPA's GHG reporting rule. Activities included under Alternative 5 would not be subject to state or local GHG regulations.

Construction activities related to navigation channel dredging may also result in the release of stored carbon into the atmosphere. In addition, studies have shown that some GHG emissions can increase in areas where soil disturbance occurs (Kessavalou et al. 1998).

Dredging of the navigation channel, transport and placement of dredged material, and associated construction activities may have minor temporary, adverse effects on air quality at locations in the immediate vicinity of dredge sites. Existing air quality in the lower Snake River subbasin is currently in attainment with NAAQS criteria pollutants. As a result, temporary dredging,

transport, placement, and construction activities are not likely to cause exceedance of the NAAQS.

No long-term air quality effects would result from the measures included under Alternative 5.

4.9.2.2 Immediate Action

Activities associated with the immediate action would have little effect on air quality. The activities would not likely generate windblown particulate matter (fugitive dust). The dredged soils would be wet, even after transport to the disposal site, and not subject to wind entrainment. Therefore, no air quality impacts are expected in the study area from the dredging and dredged material placement. Additionally, equipment used for dredging, material transport, and placement would include mechanical dredging equipment and tug boats for pulling/pushing barges. These are generally powered by diesel engines that emit low quantities of hydrocarbon and carbon monoxide emissions. Localized diesel emissions would increase during dredging, transport, and disposal, but should have a de minimis impact on ambient air quality.

4.9.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.9.3.1 Future Actions

Direct air quality effects from dredging-based sediment management measures under Alternative 7 in the lower Snake River subbasin would result from emissions associated with navigation channel dredging and beneficial use of sediment and would be the same as those described under Alternative 5.

Direct, temporary air quality effects would result from activities associated with the construction of bendway weirs, dikes (or dike fields), reconfiguration or relocation of affected facilities, sediment trapping and agitation, and raising levees. Construction of these structural and system sediment management measures would require the use of typical construction equipment with internal combustion engines. The air quality effects would occur during construction activities. Based on the existing air quality designations for the lower Snake River subbasin, temporary construction activities associated building bendway weirs and dikes are not likely to cause exceedance of the NAAQS.

Operational air pollutant emissions would result from the use of internal combustion engines to power mechanized conveyor systems or mechanical dredges associated with sediment trapping. Mechanical dredge emissions would be similar to those described for navigation channel dredging under Alternative 5. Conveyor belt emissions would likely be similar to those from construction equipment described above. Long-term emissions would be intermittent, minor, and not likely to cause exceedance of the NAAQS.

No long-term direct air quality effects would result from Alternative 7.

Climate change effects for system management measures under Alternative 7 would be the same as those described for Alternative 5, above.

4.9.3.2 Immediate Action

The effects to air quality as a result of immediate action under Alternative 7 would be the same as the effects described above under immediate action for Alternative 5.

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4.10 Aesthetics

4.10.1 Alternative 1: No Action (Continue Current Practices)

Navigation objective reservoir operation would likely have an imperceptible effect on the appearance of water levels in the majority of the Snake River and would not change aesthetic resources or viewing patterns of highway travelers, recreational river users, or local residents. Raising the pool level would have a greater relative effect and the change in water level may be perceptible near the dams, which could result in a slight improvement in aesthetic resources by covering cut banks and barren shoreline areas that may be exposed during the annual spring minimum operating pool operation. This would result in a temporary, minor beneficial effect to all viewers.

4.10.2 Alternative 5: Dredging-Based Sediment Management

Alternative 5 would have a temporary, direct effect on aesthetic resources in the areas where navigation channel and other dredging and beneficial use of sediment would take place. Dredging and disposal activities would be visible to drivers on adjacent highways and roads, boaters on the Snake River, recreation area users along the shorelines, and local residents. Some members of the public may find the activities displeasing and in contrast to the rural nature of the Snake River canyon while others may find the activities to be of interest or at least consistent with other industrial uses of the reservoirs.

The measures associated with Alternative 5 would be short-term events and effects to aesthetic resources and would only occur during the duration of dredging activities. Thus measures associated with Alternative 5 would have a minor, temporary adverse direct effect on the visual quality of the study area. Alternative 1 is not anticipated to change viewing patterns for aesthetic resources in the lower Snake River subbasin.

The use of mechanized equipment to dewater dredged material and transport material from barges to the Joso site under the upland placement measure would be visible by recreation river users, highway travelers adjacent to the site (Highway 261), and individuals present at Lyons Ferry Park across the river. Viewers would experience a negative effect locally from these activities; however, this effect would occur only temporarily and would be visible only in the areas where dredged material would be placed; thus, it would constitute a minor adverse direct impact to aesthetic resources.

There would be no long-term effects to aesthetic resources associated with the navigation channel and other dredging or beneficial use of sediment. Once a measure’s implementation is complete, all equipment would be removed from the river and the aesthetic conditions would return to the existing conditions. None of the measures that are part of Alternative 5 would have lasting visual effects.

4.10.2.1 Immediate Action

This alternative is anticipated to have a temporary, direct impact on aesthetics in the area where dredging and disposal operations are taking place. Dredging activities would be visible to drivers on U.S. Highway 12 and also to recreational boaters of the Snake River. Disposal activities would be visible to boaters and to drivers on Whitman County Road 9000, although the disposal area would be on the opposite side of the river from the road. This effect would result from the presence of dredging equipment in the river and the turbidity plume from dredging and disposal at the beneficial use site at RM 116. This impact would occur during the duration of the dredging operation and would have a minor effect on the visual quality of the study area. This alternative is not expected to change viewing patterns for the aesthetic resources in the study area.

4.10.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

4.10.3.1 Future Actions

Construction-related activities associated with the bendway weir, dikes/dike fields, reconstruction or relocation of affected facilities, trapping upstream sediment, agitation and levee raise, would include the use of heavy equipment operation, material stockpiles, and worker presence would represent a noticeable change from existing conditions and would be visible by highway travelers, recreational users on the river and along trails, and local residents throughout construction. These viewers would experience a negative effect locally from construction activities, depending on the selected location of the placement of the measures; however, this effect would only occur for a temporary period of time and constitute a minor adverse direct impact to aesthetic resources.

The measure for agitation would have no temporary affect on the viewing patterns of recreational river users, highway travelers, or local residents because the placement of a boat or barge (with propeller or jet features) for a short period of time would be similar to other boats and barges present on the Snake River. The addition of a boat or barge present on the river performing agitation would not change viewing patterns, as most activity will occur below the water surface and would not be visible.

Temporary effects associated with dredging and dredged material management would be the same as those described above under Alternative 5.

Any levee raise would likely be small (a three-foot or less increase in the levee height), and sites would be restored following construction, so the long-term effect on the appearance of the levee would likely be minimal. Raising the levee would have a long-term adverse effect by reducing the visibility of Lower Granite Reservoir from parts of Lewiston. Since the levee raise would be less than three feet in most locations, the effect on visibility of the reservoir would be minor.

The measure to trap upstream sediments would place permanent in-water structures in the Snake River near its confluence with the Clearwater River. The sediment traps and structures associated

with ‘sediment harvesting’ activities would be constructed partially above the water and would be visible to recreational river users, local residents, and highway travelers. The sediment trap would also be visible to travelers on U.S. Highway 12, which is designated as the Lewis and Clark Scenic Byway. This measure would introduce a prominent mechanized built feature into the landscape; thus, this measure would have a moderate, long-term adverse effect on aesthetic resources in the Snake River subbasin.

The measures for bendway weirs and dikes/dike fields would place permanent in-water structures in the Snake River near its confluence with the Clearwater River. Part or all of the bendway weirs or dikes could be designed to be above the typical operating levels of reservoir(s). If these structures are designed to be above the water, they would be visible to recreational river users, local residents, and highway travelers. Bendway weirs or dikes potentially constructed around the confluence of the Snake and Clearwater Rivers would be visible to travelers on U.S. Highway 12, which is designated as the Lewis and Clark Scenic Byway. This measure would introduce additional built features into the landscape; thus, these measures would have a minor, long-term adverse effect on aesthetic resources in the Snake River subbasin. There would be no long-term effects to aesthetic resources associated with the following measures: agitation, dredging, beneficial use of sediment, in-water disposal, or upland disposal. These measures are considered to be one time events and would have no long-lasting effects to viewers or viewing patterns.

During the drawdown portion of the modify flows to flush sediment measure, large areas of river bottom would be temporarily exposed along the entire length of the Lower Granite Reservoir. This would expose a shoreline that is devoid of vegetation and gray-colored, and may be visually displeasing to highway travelers (Whitman County Road 9000 and U.S. Highway 12), recreational river users, and residents in the Clarkston/Lewiston area. This measure also creates the potential for material along the shore to slump, slough, and crack, which could also be considered displeasing to these viewers. However, some members of the public may find the drawdown to be of interest as the shoreline is not exposed to this degree during normal pool operations. The effects of this measure would only occur temporarily and would constitute a major adverse direct impact to aesthetic resources.

Long-term effects associated with the measure to reconfigure affected facilities would constitute a minor change to the local environment. The Corps assumes that reconfiguring of facilities would comply with applicable local development requirements, and would be generally consistent with existing development and its associated visual quality. Therefore, reconfiguring affected facilities would not result in an adverse effect to aesthetic resources.

Long-term effects associated with the measure to relocate affected facilities would constitute a moderate change to the local environment by adding a new or larger existing built feature to the landscape. The relocated facility would be visible to highway travelers, recreational users of the river, and local residents. As with reconfigured affected facilities, the Corps assumes that relocated facilities would comply with applicable local development requirements and be

generally consistent with existing development in the surrounding area. The change in viewing patterns would constitute a moderate adverse direct impact to aesthetic resources.

