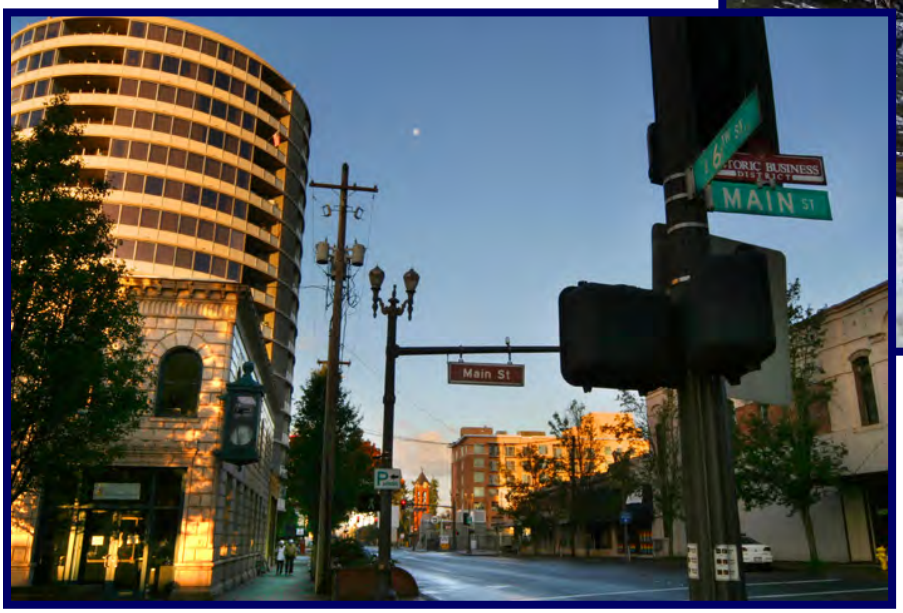
Salmon-Washougal and Lewis Detailed Implementation Plan

"Our mission is to develop and implement a watershed management plan for the responsible use of water to balance the needs of people and natural resources."



Volume III-Appendices I-L

Lower Columbia Fish Recovery Board, Lead Agency
Counties of Clark, Cowlitz and Skamania

June 9, 2008

Salmon-Washougal & Lewis Detailed Implementation Plan

WRIA 27 and 28

WA Department of Ecology
Grants G0700278, G0700274, G0800067

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Volume III of III

Approved June 9, 2008

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Lower Columbia Fish Recovery Board

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- Commissioner Betty Sue Morris
- Commissioner Steve Stewart

Cowlitz County Board of Commissioners
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- Commissioner George Raiter
- Commissioner Alex Swanson

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- Commissioner Jamie Tolfree

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Lower Columbia Fish Enhancement Group
PacifiCorp
Skamania County
Town of Yacolt
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WA Department of Agriculture
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Acronyms

ACWSP	Abbreviated Coordinated Water System Plan
ADD	Average Day Demand
AFY	Acre Feet Per Year
APA	Aquifer Protection Area
ASR	Aquifer Storage and Recovery
BMP	Best Management Practice
CARA	Critical Aquifer Recharge Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFS	Cubic Feet Per Second
CIR	Crop Irrigation Demand
CMS	Comprehensive Monitoring Strategy
COA	Coordination and Oversight Agency
CPU	Clark Public Utilities
CWA	Clean Water Act
DIP	Detailed Implementation Plan
DO	Dissolved Oxygen
DOH	Washington State Department of Health
EAP	Environmental Assessment Program
Ecology	Washington State Department of Ecology
EES	Economic and Engineering Services
EIS	Environmental Impact Statement
ENSO	El Nino/Southern Oscillation
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESHB	Engrossed Substitute House Bill
FC	Fecal Coliform
FERC	Federal Energy Regulatory Commission
FFA	Washington Farm Forest Association
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FTE	full time equivalent
GMA	Growth Management Act
GPM	Gallons Per Minute
GPS	Global Positioning System
GWAC	Ground Water Advisory Committee
GWMA	Ground Water Management Area
GWMP	Ground Water Management Plan
HWS	Habitat Work Schedule
IFIM	Instream Flow Incremental Methodology
IOCs	Inorganic Compounds
IWS	Implementation Work Schedule
LCFRB	Lower Columbia Fish Recovery Board
LFA	Limiting Factors Analysis
LWD	large woody debris
MCLs	Maximum Contaminant Levels