There would be no long-term effects to aesthetic resources associated modifying flows to flush sediment. This measure is considered to be one time events and would have no long-lasting effects to viewers or viewing patterns.

4.10.3.2 Immediate Action

The effects to aesthetic resources as a result of immediate action under Alternative 7 would be to the same as the effects described above under immediate action for Alternative 5.

4.11 Cumulative Effects

The CEQ regulations implementing NEPA require the Corps to consider the cumulative effects of their actions though the NEPA process. Cumulative effects are defined as effects "on the environment which result from incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time" (40 CFR § 1508.7).

This section presents the Corps' evaluation of the potential cumulative effects of its actions as part of programmatic alternatives for managing sediment in the LSRP reservoirs. The Corps' cumulative effects analysis focuses on actions that are within the Corps' authority to implement and are described as components of all three PSMP alternatives. Potential effects from other agencies' actions are addressed in Alternative 3 only.

The Corps used public scoping input (see Section 2 and Appendix G), as well as technical analysis conducted for this EIS, to focus this analysis on cumulative effects that are "truly meaningful" in terms of local, regional, or national significance (CEQ 1997). While the EIS addresses the effects of alternatives on the range of resources representative of the human and natural environment, not all resources need to be included in the cumulative effects analysis–just those that are relevant to the decision to be made on the proposed action (to adopt and implement a long-term, programmatic sediment management plan for the LSRP). To determine the scope of resources to cover, the Corps reviewed input received during scoping for this EIS (see Appendix G), from the LSMG and technical workshops, and the analysis of the affected environment and environmental consequences of the plan alternatives conducted for this EIS. The Corps has identified the following resources that are notable for their importance to the region and potential for substantial cumulative effects. Those resources are:

- Threatened and endangered fish;
- Water and sediment quality;
- Hydrology and sediment; and
- Cultural resources.

4.11.1 Geographic and Temporal Scope of Cumulative Effects Analysis

The term "cumulative effects area" is used in this section to describe the geographic area analyzed for cumulative effects for each resource. The geographic and temporal scope of the cumulative effects analysis can be broader than the [EIS] study area defined for the assessment of direct and indirect environmental effects of the plan alternatives and is determined by the characteristics of each resource (CEQ 1997). The geographic scope of the cumulative effects analysis includes the LSRP and the approximately 32,500 square mile drainage area that contributes sediment to the LSRP (see Section 1.6), referred to here as the "cumulative effects

study area". For threatened and endangered fish species the cumulative effects area is expanded beyond the EIS study area to include the Columbia River from the confluence with the Snake River to the Pacific Ocean. The Water and Sediment Quality and Hydrology and Sediment geographic areas for cumulative effects analysis focus on the LSRP but include the sediment-contributing watershed.

The temporal scope of the analysis includes past actions that have substantially altered the environmental conditions in the cumulative effects area, including: the wide-scale settlement and development of the area by Euro-Americans beginning in the 1800s; federal ownership and management of large portions of the area; and substantial alteration of land and water resources for multiple purposes.

The temporal boundaries are:

- Past and present: the general settlement of the cumulative effects area by Euro-Americans, and the subsequent broad development of land and natural resources that continues until the present.
- Future: the "economic life"[1] of the Lower Granite Lock and Dam project extends until 2074. Because the aim of the EIS alternative plans is management of sediments that affect the authorized purposes of the LSRP reservoirs, the Corps determined that the economic life of the Lower Granite Reservoir provides an appropriate temporal boundary for the cumulative effects assessment of programmatic sediment management alternatives.

Discussed below are the past, present, and reasonably foreseeable future actions that were considered for the cumulative effects analysis, the effects of those actions on the resources assessed, and a summary of the cumulative effects of the plan alternatives.

4.11.2 Past, Present, and Reasonably Foreseeable Future Actions and Implications for Resources

4.11.2.1 Past Actions

Settlement and Development by Euro-Americans

Euro-American influence in the cumulative effects area began in the late 1700s (USACE 2005). By the mid 1800s, new settlements were being established and the cumulative effects area was being increasingly populated by Euro-American settlers migrating from the eastern United States. Prior to the arrival of new settlers, human-caused changes to the land and rivers were generally limited in comparison to methods employed following settlement by Euro-Americans (USACE 2005). Commercial harvest of salmon and steelhead in the Columbia-Snake basin began to quickly deplete fish populations.

[1] The economic life of a Corps project such as Lower Granite Lock and Dam is the time period over which construction costs, life cycle costs (e.g., maintenance and repair) and benefits, and replacement costs of the project are analyzed during planning.

Concurrent with increased fishing, dramatic changes in the landscape were taking place. Farming, grazing, mining, and timber harvest were practiced throughout the cumulative effects area. These land use changes, in turn, spurred development of a transportation network throughout the region. Railroads and road networks developed through the 19th and 20th centuries. Beginning in the 1800s rivers throughout the cumulative effects area were modified for navigation, as well as for mining, and shoreline grazing, and later for power, irrigation, and water storage. Improvements in transportation systems spurred further development of agriculture, timber, livestock, and mining in the region. Railroads shipped materials produced in the cumulative effects area, as well as those produced from outside the area bound for markets and ports in larger cities like Portland, Seattle, and Tacoma. With increased development, the scope of human-caused impacts on natural and cultural resources increased (USACE 2005).

Public Land Management

Federal land comprises more than 60 percent of the cumulative effects study area, and additional public lands are present in the Columbia River basin. National Forests in the cumulative effects area were established in the early 20th century and created large areas managed for multiple uses. During the mid-20th century, timber management became an emphasis for the Forest Service management of National Forests. Timber production generally increased in the 1970s. The Multiple-Use Sustained-Yield Act, passed by the U.S. Congress in 1960, gave recreation, fish, wildlife, water, wilderness, and grazing enhanced management status, along with timber management (USFS 2011). The Wilderness Act of 1964 provided additional protection for designated areas within National Forests and other federal land. Management of National Forests, as well as other federally-managed lands, has defined the use of large portions of the cumulative effects area that are public lands. National Forest and public land management has had notable and varied effects on natural resources in the cumulative effects area. Wilderness designation, for instance, has preserved large portions of the cumulative effects study area in a relatively natural state, which benefits wildlife, aquatic resources, and other natural resources. Timber harvest, grazing, mining, road building, and other activities on public land have had socio-economic benefits to the region, but have also historically had adverse effects on wildlife, water quality, cultural and natural resources.

Dams and Waterway Modifications

Development in the cumulative effects area has included building numerous dams on streams and rivers throughout the Columbia River basin. Early dams were built for irrigation, logging and mining (USACE 2005). Beginning in the early 1900s, larger dams were constructed on the Snake River and major tributaries for water storage, irrigation, and power generation purposes. The Federal Reclamation Act of 1902 provided the impetus for construction of larger dams on the Snake River system.

From the 1930s through the 1970s, the federal government and others constructed dams on the Snake River system for multiple purposes that included hydropower, navigation, recreation, water storage, and irrigation. Federal dams in the cumulative effects area are part of the Federal

Columbia River Power System. Dam building on the Snake River system has resulted today in 17 dams on the mainstem of the Snake River and more than 20 dams on tributaries, though most are out side the cumulative effects area (USACE 2005). Of those dams, four are on the mainstem Snake River within the cumulative effects study area (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). All four were designed and constructed by the Corps and are dams that impound sufficient water for navigation, but generate power based on available flow in the river. Each dam has fish passage facilities. In addition, dams have been constructed throughout the Columbia River basin, including the John Day, The Dalles, and Bonneville dams on the mainstem Columbia between the Snake River and the Pacific Ocean (all are operated by the Corps of Engineers)

Dams on the Columbia-Snake River system have contributed to declines in anadromous fish runs. Since the 1950s, the combined consequences of dams, increased ocean fishing, and lessened quality and availability of aquatic habitats have adversely affected Columbia-Snake River aquatic resources and, in particular, anadromous fish. Since the 1970s, the catch of salmonids has declined, with hatchery-raised species making up more than 80 percent of commercially caught salmon in the Columbia-Snake system (CCRH 2011). Fish hatcheries began operation in the Columbia River basin in 1877 and have offset salmon and steelhead declines during the late 20th century. Nonetheless, reduced salmonid populations resulted in the listings of multiple Snake and Columbia River species under the Endangered Species Act (see Section 3.1).

Dams, and the impoundments they created, also inundated cultural resources, particularly archaeology sites and historic properties of religious and cultural significance, throughout the cumulative effects study area. Cultural resources in upland areas adjacent to dammed rivers were also put at risk by impoundments, since wave action and changing water levels could erode the resources.

Development of dams has also created substantial economic benefits to the cumulative effects area and the surrounding region. Dams on the lower Snake River and middle and lower Columbia River create an inland commercial navigation system that stretches 465 miles from the Pacific Ocean to Lewiston, Idaho, and is an integral part of a transportation network that moves products to and from the area. They also provide hydropower and storage for irrigation.

As documented in Section 1, since the development of dams on the Lower Snake River, the Corps has periodically dredged portions of the river to maintain authorized purposes (primarily navigation and flow conveyance) of the river system. The last navigation maintenance dredging took place in winter of 2005/2006. Since 2006, the Corps has not dredged in the Lower Snake River.

4.11.2.2 Present Actions

Many past actions described above continue through the present. The scope and location of land uses that affect the environment have changed over time, with resulting shifts in how the

environment is affected. For example, wilderness designations in large portions of the Salmon and Clearwater subbasins, have reduced the extent of uses like logging, roads, mining, and grazing in those areas, as well as allowed the wildfire processes to shift toward more natural cycles. Section 3 of this EIS describes current conditions of resources that have resulted from past and present actions.

Multiple resource management plans provide guidelines for land management on public lands, which make up more than 60 percent of the cumulative effect study area. As noted in the previous section, management practices that reduce erosion and sedimentation have been, and continue to be, implemented and have reduced loads of sediment to streams in the cumulative effects study area. Similarly, current levels of implementation of agricultural conservation practices contribute to reducing erosion and sediment loads from cropland.

Current actions by the Corps and other agencies that manage dams on the Snake and Columbia Rivers include operation and maintenance of existing facilities. Corps operation of the dams and reservoirs must comply with the terms and conditions of the 2010 FCRPS biological opinion (NMFS 2010). In addition, numerous plans and programs exist throughout the cumulative effects area and surrounding region that aim to improve water quality, habitat, and ecosystem functions to benefit the recovery of endangered fish. These include, but are not limited to:

- Tribal programs and partnerships in watershed planning and ecosystem restoration.
- State watershed plans and programs, including the Oregon Plan for Salmon and Watersheds, the Washington Watershed Planning Act and Shoreline Management Act, and recovery efforts by state fish and wildlife/game departments.
- The Lower Snake River Fish and Wildlife Compensation Program (USACE 1977).
- Interagency efforts such as the Northwest Power and Conservation Council's Columbia River Basin Fish and Wildlife Program (NWPCC 2009).
- Actions by local governments and nongovernmental agencies to improve water quality and habitat.

The effects of recovery efforts on threatened and endangered fish species is illustrated by the existing conditions of these resources described in Section 3.1. Recovery efforts have helped restore local ecosystems and have had benefits to water quality and habitat in portions of the cumulative effects area. The present actions described above contribute to the environmental conditions for the resources described in Section 4.11.2.3 below, and do not change any of the condition or trends described.

4.11.2.3 Effects of Past and Present Actions

Threatened and Endangered Fish

As noted above, over the past 200 years salmon and steelhead runs and populations in the Columbia-Snake River system have been adversely affected by changes within the cumulative

effects area. All native salmonid species in the cumulative effects area have decreased from historical levels as a result of dams, overfishing, loss and degradation of habitat, and the influence of hatchery stocks, as well as variations in ocean conditions (USACE 2005). The results of past actions on threatened and endangered fish species have been documented in past NEPA documents (USACE 2005, USACE 2002a, BPA et al. 1995, USACE 2002b), and the current status of these species is presented in Section 3.1. In summary, the results of past and present actions on anadromous fish within the cumulative effects area are substantially reduced stocks of native fish and the listing under the federal Endangered Species Act of species noted in Section 3.1.

Recovery plans developed by NMFS identify actions needed to restore these threatened and endangered species to the point that they no longer need the protections of the ESA. Recovery plans are not regulatory documents, however their intent is to serve as the central organizing tool for guiding each species' recovery throughout the Snake and Columbia River basins (Federal Caucus 2011).

Water Quality and Sediment Quality

Past activities such as land clearing, farming, grazing, logging, mining, and urbanization have adversely affected water quality in the Snake River and its tributaries. Dams have also substantially changed water quality conditions in the cumulative effects area.

Land clearing and loss of riparian vegetation has affected water temperature, causing it to rise. Similarly, the change in flow characteristics caused by dams affects water temperatures. Water temperatures in the Snake River were probably more variable prior to damming and widespread land use changes seen today. High temperatures may have been higher in the summer when flows in streams would be low, but cooling would likely have been more rapid with lower nighttime temperatures (USACE 2005). Current water quality conditions, temperature in particular, reflect the fact that the mainstem Snake River from the Columbia River to Lewiston is essentially a series of lakes, with associated seasonal warming and cooling patterns. These changes in water quality conditions have affected how fish and other aquatic organisms have used streams and rivers within the cumulative effects area.

Changes throughout the geographic area have created conditions where turbidity is likely higher in tributary streams now than it was prior to settlement in the 1800s. Land clearing, farming, road building, logging, grazing and other intensive land uses have caused land areas to lose vegetative cover and expose erosive soils (Elliot et al. 2010). Fires also expose soils and can lead to greater erosion and slope destabilization, leading to landslides and mass wasting that contributes sediments to streams. The result is increased erosion and increased turbidity in tributary streams.

Changes in land uses since settlement in the 1800s have contributed contaminants to rivers within the cumulative effects area. Contaminants include nutrients from agriculture and grazing, metals from mining and roads, and chemical contaminants from industrial uses. While chemical

constituents have been detected in water and sediments in the cumulative effects area, monitoring data indicate that concentrations do not appear to violate water quality standards (USACE 2002b).

Hydrology and Sediment – Effects of Past Actions and Current Conditions

Prior to extensive human modification of river systems and substantial changes to land use in the cumulative effects area, the Snake River and tributary streams hydrology reflected the climate within the watersheds. Generally high flows followed spring snowmelts and low flows occurred at the end of summer, reflecting the semi-arid climate of most of the cumulative effects study area. Forest fires periodically denuded large areas of vegetative cover, increasing erosion and sediment loading to streams.

As noted in the water quality and sediment quality discussion above, land clearing for logging, agriculture and urban land uses resulted in more exposed soils, greater slope instability, and ultimately greater erosion and sediment loads to streams (Goode et al. 2011). Recent changes in land management of forest and agricultural lands have helped reduce erosion and sediment loading to tributary streams. Agricultural conservation measures implemented over recent decades have had a measureable effect in reducing the erosion and loading of fine sediments to rivers (UI/WSU 2010). This is particularly noticeable in the lower Snake River subbasin due to its large proportion of agricultural land. Similarly, implementation of best management practices on forest lands related to timber harvest and road building and maintenance have likely contributed to reducing sediment loads from those sources (Elliot et al. 2010). These practices include riparian buffers, road removal, and selective harvest.

Damming of rivers created conditions in which most sediment is essentially blocked from downstream passage behind high dams (like the Hells Canyon Complex on the Snake River and Dworshak on the Clearwater River). Dams also create conditions where sand and other sediment transported by rivers settles out where a free-flowing river transitions into a reservoir. The latter example represents the condition at the confluence of the Snake and Clearwater Rivers at the head of Lower Granite Reservoir, which has contributed to the accumulation of sediment that interferes with the authorized purposes of the LSRP. Section 3.10 describes the trends and current conditions with regard to sediment loading, transport and accumulation in the LSRP, as a result of erosion and sediment transport within the cumulative effects area.

Cultural Resources – Effects of Past Actions and Current Conditions

Past development activities, including logging, grazing, modification of river systems, agriculture and urban development have profoundly affected cultural resources, and cultures, in the cultural resources study area. As noted above, damming rivers has inundated or otherwise changed cultural resources throughout the Snake River basin. Shoreline cultural resources remain at risk to erosion by wave action and fluctuations in water level. Logging, agriculture and other land-altering activities have adversely affected historic built resources, archaeological sites, and

traditional cultural properties. Ongoing present actions (e.g., erosion, vandalism, development) and those in the future (e.g., ground disturbing activities) will continue to have negative effects.

4.11.2.4 Reasonably Foreseeable Future Actions

Cumulative effects analyses must consider the effects of "reasonably foreseeable future actions regardless of what agency…or person undertakes such…action." (40 CFR §1508.7). Future actions that are speculative are not considered reasonably foreseeable (EPA 1999). Documented planned actions by local, state or federal government agencies, private entities, or individuals are considered "reasonably foreseeable." Similarly, the Corps considerers the continuation of existing programs, without major changes in policy, law, regulations, or funding, reasonably foreseeable.

Based on the CEQ guidance (CEQ 1997) and scoping input, the Corps has identified several reasonably foreseeable future actions, including continuation of existing actions, within the geographic and temporal scope of this cumulative effects analysis. These actions, when considered together with the past and present actions summarized in the preceding sections, may have cumulative effects on the resources analyzed. Also, due to the programmatic nature of this EIS, the future actions are identified on a similarly broad, programmatic level (as opposed to a project- and site-specific level). The Corps anticipates that the cumulative effects analyses of actions proposed pursuant to this EIS will conduct cumulative effects analysis at a project-specific level of detail through a tiered NEPA process.

Future actions identified by the Corps are listed in Table 4-2 below.

Table 4-2. Reasonably Foreseeable Future Actions

Reasonably Foreseeable Future Action (Responsible Party)	Location within Cumulative Effects Area
LSRP Operations - continuing (Corps) • Continued operation of dams and reservoirs (consistent with FCRPS biological opinion) • Navigation maintenance – channel dredging • Maintenance of Lewiston levee • Monitoring of sediment transport	Lower Snake River
Hydropower Operations (Corps, BOR, Idaho Power, BPA) • Continued operations of FCRPS dams	Columbia and Snake River system
Public Land Management – continuing (USFS, BLM) • Implementation of resource management plans • Multi-use management • Timber harvest and associated activities at or near current levels • Continued road decommissioning at current levels • Continued fire management and suppression	Public lands throughout the cumulative effects study area

Table 4-2. Reasonably Foreseeable Future Actions

Reasonably Foreseeable Future Action (Responsible Party)	Location within Cumulative Effects Area
Urban Land Uses including ports and transportation (private individuals and developers, local governments, port districts) • Maintain and potentially minimally expand existing urban areas • Possible changes in commodity shipments	Throughout the cumulative effects study area, focused on main transportation routes and urban centers.
Agricultural Land Management (private landowners and conservation districts) • Continued agricultural conservation practices at or near current levels.	Throughout the cumulative effects study area, focused on lower Snake River subbasin
Recovery Plans (and associated activities) for ESA-listed Fish (NMFS, USFWS, state departments of fish and wildlife/game) • Terms and conditions of 2008/2010 BiOp • Planned habitat restoration, fish passage improvements to benefit listed fish	Columbia and Snake River systems

Substantial modification of existing publicly-funded programs noted in Table 4-2 does not appear reasonably foreseeable. As such, the Corps has assumed the continuation of the programs and associated actions at or near their current levels into the future. Legislative actions may affect current programs; however making assumptions about specific legislative changes in this analysis would be speculative and not appropriate for the cumulative effects analysis.