Acronyms - Continued

MDD	maximum day demand
MGD	Million Gallons Per Day
MOU	Memorandum of Understanding
MTBE	methyl tertiary-butyl ether
NA	Not Applicable
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWPPC	Northwest Power Planning Council
PDO	Pacific Decadal Oscillation
PGG	Pacific Groundwater Group
PUD	Public Utility District
PWR	Pacific Water Resources, Inc.
PWS	Public Water System
Qa	authorized annual withdrawal/diversion
Qi	authorized instantaneous withdrawal/diversion
Ranney Well	A shallow perforated pipe used to extract shallow ground water beneath a river bed
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RFP	Request for Proposals
RM	River Mile
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
SIS	Summary Implementation Strategy
SOCs	Synthetic Organic Chemicals
SSA	Sole Source Aquifer
SWSL	Surface Water Source Limitation
SWSMP	Small Water System Management Program
SWTR	Surface Water Treatment Rule
TAG	Technical Advisory Group
TBD	To Be Determined
TSCA	Toxic Substances Control Act
TMDL	Total Maximum Daily Load
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Service
VOCs	Volatile Organic Chemicals
WMA	Watershed Management Act
WRATS	Water Rights Application Tracking System
WSDA	Washington State Department of Agriculture
WSU	Washington State University
WRIA	Water Resource Inventory Area
WSDA	Washington State Department of Agriculture
WSP	Water Supply Policy

Appendix I
Salmon-Washougal and Lewis Watersheds Habitat Implementation Actions

Appendix I Habitat actions for the Lower North Fork Lewis River Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[1]**	**Expected Biophysical Response[2]**	**Certainty of Outcome[3]**
L-Lew 1. Manage regulated stream flows to provide for critical components of the natural flow regime	Expansion of existing program or activity	PacifiCorp, Cowlitz County PUD, FERC, WDFW, NOAA Fisheries, USFWS	3	High: Lower mainstem Lewis River	High: Adequate flows for life stage requirements and habitat-forming processes	High
L-Lew 2. Ensure standards in land use and environmental programs and plans afford adequate protection of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Clark County, Cowlitz County, City of Woodland	1 & 2	High: Applies to all private lands under county jurisdiction (residential, agricultural, and forest lands)	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
L-Lew 3. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agriculture and timber lands to developed uses.	Expansion of existing program or activity	Clark County, Cowlitz County, Woodland	1 & 2	High: Applies to all private lands under county jurisdiction (residential, agricultural, and forest lands)	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
L-Lew 4. Within authorities, conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, C/WCD, CCD, NGOs, WDFW, LCFRB, USACE, LCFEG	4, 5, 8, 9 & 11	High: Lower mainstem Lewis and lower portion of major tributaries	Medium: Restoration of floodplain function, habitat diversity, and habitat availability.	High
L-Lew 5. Within authorities, prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Clark County, Cowlitz County, Woodland, WDOE	1	Medium: Applies to privately owned floodprone lands under county jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
L-Lew 6. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Medium: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High

[1] Relative amount of basin affected by action
[2] Expected response of action implementation
[3] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Lower North Fork Lewis River Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area1[4]**	**Expected Biophysical Response[5]**	**Certainty of Outcome[6]**
L-Lew 7. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Cowlitz County, Clark County, Woodland	1, 7, 8, & 9	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
L-Lew 8. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS, C/WCD, CCD, WDNR, WDFW, LCFEG, Cowlitz County, Clark County, Woodland	1, 2, 4, 5, 6, 7, 8, 9, 10 & 11	High: Private lands. Applies to lands in agriculture, rural residential, and forestland uses throughout the basin	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium
L-Lew 9. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, C/WCD, CCD	6	Medium: Lower mainstem Lewis	High: Increased habitat availability for spawning and rearing	Medium
L-Lew 10. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 5, 7, 8 & 9	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
L-Lew 11. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, City of Woodland	7	High: Entire basin	Medium: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium
L-Lew 12. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Cowlitz CD, Clark CD, LCFEG	4, 5, 6, 7, 8, 9 & 11	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium

[4] Relative amount of basin affected by action
[5] Expected response of action implementation
[6] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Lower North Fork Lewis River Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[7]**	**Expected Biophysical Response[8]**	**Certainty of Outcome[9]**
L-Lew 13. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 5 & 7	Low: Small private timberland owners	High: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
L-Lew 14. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, Cowlitz CD, Clark CD, LCFEG	1 & 8	High: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
L-Lew 15. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Clark County, Cowlitz County WSDOT, City of Woodland, LCFEG	5	Medium: As many as 16 miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
L-Lew 16. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 5, 7, 8 & 9	Medium: State timber lands in the Lower NF Lewis Basin (approximately 16% of the basin area)	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
L-Lew 17. Address water quality issues through the development and implementation of water quality clean up plans (TMDLs)	Expansion of existing program or activity	WDOE	9	Medium: streams with temperature concerns and streams on 303(d) list	Medium: Protection and restoration of water quality	Low
L-Lew 18. Within existing authorities, coordinate with appropriate entities to limit the effects of intensive recreational use of the mainstem Lewis during critical periods, where problems are identified.	Expansion of existing program or activity	Clark County, Cowlitz County, WDFW, Implementing partners	12	Low: Key reaches in the mainstem Lewis	Medium: Increased survival of salmonids	Low

[7] Relative amount of basin affected by action
[8] Expected response of action implementation
[9] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Upper North Fork Lewis Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[10]**	**Expected Biophysical Response[11]**	**Certainty of Outcome[12]**
U-Lew 1. Restore access through the hydropower system for anadromous and resident fish	Expansion of existing program or activity	PacifiCorp, Cowlitz County PUD, FERC, WDFW, NOAA Fisheries	1	High: the system of dams on the Lewis blocks anadromous access to approximately 170 miles of habitat and blocks migrations of adfluvial Bull Trout	High: Increased spawning and rearing capacity due to access to blocked habitat	High
U-Lew 2. Continue to manage federal forest lands according to the Northwest Forest Plan	Activity is currently in place	USFS	2, 3, 4, 5, 6 & 7	High: National Forest and National Monument lands in the upper basin	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	High
U-Lew 3. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	2, 3, 4, 5, 6 & 7	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
U-Lew 4. Ensure standards in land use and environmental programs and plans afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Cowlitz County, Clark County, Skamania County	2 & 3	Low: Private lands under County jurisdiction (reservoir tributary basins)	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
U-Lew 5. Within authorities, prevent new floodplain development through County ordinance and with support from the State	New program or activity	Cowlitz County, Clark County, Skamania County, WDOE	2	Low: Private lands under County jurisdiction (reservoir tributary basins)	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High

[10] Relative amount of basin affected by action
[11] Expected response of action implementation
[12] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Upper North Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[13]**	**Expected Biophysical Response[14]**	**Certainty of Outcome[15]**
U-Lew 6. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agricultural and timber lands to developed uses.	Expansion of existing program or activity	Cowlitz County, Clark County, Skamania County	2 & 3	Low: Private lands under County jurisdiction (reservoir tributary basins)	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
U-Lew 7. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit	9	High: Entire basin	Medium: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium
U-Lew 8. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, C/WCD, CCD, UCD, LCFEG	4, 5, 6, 7 & 8	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
U-Lew 9. Increase technical support and funding to small forest landowners faced with implementation of Forest Practices Rules to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	2, 3, 4, 5, 6 & 7	Low: Small private timberland owners	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
U-Lew 10. Monitor an notify FERC of significant license violations, enforce terms and conditions of section 7 consultations on FERC relicensing agreements, and encourage implementation of section 7 conservation recommendations on FERC relicensing agreements	Activity is currently in place	NOAA, USFWS	1, 6, 7, 9	High: Entire basin	High: Increased spawning and rearing capacity due to access to blocked habitat, improved conditions related to water quality, adequate instream flows to support life stages of salmonids and other aquatic biota	High

[13] Relative amount of basin affected by action
[14] Expected response of action implementation
[15] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Upper North Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[16]**	**Expected Biophysical Response[17]**	**Certainty of Outcome[18]**
U-Lew 11. Review and adjust operations to ensure compliance with the Endangered Species Act	Activity is currently in place	Cowlitz County, Clark County, Skamania County	2, 4, 5, & 6	Low: Applies to public lands under county jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
U-Lew 12. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	2 & 3	Low: Private lands in sensitive areas at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
U-Lew 13. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS,Cowlitz CD, Clark CD, UCD, WDNR, WDFW, LCFEG	2, 3, 4, 5, 6, 7, 8 & 9	Low: Private lands. Applies primarily to lands in rural residential or forestry uses along river corridors	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium
U-Lew 14. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats (passage obstruction at mainstem dams is considered in a separate action)	Expansion of existing program or activity	WDFW, WDNR, Cowlitz County, Clark County, Skamania County, WSDOT, LCFEG	7	Medium: There are many minor barriers throughout the Basin. The full extent is unknown	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is believed to be marginal in most cases	High
U-Lew 15. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	2, 3, 4, 5, 6 & 7	Low: State timber lands in the U. Lewis Basin (approximately 11% of the basin area)	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium

[16] Relative amount of basin affected by action
[17] Expected response of action implementation
[18] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Upper North Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[19]**	**Expected Biophysical Response[20]**	**Certainty of Outcome[21]**
U-Lew 16. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, Cowlitz CD, Clark CD, UCD, LCFEG	2 & 5	Low: Greatest risk is in residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
U-Lew 17. Local jurisdictions should assess, and require upgrading and replacement of on-site sewage systems in conformance with current regulations	Expansion of existing program or activity	Cowlitz County, Clark County, Skamania County, Clark CD, Cowlitz CD, UCD	7	Low: Private rural residential lands	Medium: Protection and restoration of water quality (bacteria)	Medium

[19] Relative amount of basin affected by action
[20] Expected response of action implementation
[21] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the East Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[22]**	**Expected Biophysical Response[23]**	**Certainty of Outcome[24]**
EF Lew 1. Ensure standards in land use and environmental programs and plans afford high levels of protection of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Clark County Battleground	1 & 2	High: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
EF Lew 2. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agricultural and timber lands to developed uses.	Expansion of existing program or activity	Clark County Battleground	1 & 2	High: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
EF Lew 3. Within authorities, conduct floodplain restoration where feasible along the mainstem and in major tributaries that have experienced channel confinement. Address past and potential avulsions into gravel processing ponds. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, CCD, NGOs, WDFW, LCFRB, USACE, LCFEG, Tribes	3, 5, 6, 8 & 9	High: Lower mainstem EF Lewis and lower portion of major tributaries	Medium: Restoration of floodplain function, habitat diversity, and habitat availability.	High
EF Lew 4. Continue to manage federal forest lands according to the Northwest Forest Plan	Activity is currently in place	USFS	1, 2, 4, 5, 6 & 8	Medium: National Forest lands in the upper basin	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	High
EF Lew 5. Within authorities, prevent floodplain impacts through land use controls and Best Management Practices	Expansion of existing program or activity	Clark County, Battleground WDOE	1	Medium: Applies to privately owned flood prone lands under local jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High

[22] Relative amount of basin affected by action
[23] Expected response of action implementation
[24] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the East Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[25]**	**Expected Biophysical Response[26]**	**Certainty of Outcome[27]**
EF Lew 6. Monitor, evaluate, and enforce the Stordahl Habitat Conservation Plan	Activity is currently in place	NOAA, USFWS	9	Medium: Applies to privately owned lands downstream of Daybreak Park	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), erosion, mass wasting, bank stability and sediment supply processes	High
EF Lew 7. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Medium: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
EF Lew 8. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Clark County, Battleground	1, 4, 5, & 6	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
EF Lew 9. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS, CCD, WDNR, WDFW, LCFEG, Clark County, Battleground	All measures	High: Private lands. Applies to lands in agriculture, rural residential, and forestland uses throughout the basin	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium
EF Lew 10. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 5, 6 & 8	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
EF Lew 11. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows. Develop a regional water source in the Vancouver Lake Lowlands within 10 years and assess the feasibility of a regional source in the North Fork Lewis tidal reach	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, CPU, Battleground, Ridgefield	7	High: Entire basin	High: Adequate instream flows to support life stages of salmonids and other aquatic biota.	High

[25] Relative amount of basin affected by action
[26] Expected response of action implementation
[27] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the East Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[28]**	**Expected Biophysical Response[29]**	**Certainty of Outcome[30]**
EF Lew 12. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, CCD, LCFEG	3, 4, 5, 6, 7, 8, & 10	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
EF Lew 13. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 4, 5, 6 & 8	Medium: Small private timberland owners	High: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
EF Lew 14. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, CCD	1 & 5	High: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
EF Lew 15. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Clark County WSDOT, LCFEG, Clark CD	8	Medium: As many as 30 miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
EF Lew 16. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 5, 6 & 8	Medium: State timber lands in the EF Lewis Basin (approximately 16% of the basin area)	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium

[28] Relative amount of basin affected by action
[29] Expected response of action implementation
[30] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the East Fork Lewis Basin						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[31]**	**Expected Biophysical Response[32]**	**Certainty of Outcome[33]**
EF Lew 17. Address water quality issues through the development and implementation of water quality clean up plans (TMDLs)	Expansion of existing program or activity	WDOE	6	Medium: Temperature impaired and 303(d) listed streams	Medium: Protection and restoration of water quality	Low
EF Lew 18. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD	10	Low: Lower mainstem EF Lewis	High: Increased habitat availability for spawning and rearing	Low

[31] Relative amount of basin affected by action
[32] Expected response of action implementation
[33] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Bonneville Tributaries Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[34]**	**Expected Biophysical Response[35]**	**Certainty of Outcome[36]**
Bon-Tribs 1. Within authorities, conduct floodplain restoration where feasible along the lower reaches of streams before their confluence with the Columbia where they have experienced channel confinement due to development and transportation corridors. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, UCD, NGOs, WDFW, LCFRB, USACE	3, 5, 6, 8 & 10	Medium: Lower reaches of several tributaries	High: Restoration of floodplain function, habitat diversity, and habitat availability.	High
Bon-Tribs 2. Within authorities, prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Skamania County, WDOE	1	Medium: Applies to privately owned floodprone lands under county jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
Bon-Tribs 3. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, UCD, LCFEG	10	Medium: Lower reaches of several streams	High: Increased habitat availability for spawning and rearing	High
Bon-Tribs 4. Ensure standards in land use and environmental programs and plans afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Skamania County	1 & 2	Medium: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Bon-Tribs 5. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agricultural and timber lands to developed uses.	Expansion of existing program or activity	Skamania County	1 & 2	Medium: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Bon-Tribs 6. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Low: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High

[34] Relative amount of basin affected by action
[35] Expected response of action implementation
[36] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Bonneville Tributaries Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[37]**	**Expected Biophysical Response[38]**	**Certainty of Outcome[39]**
Bon-Tribs 7. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Skamania County	1, 4, 6, & 8	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
Bon-Tribs 8. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS, UCD, WDNR, WDFW, LCFEG, Skamania County	All measures	Medium: Private lands. Applies to lands in agriculture, rural residential, and forestland uses throughout the basin	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium
Bon-Tribs 9. Continue to manage federal forest lands according to the Northwest Forest Plan	Activity is currently in place	USFS	1, 2, 4, 5, 6 & 8	Low: National Forest lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	High
Bon-Tribs 10. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 5, 6 & 8	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Bon-Tribs 11. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, Skamania County	9	High: Entire basin	Medium: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium

[37] Relative amount of basin affected by action
[38] Expected response of action implementation
[39] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Bonneville Tributaries Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[40]**	**Expected Biophysical Response[41]**	**Certainty of Outcome42**
Bon-Tribs 12. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: State timber lands in the Washougal Basin (approximately 30% of the basin area)	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
Bon-Tribs 13. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, UCD, LCFEG	3, 4, 5, 6, 7, 8 & 10	Medium: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
Bon-Tribs 14. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Skamania County, WSDOT, LCFEG	5	Medium: As many as 6 miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
Bon-Tribs 15. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 4, 5, 6 & 8	Low: Small private timberland owners	Medium: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Bon-Tribs 16. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, UCD, LCFEG	1 & 4	Medium: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
Bon-Tribs 17. Assess water quality issues through the development and implementation of water quality clean up plans (TMDLs)	Expansion of existing program or activity	WDOE	5	Medium: temperature concerns throughout basin and 303(d) listings	Medium: Protection and restoration of water quality	Low

[40] Relative amount of basin affected by action
[41] Expected response of action implementation
[42] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Salmon Creek Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[43]**	**Expected Biophysical Response[44]**	**Certainty of Outcome[45]**
Salm 1. Ensure standards in land use and environmental programs and plans afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Clark County, City of Vancouver	1 & 2	High: Applies to nearly all of the basin	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Salm 2. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agricultural and timber lands to developed uses. Use availability of water to help guide growth.	Expansion of existing program or activity	Clark County, City of Vancouver, City of Battleground	1 & 2	High: Applies to nearly all of the basin	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Salm 3. Within authorities, prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Clark County, City of Vancouver, WDOE	1	Medium: Applies to privately owned floodprone lands under county jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
Salm 4. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Medium: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
Salm 5. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Clark County, Vancouver, Battleground	1, 4, 6, & 7	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High
Salm 6. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS, Clark CD, WDNR, WDFW, LCFEG, Clark County, Vancouver	All measures	High: Applies to agriculture, forest, and developed lands throughout the basin	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium

[43] Relative amount of basin affected by action
[44] Expected response of action implementation
[45] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Salmon Creek Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[46]**	**Expected Biophysical Response[47]**	**Certainty of Outcome[48]**
Salm 7. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows. Develop a regional water source in the Vancouver Lake Lowlands within 10 years	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, Vancouver, Clark Public Utilities	3	High: Entire basin	High: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium
Salm 8. Within authorities, conduct floodplain restoration where feasible along the mainstem Salmon Creek and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, CCD, NGOs, WDFW, LCFRB, USACE, LCFEG	4, 5, 6, 8 & 10	Medium: Mainstem Salmon Creek and lower portion of major tributaries	Medium: Restoration of floodplain function, habitat diversity, and habitat availability.	Medium
Salm 9. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, Clark CD, LCFEG	1 & 5	High: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
Salm 10. Address water quality impairments through the development and implementation of water quality clean up plans (TMDLs)	Expansion of existing program or activity	WDOE	6	High: Private agricultural and rural residential lands	Medium: Protection and restoration of water quality	Low
Salm 11. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 6, 7 & 10	Low: Private commercial timber lands	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Salm 12. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, LCFEG	4, 5, 6, 7, 8, 10 & 11	Low: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium

[46] Relative amount of basin affected by action
[47] Expected response of action implementation
[48] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Salmon Creek Basin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area49**	**Expected Biophysical Response50**	**Certainty of Outcome51**
Salm 13. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 4, 6, 7 & 10	Low: Small private timberland owners	Medium: Reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Salm 14. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Clark County WSDOT, LCFEG	10	Low: Only approximately 3 miles of potential habitat is blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
Salm 15. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 4, 6, 7 & 10	Low: State timber lands in the Salmon Creek Basin (approximately 4% of the basin area)	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
Salm 16. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, LCFEG	11	Low: Lake River and lower mainstem Salmon Creek	High: Increased habitat availability for spawning and rearing	Low
Salm 17. Within existing authorities, coordinate with appropriate entities to limit the effects of intensive recreational use of priority reaches in Salmon Creek during critical periods where problems are identified.	Expansion of existing program or activity	Clark County, City of Vancouver, WDFW, Implementing Partners	9	Low: Key reaches in Salmon Creek	Medium: Increased survival of salmonids	Low

[49] Relative amount of basin affected by action
[50] Expected response of action implementation
[51] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Washougal Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[52]**	**Expected Biophysical Response[53]**	**Certainty of Outcome[54]**
Wash 1. Ensure standards in land use and environmental programs and plans afford high levels of protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Clark County, Skamania County, City of Washougal, City of Camas	1 & 2	High: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Wash 2. Using available planning tools (e.g., GMA, comprehensive planning, zoning, best management practices, etc.), manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the effects of conversion of agricultural and timber lands to developed uses.	Expansion of existing program or activity	Clark County, Skamania County, City of Washougal, City of Camas	1 & 2	High: Applies to all private lands under county jurisdiction	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Wash 3. Within authorities, conduct floodplain restoration where feasible along the lower mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	New program or activity	NRCS, Clark CD, UCD, NGOs, WDFW, LCFRB, USACE, LCFEG	4, 5, 7, 8 & 9	Medium: Lower mainstem Washougal, Little Washougal, and Lacamas Creek	Medium: Restoration of floodplain function, habitat diversity, and habitat availability.	High
Wash 4. Within authorities, prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Clark County, Skamania County, City of Washougal, City of Camas, WDOE	1	Medium: Applies to privately owned floodprone lands under local government jurisdiction	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
Wash 5. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Medium: Residential, agricultural, or forest lands at risk of further degradation	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
Wash 6. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Clark County, Skamania County, Camas, Washougal	1, 3, 4, & 5	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High

[52] Relative amount of basin affected by action
[53] Expected response of action implementation
[54] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (Cont.) Habitat actions for the Washougal Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[55]**	**Expected Biophysical Response[56]**	**Certainty of Outcome[57]**
Wash 7. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	Expansion of existing program or activity	NRCS, CCD, UCD, WDNR, WDFW, Clark County, Skamania County	All measures	High: Private lands. Applies to lands in agriculture, rural residential, and forestland uses throughout the basin	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium
Wash 8. Continue to manage federal forest lands according to the Northwest Forest Plan	Activity is currently in place	USFS	1, 2, 3, 4, 5 & 7	Low: National Forest lands in the upper basin	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	High
Wash 9. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Wash 10. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows. Develop a regional water source in the Vancouver Lake Lowlands (or Steigerwald area) within 10 years	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, City of Camas, City of Washougal	6	High: Entire basin	High: Adequate instream flows to support life stages of salmonids and other aquatic biota.	High
Wash 11. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, UCD, LCFEG	3, 4, 5, 7, 8, 9 & 10	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
Wash 12. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 3, 4, 5 & 7	Medium: Small private timberland owners	High: Reduction in road-related fine sediment delivery; restoration and preservation of fish access to habitats	Medium