Continuation of existing programs at current levels would essentially affect no change to the environmental conditions and trends identified for environmental resources in Section 3 and in Section 4.11.2.3.

4.11.3 Cumulative Effects of Alternatives

The cumulative effects analysis considers how the direct and indirect effects of the alternatives would contribute to the cumulative effects of past, present and future actions and change the conditions that have and are expected to result from those actions.

4.11.3.1 Alternative 1: No Action (Continue Current Practices)

Threatened and Endangered Fish

The cumulative effects of past, present and reasonably foreseeable future actions have resulted in environmental conditions that have led to the threatened or endangered status of anadromous fish species in the Snake and Columbia Rivers. The profound changes to the Columbia-Snake River system documented in Section 3 and Section 4.11.2.1 have adversely affected the habitat and populations of listed fish species. Navigation objective reservoir operations reduce reservoir

levels to MOP, or as close to it as possible while still providing a 14-foot-deep navigation channel, during juvenile salmonid outmigration. This management measure aids fish migration in accordance with the 2008/2010 BiOp (RPA Action 5). Continued recovery efforts would incrementally improve conditions for anadromous fish, having a cumulative beneficial effect on anadromous fish populations, including threatened and endangered species. However fish would also continue to be faced with multiple environmental factors that present challenges, such as dams and degraded habitat. The effects of Alternative 1 on threatened and endangered fish, when combined with past, present, and reasonably foreseeable future actions, would not change current conditions, including the listing status of threatened and endangered fish. Therefore Alternative5 would not have a cumulative effect on threatened and endangered fish species.

Water Quality and Sediment Quality

Alternative 1 would not affect water quality or sediment quality. Water and sediment quality effects of Alternative 1 when combined with the effects of past, present, and reasonably foreseeable future actions would not contribute to cumulative effects on water or sediment quality.

Hydrology and Sediment

Past and present actions have resulted in current conditions in the cumulative effects area of erosion, sediment transport and deposition that substantially contribute to the accumulation of sediment that interferes with authorized purposes of the LSRP. Alternative 1 would address the accumulation of sediment by modifying reservoir levels where it interferes with authorized purposes, but would not affect hydrology or sediment loading or transport of the Snake River system. Therefore, Alternative 1 would not contribute to cumulative effects of past, present and reasonably foreseeable further actions on hydrology and sediment.

Cultural Resources

Past and present actions have adversely affected cultural resources throughout the cumulative effects study area. Alternative 1 would not substantially change the condition of cultural resources within the LSRP, and would not affect them outside the LSRP. Navigation objective reservoir operation would not affect submerged cultural resources. Shoreline cultural resources sites would still continue to be impacted by erosion due to the fluctuation of the reservoirs and natural processes, and this effect may be increased by prolonged exposure to higher reservoir levels expected with navigation objective reservoir operations. On going land disturbing and development actions (by private land owners and public agencies) in the cumulative effects study area would potentially affect cultural resources. The effects of Alternative5 on cultural resources, when combined with past, present, and reasonably foreseeable future actions, would not change current conditions and, thus, would not contribute to cumulative effects on cultural resources.

4.11.3.2 Alternative 5: 5Dredging Based Sediment Management

Threatened and Endangered Fish

The cumulative effects of past, present and reasonably foreseeable future actions have resulted in environmental conditions that have led to the threatened or endangered status of anadromous fish species in the Snake and Columbia Rivers. The profound changes to the Columbia-Snake River system documented in Section 3 and Section 4.11.2.1 have adversely affected the habitat and populations of listed fish species. Periodic maintenance dredging in the LSRP and beneficial use of dredged material would not significantly change the regional conditions that adversely affect listed fish species. Beneficial use of dredged material could have a beneficial effect for fish and would contribute to improving habitat. Continued recovery efforts would incrementally improve conditions for anadromous fish, having a cumulative beneficial effect on anadromous fish populations, including threatened and endangered species. However fish would also continue to be faced with multiple environmental factors that present challenges, such as dams and degraded habitat. The effects of Alternative 5 on threatened and endangered fish, when combined with past, present, and reasonably foreseeable future actions, would not change current conditions, including the listing status of threatened and endangered fish. Therefore Alternative5 would not have a cumulative effect on threatened and endangered fish species.

Water Quality and Sediment Quality

Alternative 5 would have direct temporary water quality effects of increased turbidity from periodic dredging and dredged material placement for beneficial use. Effects would be confined to the dredging and beneficial use areas within the Lower Snake River. Alternative 5 would not affect sediment quality. The water and sediment quality effects of Alternative5 when combined with the effects of past, present, and reasonably foreseeable future actions would not contribute to cumulative effects on water or sediment quality.

Hydrology and Sediment

Past and present actions have resulted in current conditions in the cumulative effects area of erosion, sediment transport and deposition that substantially contribute to the accumulation of sediment that interferes with authorized purposes of the LSRP. Alternative5 would address the accumulation of sediment at the point where it interferes with authorized purposes, but would not affect hydrology or sediment loading or transport of the Snake River system. Therefore, Alternative5 would not contribute to cumulative effects of past, present and reasonably foreseeable further actions on hydrology and sediment.

Cultural Resources

Past and present actions have adversely affected cultural resources throughout the cumulative effects study area. Alternative 1 would not substantially change the condition of cultural resources within the LSRP, and would not affect them outside the LSRP. Dredging would be

unlikely to disturb submerged archaeological sites, since it would be largely limited to the existing navigation channel. Beneficial use of dredged material for habitat creation could affect existing submerged sites by compacting sediments overlaying sites, if sites are present. Shoreline cultural resources sites would still continue to be impacted by erosion due to the fluctuation of the reservoirs and natural processes. On going land disturbing and development actions (by private land owners and public agencies) in the cumulative effects study area would potentially affect cultural resources. The effects of Alternative5 on cultural resources, when combined with past, present, and reasonably foreseeable future actions, would not change current conditions and, thus, would not contribute to cumulative effects on cultural resources.

4.11.3.3 Alternative 7: Comprehensive (Full System and Sediment Management Measures)

Threatened and Endangered Fish

Alternative 7 includes the range of management measures that the Corps could potentially implement. Alternative 7 includes measures that address sediments at the locations where they accumulate and measures that potentially reduce or potentially avoid problem sediment accumulation. Beneficial use of dredged material could have a beneficial effect for fish and would contribute to improving habitat and other measures have potential adverse effects (see Section 4.1). However, the direct and indirect effects of Alternative 7 on threatened and endangered fish, when combined with past, present, and reasonably foreseeable future actions, would not change current conditions and, thus, would not contribute to cumulative effects on threatened and endangered fish species. As part of implementation of any action, the Corps would work with resource agencies to design projects that minimize and avoid adverse effects on listed species and their habitat.

Water and Sediment Quality

Alternative 7 would generally have temporary water quality effects of increased turbidity during implementation of measures. Drawdown to flush sediments would have larger and more long-lasting turbidity effects, as well as having the potential to disturb and mobilize sediments that have not yet been evaluated for contaminants. Water quality and sediment quality effects would be limited to the reservoir in which drawdown occurred, so those effects of Alternative 7 would be limited to the LSRP. The water quality and sediment quality effects of Alternative 7, when combined with past, present, and reasonably foreseeable future actions, would not have a cumulative effect on water and sediment quality.

Hydrology and Sediment

Alternative 7 would have direct and indirect effects on sediment accumulation and transport within the LSRP system. Alternative 7 includes measures that could move or redirect sediment within specific reservoirs. Like Alternative 5, Alternative7 would not affect sediment loading or transport of the Snake River system that has resulted from past and present actions and is unlikely to change substantially as a result of reasonably foreseeable future actions. Sediment

entering the LSRP from upland sources is the result of and subject to a variety of factors (see Section 3.7, Appendices C, D and F). Conditions related to climate change could change sediment loading and transport dynamics in the cumulative effects study area. Therefore, Alternative 7 would not have a cumulative effect on hydrology and sediment.

Cultural Resources

Past and present actions have adversely affected cultural resources throughout the cumulative effects study area. Alternative 7 would not substantially change the condition of cultural resources within the LSRP, and would not affect them outside the LSRP. Alternative 7 includes measures (in addition to those included in Alternative 5) that could potentially change flows and water levels (e.g., drawdown to flush sediments, structures to change flow and redirect sediments); these measures could expose inundated sites or locally increase the potential for erosion of shoreline sites. On going land disturbing and development actions (by private land owners and public agencies) in the cumulative effects study area would potentially affect cultural resources. Because Alternative 7 would not substantially change the condition of cultural resources it is not anticipated to have a cumulative effect on cultural resources.

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SECTION 5.0 COMPLIANCE WITH APPLICABLE ENVIRONMENTAL LAWS AND REGULATIONS

This section addresses Federal statutes, implementing regulations, and executive orders potentially applicable to the proposed PSMP adoption and implementation. In each case, the text provides a brief summary of the relevant aspects of the law or order. The conclusions on compliance are based on the impact analysis presented in Section 4, Environmental Consequences. The Corps would comply with all applicable laws and regulations for the proposed immediate action to address current sediment interference with authorized purposes; these specific procedures are discussed where applicable.

5.1 Federal Statutes

5.1.1 American Indian Religious Freedom Act (AIRFA)

The AIRFA of 1978 (42 U.S.C.A. 1996) established protection and preservation of Native Americans' rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that public officials must consider Native Americans' interests before undertaking actions that might harm those interests. The Corps will continue to coordinate with affected Native American Tribes on this study and future implementation of the PSMP.

5.1.2 Archeological Resources Protection Act

The Archeological Resources Protection Act (16 U.S.C. 470aa-470ll) provides for the protection of archeological sites located on public and Native American lands, establishes permit requirements for the excavation or removal of cultural properties from public or Native American lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of cultural properties.

The Corps will continue to protect archeological resources and sites on lands within the Corps' jurisdiction. The Corps will configure individual PSMP implementation measures to avoid known cultural properties and will consult with appropriate authorities should inadvertent discoveries occur during measure implementation.

5.1.3 Clean Air Act

The Clean Air Act (CAA) (42 U.S.C. 7401 et seq.), amended in 1977 and 1990, was established "to protect and enhance the quality of the nation's air resources so as to promote public health and welfare and the productive capacity of its population." The CAA authorizes the EPA to establish the NAAQS to protect public health and the environment. The CAA establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. The CAA also requires the states to develop implementation plans applicable to particular industrial sources.

Construction activities associated with some PSMP measures have the potential to increase dust and create other temporary air quality effects. With the implementation of BMPs, activities associated with implementation of the PSMP are not anticipated to adversely affect air quality.

5.1.4 Endangered Species Act

The ESA (16 U.S.C. 1531-1544), amended 1988, established a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) of the ESA requires federal agencies to consult with the USFWS and NMFS (the Services), as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats.

The Corps has and would continue to consult with the Services concerning listed species within the study area that could be affected by the actions addressed in the PSMP. Section 7(c) of the ESA and the Federal regulations on endangered species coordination (50 CFR § 402.12) require that Federal agencies prepare biological assessments of the potential effects of major actions on listed species and critical habitat. The Corps has coordinated with the Services concerning ESA compliance for the PSMP and determined that meaningful consultation was not possible on a programmatic level. The Corps and the Services agreed that, when specific projects are developed following the adoption of the PSMP, the Corps will consult with USFWS and/or NMFS as required by the ESA. Depending on the type and location of the proposed project, consulting agencies may require preparation of a project-specific Biological Assessment for potentially effected protected species.

The Corps has prepared a biological assessment documenting the anticipated effect of the proposed immediate action to reestablish the navigation channel to its authorized dimensions (included in Alternatives 5 and 7) to address sediment accumulation that currently interferes with commercial navigation. The Biological Assessment is included as Appendix K. The Corps is requesting formal consultation with NMFS and the USFWS for this proposed immediate action.

5.1.5 Federal Water Pollution Control Act (Clean Water Act)

The Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.) is more commonly referred to as the CWA. This act is the primary legislative vehicle for Federal water pollution control programs and the basic structure for regulating discharges of pollutants into waters of the United States. The CWA was established to “restore and maintain the chemical, physical, and biological integrity of the nation’s waters.” The CWA sets goals to eliminate discharges of pollutants into navigable water, protect fish and wildlife, and prohibit the discharge of toxic pollutants in quantities that could adversely affect the environment. The Act has been amended numerous times and given a number of titles and codifications.

Water Quality Certification for projects developed pursuant to the adopted PSMP will be requested from the regulating agencies for the state(s) in which projects are proposed, as

appropriate each time a project is proposed. There is insufficient information available on future actions to request water quality certification for the adopted PSMP. Corps actions involving the discharge of dredged or fill materials into the waters of the United States will be in accordance with guidelines promulgated by the EPA in conjunction with the Secretary of the Army under the authority of Section 404(b)(1) of the CWA. Section 404(b)(1) evaluations will be prepared as needed for each project involving discharges of dredged or fill material in waters of the United States, and submitted to the appropriate state(s) along with a request for water quality certification. For the proposed immediate action to reestablish the navigation channel dimensions, the Corps has prepared a Section 404(b)(1) evaluation, which is included as Appendix L. The sediment at one of the potential dredging sites, the Port of Clarkston's Crane Dock site at RM 137, had not been evaluated for contaminants at the time this draft PSMP/EIS was prepared. The results of the sediment evaluation should be available in January 2013. The 404(b)(1) evaluation and the PSMP/EIS will be updated with those results prior to finalization. The Corps anticipates the sediment from the Crane Dock will be suitable for unconfined open in-water disposal. The Corps will be issuing a public notice for the immediate action and requesting Section 401 Water Quality Certification from the Washington Department of Ecology as the dredged material disposal would occur in Washington. Although the Corps would not be disposing of any dredged material in Idaho, the Corps will be requesting a Short Term Activity Exemption from Idaho Department of Environmental Quality for the dredging activities that would take place in Idaho.

5.1.6 Federal Water Project Recreation Act

In the planning of any Federal navigation, flood control, reclamation, or water resources project, the Federal Water Project Recreation Act (16 U.S.C.A. 4612 et seq.) requires that full consideration be given to the opportunities that the project affords for outdoor recreation and fish and wildlife enhancement. More specifically, the Act requires planning with respect to development of recreation potential. Projects must be constructed, maintained, and operated in a manner consistent with this Act if recreational opportunities are a potential component of a proposed project and would not counter the purpose of the project.

Recreation sites have been developed on the lower Snake River reservoirs and are operated by a variety of entities. No PSMP measures are expected to have a significant, long-term impact on recreation facilities, activities, or use patterns. Small boat marinas and HMUs would experience a positive effect from several measures that would keep access clear or involve reconfiguration of the facilities to avoid sediment accumulation problems.

5.1.7 Fish and Wildlife Coordination Act (FWCA)

The FWCA of 1934, as amended (16 U.S.C. 661 et seq.) requires consultation with USFWS when any water body is impounded, diverted, controlled, or modified for any purpose. The USFWS and state agencies charged with administering wildlife resources are to conduct surveys and investigations to determine the potential damage to wildlife and the mitigation measures that should be taken. The USFWS incorporates the concerns and findings of the state agencies and

other Federal agencies, including NMFS, into a report that addresses fish and wildlife factors and provides recommendations for mitigating or enhancing impacts to fish and wildlife affected by a Federal project. The Corps is not required to consult with the USFWS for existing water resource projects with standard operation and maintenance procedures in place.

This PSMP EIS has been coordinated with the USFWS and other Federal and state resource agencies. The Corps will continue to consult with wildlife agencies through the adoption and implementation of the PSMP.

5.1.8 Fishery Conservation and Management Act of 1976

The Fishery Conservation and Management Act of 1976 (16 U.S.C. 1801-1882; 90 Stat. 331; as amended), also known as the Magnuson Fishery Conservation and Management Act, established a 200-mile fishery conservation zone, effective March 1, 1977, and established the Regional Fishery Management Councils consisting of Federal and state officials, including the USFWS. The fishery conservation zone was subsequently dropped by amendment and the geographical area of coverage was changed to the Exclusive Economic Zone, with the inner boundary being the seaward boundary of the coastal States. Columbia River salmon and steelhead are found in this zone. Therefore, the potential effects of the alternatives on the fisheries in this zone have been examined in Section 4.1 of this EIS. The Biological Assessment (Appendix K) documents the essential fish habitat effects of the proposed immediate action to reestablish the navigation channel to its authorized dimension.

5.1.9 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918, as amended, (16 U.S.C. 715 et seq.) requires that lands, waters, or interests acquired or reserved for purposes established under the Act be administered under regulations promulgated by the Secretary of the Interior. This act involves conservation and protection of migratory birds in accordance with treaties entered into between the United States and Mexico, Canada, Japan, and the former Union of Soviet Socialist Republics. It protects other wildlife, including threatened or endangered species, and restores or develops adequate wildlife habitat. The migratory birds protected under this Act are specified in the respective treaties. In regulating these areas, the Secretary of the Interior is authorized to manage timber, range, agricultural crops, and other species of animals, and to enter into agreements with public and private entities. The Corps did not identify potential effects on migratory birds from the proposed immediate action to reestablish the navigation channel to its authorized dimensions. Compliance with the Act would be conducted on a project-specific basis for future actions.

5.1.10 National Environmental Policy Act

This PSMP EIS was prepared pursuant to regulations implementing the NEPA (42 U.S.C. 4321 et seq.). The NEPA provides a commitment that Federal agencies will consider the environmental effects of their actions. It also requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, potential mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that these factors have been considered by decision makers prior to undertaking actions. Development of this PSMP EIS is in compliance with NEPA requirements for the proposed action. The NEPA compliance will be considered complete with the signing of a Record of Decision.