[55] Relative amount of basin affected by action
[56] Expected response of action implementation
[57] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (cont.) Habitat actions for the Washougal Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[58]**	**Expected Biophysical Response[59]**	**Certainty of Outcome[60]**
Wash 13. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: State timber lands in the Washougal Basin (approximately 30% of the basin area)	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
Wash 14. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, Clark CD, UCD, LCFEG	1 & 4	High: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
Wash 15. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Clark County, Skamania County WSDOT, LCFEG	7	Medium: Several miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
Wash 16. Local jurisdictions should assess and require upgrading and replacement of on-site sewage systems, in conformance with current regulations	Expansion of existing program or activity	Clark County, Skamania County, Clark CD, UCD, LCFEG	5	High: Private agricultural and rural residential lands	Medium: Protection and restoration of water quality (bacteria)	Low
Wash 17. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, UCD, LCFEG	10	Low: Lower mainstem Washougal	High: Increased habitat availability for spawning and rearing	Low

[58] Relative amount of basin affected by action
[59] Expected response of action implementation
[60] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (cont.) Habitat actions for the Kalama Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[61]**	**Expected Biophysical Response[62]**	**Certainty of Outcome[63]**
Kal 1. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 9	High: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Kal 2. Evaluate standards and review/compliance processes in County and City comprehensive plans and regulations, as necessary, to afford adequate protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	Expansion of existing program or activity	Cowlitz County, City of Kalama	1 & 2	Medium: Private lands. Applies primarily to lands in the lower basin in rural residential and forestland uses	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Kal 3. Consistent with existing and future land use regulations and authorities, manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the conversion of lands to developed uses through zoning regulations and tax incentives	Expansion of existing program or activity	Cowlitz County, City of Kalama	1 & 2	Medium: Private lands. Applies primarily to lands in the lower basin in rural residential and forestland uses	High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes	High
Kal 4. Within authorities, prevent floodplain impacts from new development through land use controls and Best Management Practices	New program or activity	Cowlitz County, City of Kalama, WDOE	1	Low: Private lands. Applies to lands in lowland areas in the lower basin in rural residential and forestland uses	High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability	High
Kal 5. Within authorities, conduct floodplain restoration where feasible along the lower mainstem that has	New program or	NRCS, C/W CD, NGOs, WDFW, LCFRB,	4, 5, 6, 7 & 8	Low: Lower mainstem Kalama	High: Restoration of floodplain function, CMZ function, habitat	High

[61] Relative amount of basin affected by action
[62] Expected response of action implementation
[63] Relative certainty that expected results will occur as a result of full implementation of action

Appendix I (cont.) Habitat actions for the Kalama Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[61]**	**Expected Biophysical Response[62]**	**Certainty of Outcome[63]**
experienced channel confinement. Build partnerships with the Port of Kalama and other landowners and provide financial incentives	activity	USACE, Port of Kalama			diversity, and habitat availability	
Kal 6. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, City of Kalama	8	High: Entire basin	Medium: Adequate instream flows to support life stages of salmonids and other aquatic biota.	Medium
Kal 7. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, C/W CD, LCFEG	3, 4, 5, 6, 7, 9 & 10	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
Kal 8. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 3, 4, 5 & 9	Low: Small private timberland owners	High: Reduction in road-related fine sediment delivery; restoration and preservation of fish access to habitats	Medium
Kal 9. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	Expansion of existing program or activity	LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)	1 & 2	Low: Private lands. Applies primarily to riparian, floodplain, and wetland areas in the lower basin in rural residential and forestland uses	High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes	High
Kal 10. Within authorities, increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Encourage development of incentives (financial or regulatory) and increasing program marketing and	Expansion of existing program or activity	NRCS, C/W CD, WDNR, WDFW, LCFEG, Cowlitz County	All measures	Medium: Private lands. Applies primarily to lands in the lower basin in rural residential and forestland uses	High: Increased landowner stewardship of habitat. Potential improvement in all factors	Medium