This is a programmatic EIS, which means that the EIS alternatives define broad programs for managing sediments as they relate to the authorized project purposes of the LSRP. This EIS addresses the environmental effects of the programmatic sediment management plan and the first proposed site-specific action to be taken under this plan, the immediate action to dredge four locations to reestablish the navigation channel to its authorized dimension. Specific actions to be taken in the future (following approval of this programmatic EIS) will require project-specific environmental reviews, including preparation of NEPA documents (i.e., EA or EIS).

5.1.11 Native American Graves Protection and Repatriation Act (NAGPRA)

The NAGPRA (25 U.S.C.A. 3001) addresses the discovery, identification, treatment, and repatriation of Native American (and Native Hawaiian) human remains, associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony. This Act also establishes fines and penalties for the sale, use, and transport of Native American cultural items. Consistent with procedures set forth in applicable Federal laws, regulations, and policies, the Corps will proactively work to preserve and protect cultural resources, establish NAGPRA protocols and procedures, and allow reasonable access to sacred sites. Should human remains or associated objects be discovered during implementation of any action under this PSMP, all work would stop, and the Corps would notify Native American tribes and comply with the requirements of NAGPRA.

5.1.12 The National Historic Preservation Act (NHPA)

Section 106 of the NHPA (16 U.S.C. 470) requires that Federal agencies evaluate the effects of Federal undertakings on historic properties and afford the Advisory Council on Historic Preservation opportunities to comment on the proposed undertaking. The first step in the process is to identify cultural resources included in (or eligible for inclusion in) the NRHP that are located in or near the study area. The second step is to identify the possible effects of proposed actions. The lead agency must examine whether feasible alternatives exist that would avoid such effects. If an effect cannot reasonably be avoided, measures must be taken to minimize or

mitigate potential adverse effects. Cultural resource literature searches have been conducted in support of the EIS. . This EIS identifies alternatives for broad programs for managing sediments as they relate to the authorized project purposes of the LSRP. As such, the EIS does not define or evaluate specific, discrete sediment management projects (such as conducting sediment reduction or dredging in a specific location and time), but rather it identifies a range of potential actions over a wide area and long period of time. Specific actions to be taken following approval of this programmatic EIS will require project-specific determination of effects in accordance with Section 106 of the NHPA.

This EIS also proposes the immediate undertaking to dredge four locations in 2013/2014. The Corps has determined that the proposed immediate dredging will result in no adverse affects to historic properties. This determination will be provided to the State Historic Preservation Officers of both Washington and Idaho, as well as interested Tribes in accordance with Section 106 of the NHPA. This process is happening concurrent to the public comment period of this EIS.

The following cultural resource protection laws were also considered in the preparation of this PSMP EIS:

- The Antiquities Act of 1906 (16 U.S.C. 431).
- Historic Sites Act of 1935 (16 U.S.C. 461).
- Reservoir Salvage Act of 1960 (16 U.S.C. 469).
- Archeological and Historic Preservation Act of 1974 (16 U.S.C. 469a-1).

The Corps will consult with the state historic preservation officers of Washington and Idaho regarding its effect determination for the proposed immediate action to address sediment that currently interferes with commercial navigation. In the future, the Corps will consult with state historic preservation officers on a project-specific basis.

5.1.13 Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act)

The Northwest Power Act was passed by Congress on December 5, 1980 (16 U.S.C. 829d-1). This law created the eight-member Northwest Power Planning Council (NPPC), an interstate agency whose members are appointed by the Idaho, Montana, Oregon, and Washington governors. The NPPC was entrusted with adopting a Fish and Wildlife Program for the Columbia River Basin by November 1982 and preparing a 20-year Regional Electric Power and Conservation Plan by April 1983. These plans are periodically updated and amended.

The NPPC’s Fish and Wildlife Program established a number of goals for restoring and protecting fish and wildlife populations in the basin. These goals led to changes in the operation of the Coordinated Columbia River System during the mid-1980s. One of the most notable

changes resulted in the Water Budget, which provides for the release of specific amounts of water in the upper Columbia and Snake Rivers to help juvenile salmon migrate downstream in the spring. More recently, the NPPC developed its own proposals to protect threatened and endangered salmon stocks. The NPPC has completed amendments to its Columbia River Basin Fish and Wildlife Program. The amendments adopted to date include main stem survival, harvest, production, habitat, and flow measures that can be used to increase salmon and steelhead runs, and resident fish and wildlife measures. The Corps takes these amendments into consideration when making operating plans. The alternatives considered in the PSMP EIS to maintain the existing authorized project purposes of the LSRP would have no long-term, adverse impacts on generation of electrical power in the Northwest or on fish and wildlife populations present in the study area.

5.1.14 Pollution Control at Federal Facilities

In addition to their responsibilities under NEPA, Federal agencies are required to carry out the provisions of other Federal environmental laws. To the extent applicable to an alternative presented in this EIS, compliance with the standards contained in the following legislation was included in this evaluation:

- The Safe Drinking Water Act, as amended (42 U.S.C. 300F et seq.).
- The Solid Waste Disposal Act (42 U.S.C. 6901 et seq.).
- Oil Pollution Act (33 U.S.C. 2701 et seq.).
- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended (42 U.S.C. 9601 [9615] et seq.).
- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.).
- The Resource Conservation and Recovery Act (RCRA) of 1976, as amended (42 U.S.C. 6901 et seq.).
- Toxic Substances Control Act (TSCA), as amended; Title 40 CFR Part 761, “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions” (15 U.S.C. et seq.).
- The Noise Control Act of 1972, as amended (42 U.S.C. 4901 et seq.).
- Occupational Health and Safety Act (29 U.S.C. 651 et seq.).

5.1.15 Rivers and Harbors Act of 1899

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 401-418) regulates structures or work in or affecting navigable waters of the United States including discharges of dredged or fill material. The EIS considered effects to navigation (as well as water resources in accordance with the Clean Water Act). The public will be notified each time the Corps proposes to perform in-water work in projects developed pursuant to the adopted PSMP.

The Corps will be issuing a public notice in early 2013 for the first proposed immediate action to reestablish the navigation channel dimensions. This notice will be combined with the request to Washington Department of Ecology for Clean Water Act Section 401 water quality certification.

5.2 Executive Orders

5.2.1 Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 13, 1971

Executive Order 11593 outlines the responsibilities of Federal agencies to consider effects to historic properties in consultation with the Advisory Council on Historic Preservation where a Federal undertaking may adversely affect a property. Agencies are also to preserve, rehabilitate, and restore historic properties. Agencies are encouraged to avoid, or at least mitigate, an adverse effect on listed properties. The executive order furthers the purpose and policies associated with the National Environmental Policy Act of 1969; the National Historic Preservation Act of 1966; the Historic Sites Act of 1935 and the Antiquities Act of 1906.

5.2.2 Executive Order 11988, Floodplain Management Guidelines, May 24, 1977

This order outlines the responsibilities of Federal agencies in the role of floodplain management. Each agency shall evaluate the potential effects of actions on floodplains and should avoid undertaking actions that directly or indirectly induce growth in the floodplain or adversely affect natural floodplain values. Sediment management project developed pursuant to the adoption of the PSMP will need to comply with the provisions of this Executive Order.

5.2.3 Executive Order 11990, Protection of Wetlands

Executive Order 11990 encourages Federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. It has been the goal of the Corps to avoid or minimize wetland impacts associated with their planned actions.

5.2.4 Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994

Executive Order 12898 requires Federal agencies to consider and address environmental justice by identifying and assessing whether agency actions may have *disproportionately high and adverse human health or environmental effects on minority or low-income populations*. Disproportionately high and adverse effects are those effects that are *predominantly* borne by minority and/or low-income populations *and* are appreciably more severe or greater in magnitude than the effects on nonminority or non-low income populations.

This EIS programmatically considers activities related to long-term management of sediment. Plan measures, as proposed, are not expected to disproportionately affect any particular demographic group.

5.2.5 Executive Order 13007, Native American Sacred Sites, May 24, 1996

Executive Order 13007 directs Federal agencies to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners. Agencies are to avoid adversely affecting the physical integrity of such sacred sites and to maintain the confidentiality of sacred sites when appropriate. The act encourages government-to-government consultation with tribes concerning sacred sites. Some sacred sites may qualify as historic properties under the NHPA.

The Corps welcomes discussion of concerns or issues involving sacred sites and invites tribes to bring concerns as a part of the consultation process for the PSMP.

5.3 Executive Memoranda

5.3.1 Council on Environmental Quality Memorandum, August 11, 1990, Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA

The Council on Environmental Quality Memorandum establishes criteria to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmland, to consider alternative actions, as appropriate, that could lessen adverse effects, and to ensure Federal programs are consistent with all state and local programs for the protection of farmland. Implementation of measures potentially affecting prime or unique agricultural lands must address this requirement.

5.4 State Statutes

The CEQ regulations (40 CFR 1506.2) require consideration of the consistency of a proposed action with approved state and local plans and laws. In-water sediment management activities proposed in this PSMP EIS have been evaluated with regard to applicable state statutes and regulations. Compliance issues have been considered and addressed where applicable to the subject activities. A few statutes considered include, but are not limited to:

- Stream Channel Alteration Permit (Idaho)
- Hydraulic Project Approval (Washington)
- Shoreline Management Act (Washington)

The Corps will coordinate with the appropriate state agencies regarding conditions the states would normally require for compliance with the statutes, but the Corps would not obtain the state permits.

For the first proposed immediate action to reestablish the navigation channel, the Corps will be coordinating with the appropriate habitat biologists from Washington Department of Fish and Wildlife regarding conditions normally required under a Hydraulic Project Approval. The Corps will not need to coordinate with Idaho Department of Water Resources regarding a Stream Channel Alteration Permit as the proposed immediate action would take place within the Port of Lewiston Port District and is therefore exempt from this permit requirement.

SECTION 6.0 NOTICE OF INTENT COORDINATION, CONSULTATION, AND PUBLIC INVOLVEMENT

The Corps published an NOI in the Federal Register on October 3, 2005. The NOI provided a summary of the objectives of the Programmatic Sediment Management Plan and the watershed approach. In addition, the NOI provided background on the Corps' historic approach to sediment management, the array of sediment management measures that would be considered, and the scoping process.

6.1 Scoping

Scoping is the process by which the Corps gathered input from the public, tribes, and government agencies to help determine the scope of the EIS' alternatives and analysis. Public scoping is a critical component of the NEPA process, and one of the first steps taken in developing an EIS. During the scoping process, the Corps informs the public about the EIS preparation and allows the public and other agencies to provide input on the EIS. Public involvement allows the Corps to identify and address important issues early in the EIS process. In the case of the PSMP, it also aids the Corps in developing a range of measures and alternatives to consider in the EIS and in developing evaluation methods to assess the measures and alternatives.

Following the NOI, the Corps conducted several scoping activities to gather public input; these included:

- LSMG meetings
- Agency scoping workshops in each of the study area subbasins
- Considering written comments submitted by agencies and the public

In addition, the Corps conducted extensive coordination with agencies that have specific expertise in erosion, hydrology, and sediment management.

6.1.1 Local Sediment Management Group

The Corps reconvened the group in 2006 to conduct scoping for the PSMP. Prior to the preparation of this EIS, the Corps held another LSMG meeting to update the group on the project. The group adopted a new charter and has met throughout the EIS preparation process, providing input and direction to the Corps on sediment management on the lower Snake River. The Corps has convened the LSMG four times since 2006 to share information with the member agencies and stakeholders.

6.1.2 Agency Scoping Workshops

As part of scoping, the Corps conducted targeted agency outreach to gather the input and encourage the participation of federal and state agencies within the study area. In 2006 and 2007, the Corps met with federal agencies involved in land and water resource management in each of the major subbasins to solicit input on the scope of the study and specific technical expertise on sediment management from those agencies (Appendix G).

6.1.3 Public Scoping

Public scoping activities included public scoping open houses and meetings during February 2007 in Clarkston, Washington, Boise, Idaho, La Grande, Oregon, and Portland, Oregon. The Corps received public comments (submitted at the scoping meetings and by mail and e-mail), and considered all comments in the development of the EIS. The Corps received 21 written comments from federal and state agencies, conservation districts, a county advisory committee, a city, ports, nongovernmental organizations, and citizens. Appendix G presents a complete scoping summary. The Corps considered these comments in developing the scope of analysis and in preparing this draft EIS.

Information on the PSMP EIS has been made available since the initiation of scoping on the Corps' website http://www.nww.usace.army.mil/psmp/.

6.2 Tribal Consultation

Treaties between the United States and the three of the four lower Snake River tribe's document agreements reached between the Federal government and the tribes. In exchange for ceding much of their ancestral land, the government established reservation lands and guaranteed that the government would respect the treaty right, including fishing and hunting rights. These treaties, as well as statutes, regulations, and national policy statements originating from the Executive Branch of the Federal Government provide direction to Federal agencies on how to formulate relations with Native American tribes and people. The following policies are those most often referred to by Federal and tribal representatives:

- *1983 - Presidential Statement on American Indian Policy 19 Weekly Comp. Doc. 98-102).* President Reagan's statement dated January 24, 1983, provided direction on treatment of Native American tribes and their interests.
- *1984 - Department of Defense Directive No. 4710.1*- June 21, 1984.
- *1993 - Executive Order 12866, Regulatory Planning and Review.* The Order enhanced planning and coordination concerning new and existing regulations. It made the regulatory process more accessible and open to the public. Agencies were directed to seek views of tribal officials before imposing regulatory requirements that might affect them.
- *1994 - Executive Order 12898 on Environmental Justice*.
- *1994 - White House Memorandum for the Heads of Executive Departments and Agencies*. This emphasized the importance of government-to-government relations with tribal

governments and the need to consult with tribes prior to taking actions that may affect tribal interests, rights, or trust resources.

- *1994 - Government -to-Government Relations with Native American Tribal Governments, Memorandum* of April 22, 1994.
- *1995 - Government -to-Government Relations.* The United States Justice Department, Attorney General, issued and signed a policy statement on government-to-government relations on June 1, 1995. It includes references to tribes' sovereignty status and the Federal government's trust responsibility to tribal governments.
- *1998 - Executive Order 13084, Consultation and Coordination with Indian Tribal Governments*, May 14, 1998.
- *Policy Guidance Letter No. 57, Indian Sovereignty and Government Relations with Indian Tribes.* Implements Executive Order 13084.
- *1998 - DOD American Indian and Alaskan Native Policy*, October 20, 1998.
- *1999 - Project Operations Native American Policy*, July 12, 1999.

As noted in Executive Order 13084, the Federal government continues to work with tribes on issues concerning tribal self-government, trust resources, tribal treaty, and other rights as one government to another government. The Order directs agencies to consider affected Federally recognized tribes through the following policy principles:

- The United States has a unique legal relationship with tribal governments as set forth in the Constitution, treaties, statutes, executive orders, and court decisions.
- Tribes, as dependent nations, have inherent sovereign powers over their members and territories with rights to self- government. The United States works with tribes as one government to another government addressing issues concerning tribal self-government, trust resources, and tribes' treaty and other rights.
- Agencies will provide regular, meaningful, and collaborative opportunities to address the development of regulatory practices that may have significant or unique effects on tribal communities.
- Cooperation in developing regulations on issues relating to tribal self-government, trust resources, or treaty and other rights should use, where appropriate, consensus building methods such as rule-making.

The Corps sent letters to the tribal chairs of the Umatilla Tribe, the Nez Perce Tribe, the Colville Tribe, and the Yakama Nation at the onset of the NEPA process.

6.3 Agency Coordination

The ESA requires the Corps to consult with NMFS and the USFWS concerning the listed and proposed threatened and endangered species that may occur in the study area. The Corps has coordinated with the USFWS and NMFS regarding compliance with the ESA for the PSMP planning process and subsequent projects developed following PSMP adoption. The biological assessment documenting the anticipated effects of the proposed immediate action on listed species is included as Appendix K.

The Corps has also coordinated with the US EPA and other agencies regarding plan development and NEPA compliance during the EIS development. As noted in Section 2, the Corps conducted a measures screening workshop that involved representatives from US EPA, USFS, and USGS.

6.4 Public Outreach and Comment on the DEIS

Upon release of the DEIS, the Corps will publish a notice of availability in the Federal Register. The Corps will hold two public meetings where the public may submit comments. Also, the public may provide written comments via the project Web site (http://www.nww.usace.army.mil/psmp/default.htm), or mail comments to the Corps address below.

Sandra Shelin
Walla Walla District, Corps of Engineers
201 North 3rd Avenue
Walla Walla, WA 99362-1878

The public comment period will be held open for 45 days following the publication of the notice of availability. The Corps will carefully review and consider public comments and then prepare the final EIS, which will identify the preferred alternative that will identify how it will manage sediment within the lower Snake River system for the next 50 years.

SECTION 7.0 LIST OF PREPARERS

Preparer	Role in EIS Preparation	Experience
U.S. Army Corps of Engineers, Walla Walla District		
Gent, John	Geotechnical Analysis	BSCE, Civil Engineering MSCE, Civil Engineering (geotechnical) 32 years of experience PE, geotechnical endorsement
Hall, Scott	Cultural Resources	BA, Anthropology MA, Anthropology 14 years of experience
Juul, Steve	Water Quality, Sediment Quality	BS, Wildlife Science MS, Environmental Science PhD, Civil Engineering 27 years of experience
Newcomb, Craig	Socioeconomics	BA, Economics 25 years of experience
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SECTION 10.0 GLOSSARY

Term	Definition
adfluvial	Migrating from lakes into rivers and streams to spawn (referring to fish).
alkaline	A solution having a relatively low concentration of hydrogen ions and correspondingly higher concentrations of hydroxide ions, therefore with a pH greater than 7, and the ability to neutralize acids.
alluvial	Pertaining to the fan-shaped deposit of soil or sediment formed where a fast-flowing stream flattens, slows and spreads.
ammocoetes	The larval form of lamprey.
anadromous	Pertaining to the migration of fish from the ocean to spawn in fresh water.
anthropogenic	Caused by the influence of human beings.
appurtenant	An accessory or additional component element.
backwater	Water held by a dam.
batholith	A large body of igneous rock formed beneath the Earth's surface by the intrusion and solidification of magma.
bed load	Particles of sand, gravel and soil carried by the natural flow of a stream on or immediately above its bed (in contrast to "suspended sediment").
benthic	Pertaining to the collection of organisms that live on or in the sediment at the bottom of a water body.
berm	A linear mound of earthen material.
biological oxygen demand	A measure of the oxygen required for metabolism by aerobic organisms in an aquatic environment.
biomass	Biological material from living or recently living organisms.
broodstock	A group of mature individuals (generally fish) used in aquaculture for breeding purposes.
cairn	A mound of stones erected as a memorial or landmark (generally associated with archaeological sites).
camas	A plant with grassy leaves and an edible bulb.
chironomid	A member of the insect family Chironomidae; nonbiting midges.
chlorophyll a	The type of chlorophyll that is most common and predominant in all oxygen-producing photosynthetic organisms such as vascular plants and algae.
chokepoint	A geographical constriction that reduces flow of water through a channel.
congener	Derivatives of related chemicals with similar properties and toxicities.
Corophium species	Species belonging to the family Amphipoda, which are very small organisms mainly found in aquatic environments where they act scavengers, eating decaying material in the sediments.
diadromous	Pertaining to migration of fish between fresh and salt water.
distinct population segment (DPS)	An animal population or group of populations that is discrete from other populations of the species and significant in relation to the entire species; DPSs, as a classification, are eligible for listing under the ESA.
diurnal	Relating to or occurring within a 24-hour period; daily.
drawdown	The lowering of a water body's water surface level, as by releasing flow through a dam.
elutriate	To purify, separate, or extract, or related to the chemical process to do so.
embayment	A bay or bay-like shape of a water body.

Term	Definition
entrainment	To be gathered up unintentionally.
epibenthic	Living on the surface of bottom sediments in a water body.
escapement	The number of fish arriving at a natal stream or river to spawn.
ethnographic	Pertaining to the study or systematic recording of human cultures.
eutrophication	The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates.
evolutionarily significant unit	A population of organisms that is considered distinct for the purposes of conservation.
extirpated	The condition of a species which ceases to exist in a given geographic area but still exists elsewhere; local extinction.
fault-block	A rock mass that is bounded by faults; the faults may be elevated or depressed and not necessarily the same on all sides.
fluvial	Pertaining to or inhabiting a stream or river.
flyway	A seasonal route followed by birds migrating to or from wintering or breeding regions.
forb	A broad-leaved herb other than a grass, especially one growing in a field, prairie, or meadow.
forebay	The portion of a reservoir immediately behind a dam.
freeboard	The vertical distance from the water surface and the top of a confining levee.
fry	The life stage of fish that occurs just after hatching
gabion	A container usually made of metal wire and filled with earth and stones, used in the construction and rerouting of waterways.
gallinaceous	Relating or belonging to the bird order Galliformes, including domestic fowl, pheasants, grouse, etc., having a heavy rounded body, short bill, and strong legs.
geomorphology	Pertaining to the characteristics, origin, and development of landforms.
glide	Portion of a stream at which the water has motion but the surface is generally not broken or turbulent.
habitat management unit	Areas set aside by the Corps for wildlife habitat as a way to mitigate for lost habitat due to reservoir impoundments.
hydrograph	The graphical representation of stage, flow, velocity, or other characteristics of water over time at a given location.
hyporheic flow	The percolating flow of groundwater and surface water through sand, gravel, sediments and other permeable substrate under the streambed.
indigenous	Produced, growing, living, or occurring naturally in a particular region or environment.
intermontane	Occurring or situated between mountain ranges.
interstitial	Pertaining to or situated between parts of a structure, tissue, or matter.
invertebrate	Pertaining to organisms without a spinal column.
jack salmon	Salmon that return to freshwater after spending relatively little time at sea (1 to 2 years as opposed to 2 to 8 years).
kelt	A salmon that has recently spawned.
kokanee	Land-locked lake populations of sockeye salmon.
lacustrine	Of or pertaining to a lake.
lanceolate	Tapered from a rounded base toward a narrow tip or apex.

Term	Definition
Laramie orogeny	A series of mountain-building events that affected much of western North America in Late Cretaceous and Early Paleogene time (about 65.5 million years ago).
lek	The communal area in which two or more males of a species gather and perform courtship displays.
lithics	Items consisting of or relating to stone or rock, typically related to items found at archaeology sites.
loaded draft	A measure of how much lower a vessel will sit in the water after loading cargo, passengers, fuel, and such other items necessary for use its voyage.
loess	Windblown deposit of fine-grained, calcareous silt or clay.
macroinvertebrate	Any invertebrate organism large enough to be seen without magnification.
macrophyte	Aquatic plants, growing in or near water, that are either emergent, submerged, or floating.
maritime	Climate conditions influenced by the ocean.
mass-wasting	The dislodging and down slope transport of loose rock and soil material under the direct influence of gravitational stresses; a landslide is an example of mass wasting.
mesic	Characterized by, related to, or requiring a moderate amount of moisture.
metabolite	The product of a metabolic action.
mima mounds	Circular or oval domelike structures composed of loose silt and soil, generally generated by a combination of geomorphic processes and burrowing by animals.
minimum operating pool	The lowest level of water in the river channel that the Corps must maintain to allow for commercial navigation.
montane	Of, related to, growing in, or being the biogeographical zone of relatively cool, moist upland slopes below timberline dominated by large coniferous (evergreen) trees.
mustelids	The family carnivorous mammals including skunks, ferrets, otters, badgers, martens, weasels and minks.
nephalometric turbidity unit	A standard unit of measurement for turbidity. Higher NTU measurement indicate more suspended sediment and turbidity.
noxious weed	Any plant or plant product that can directly or indirectly cause damage to: crops, livestock, poultry, or other agricultural interests of agriculture; irrigation; navigation; and/or natural resources (such as native plants and wildlife).
oligochaete	A class of the phylum Annelida that include terrestrial and freshwater worms.
palustrine	Relating to a system of inland, nontidal wetlands characterized by the presence of trees, shrubs, and emergent vegetation.
passerines	Of or relating to birds of the order Passeriformes, which includes perching birds and songbirds.
pelagic	Open water that is not close to the bottom of the water body or near to the shore.
periphyton	A complex mixture of algae, other microbes, and detritus (dead or decaying material) that are attached to submerged surfaces in most aquatic ecosystems.
petroglyph	A carving or inscription on rock surfaces.
photic zone	The upper layer of a water body delineated by the depth to which enough sunlight can penetrate.
phytoplankton	Small plants and photosynthetic bacterial suspended in the water columns
pictograph	An ancient or prehistoric drawing or painting on a rock wall.
piscivorous	Habitually feeding on fish; fish-eating.

Term	Definition
planktonic	Of or pertaining to small or microscopic organisms, including algae and small floating plants and animals, that float or drift in great numbers, especially at or near the water surface, and serve as food for fish and other larger organisms.
point bar	A feature of a river or stream composed of a series of low, sand and/or gravel ridges formed on the inside of a bend by the gradual deposition of transported sediments.
pool tailout	The most downstream part of a pool, or slow flowing portion of a stream, just before the beginning of a more swiftly flowing riffle.
primary productivity	The rate at which biomass is produced by organisms that convert inorganic substrates or complex organic compounds.
prolarvae	A newly hatched fish in which the mouth parts are underdeveloped and nutrition is provided by the yolk sac.
protohistoric	Pertaining to the study of culture just before the time of its earliest recorded history.
rain shadow	An area having relatively little precipitation due to the effect of a barrier, such as a mountain range, that causes the prevailing winds to lose their moisture before reaching it.
recruitment	The natural increase in the harvestable portion of the population (fish above a certain size) by growth of smaller (e.g., newly hatched) fish; typically only a small fraction of eggs become recruits.
redd	A spawning nest made by a fish, particularly salmon or trout.
refugia	An area where prevailing conditions have enabled a species or community of species to survive/function when surrounding areas are degraded.
revetment	A wall, as of stone or concrete, used to support an embankment.
riffle	A stretch of relatively turbulent water in a stream caused by an underlying shoal, sandbar, or other rough bottom condition.
rill	A small, transient narrow channel.
riparian	Situated or taking place along or adjacent to the bank of a river.
riverine	Of or pertaining to a river.
salmonids	Fish belonging or pertaining to the family of Salmonidae, including salmon, trout, chars and whitefishes.
sediment yield	The amount of sediment eroded and exported from a particular drainage basin or watershed.
sedimentation	The process of deposition of a solid material from a state of suspension in a water body.
seral	An intermediate stage found in the ecological succession, or maturation, of a vegetative community. Forests typically go through multiple successional stages as they reach a mature, or climax, stage.
shoaling	The formation of sandbars or other similar increases in the elevation of the bottom of a body of water, sometimes constituting a hazard to navigation.
slough	A generally slow-moving side channel, inlet, or backwater associated with a river.
smolt	A juvenile salmonid, one or more years old, that has undergone physiological transformations to cope with a marine environment.
standard project flood	A hypothetical river flow level expected to result from the most severe combination of meteorological and hydraulic conditions which area reasonably characteristic of the geographic region involved.
steppe	An extensive, generally open plain and its associated vegetative community.
stratigraphic	Of or pertaining to rock layers, especially the distribution, deposition and age of sedimentary material.

Term	Definition
suspended sediment	Typically fine-grained soil particles that remain suspended in water.
tailrace	The channel for carrying water away from a dam.
tailwater	The portion of a water body immediately downstream of a dam or other hydraulic structure.
talus pit	An area or pit dug into a field or slopes used as meat caches and hunting blinds
thalweg	The line defining the lowest points along the length of a river marking the direction of the river's flow as well as line of the river's fastest flow.
trophic state indicators	Water quality parameters used to make a rough estimate of its biological condition.
turbidity	An optical characteristic or property of water, which generally describes its cloudiness.
ungulate	Any mammal with hooves.
uplands	Area of land lying above the level where water flows or where flooding occurs.
water bar	A road or trail construction feature that is used to prevent erosion on sloping roads or trails by cutting a diagonal channel across the road surface that diverts surface water that would otherwise flow down the whole length of the road.
watershed	The area drained by a river, stream, etc.; drainage area.
young-of-the-year	Fish that are less than one year old.
zooplankton	Very small animals suspended in the water column with little or no ability to move on their own.