Appendix I (cont.) Habitat actions for the Kalama Subbasin.						
Action	**Status**	**Responsible Entity**	**Measures Addressed**	**Spatial Coverage of Target Area[61]**	**Expected Biophysical Response[62]**	**Certainty of Outcome[63]**
outreach						
Kal 11. Within geographical area of responsibility, assess the impact of fish passage barriers (especially culverts) throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Cowlitz County, WSDOT, LCFEG	5	Medium: As many as 14 miles of stream are blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	High
Kal 12. Within authorities, create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, C/W CD, LCFEG	10	Low: Lower mainstem Kalama	High: Increased habitat availability for spawning and rearing	Low
Kal 13. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1 & 2	Low: State timber lands in the Eloch-Skam Watershed (approximately 21% of the basin area)	Medium: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats.	Medium
Kal 14. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, C/W CD, LCFEG	1 & 4	Low: Greatest risk is in lower basin agriculture and residential areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
Kal 15. Local jurisdictions should assess, and require upgrading and replacement of on-site sewage systems in conformance with current regulations	Expansion of existing program or activity	Cowlitz County, C/W CD	9	Low: Private rural residential lands in lower basin	Medium: Protection and restoration of water quality (bacteria)	Low
Kal 16. Review and adjust operations to ensure compliance with the Endangered Species Act	Expansion of existing program or activity	Cowlitz County, Kalama	1, 3, 4, & 9	Low: Applies to lands under public jurisdiction	Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats	High

Appendix J
Salmon-Washougal and Lewis Watersheds Outline/Framework of Interlocal Agreement

Interlocal Agreement Outline for WRIA 27/28 Watershed Management Plan Implementation

Adopting Governments
(specify)

Public Utility Districts
(specify)

Cities
(specify)

State Agency
(specify)

Lead Agency
Lower Columbia Fish Recovery Board (LCFRB)

1. Purpose: The purposes of this agreement are:

Example:

To define and clarify the roles and responsibilities of the entities involved with implementation of the WRIA 27/28 Watershed Management Plan (Plan).

To foster cooperative working relationships among the participating entities.

To facilitate efficient and effective implementation of the Plan, and coordinate water use and allocation decisions affecting adopted land use plans.

2. Authority:

Describe statutory references addressing implementation (e.g., Watershed Management Act, Chapter 247, Laws of 1998 (ESHB 2514) and Section 90.82 Revised Code of Washington; and the Salmon Recovery Planning Act, Chapter 246, Laws of 1998 (ESHB 2496), and WRIA 27/28 Plan references.

3. Scope:

Example: The scope of this agreement encompasses all activities of participating entities necessary to implement the WRIA 27/28 Watershed Management Plan, and to implement in a coordinated way the related portions of the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (LCFRB, 2006).

4. Basic Principles:

Example:

In implementing the objectives, strategies and actions outlined in the Plan, participating entities will:

- Ensure the overall balance of the watershed plan is maintained;
- Focus efforts on identifying, prioritizing and implementing actions that achieve multiple objectives;
- Achieve goals and objectives in the most cost-effective and efficient manner possible;
- Strive to ensure overlap and duplication of efforts is avoided;
- Ensure actions are coordinated and integrated with other planning efforts in the watershed (e.g., Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan, Growth Management Planning, TMDLs, etc);
- Facilitate and promote active participation by those entities affected by actions and key decisions;
- Keep affected entities informed of key decisions and outcomes;
- Work cooperatively to achieve all goals and objectives of the plan;
- Strive to ensure planning actions are integrated into federal, state and local decision-making processes;
- Work to broaden public awareness and support of the plan;
- Identify and pursue early implementation opportunities; and
- Develop a funding strategy as an early action item in plan implementation.

5. Roles and Responsibilities of Participating Entities:

Example:

Effective implementation of the Plan will require that affected state and local jurisdictions coordinate on decisions regarding water use and allocation. Cross-jurisdictional coordination will help to ensure that water management decisions are consistent with and support adopted land use plans. The following outlines the roles and responsibilities of participating entities:

Planning Unit:

Example:

- Developing a Detailed Implementation Plan (DIP);
- Tracking implementation of Plan actions by the many organizations involved, to ensure actions are being carried out in a timely fashion; that the balanced nature of the plan is retained as actions are implemented; and that the most important priorities defined by the Planning Unit are being addressed;
- Coordinating efforts to seek funding for Plan actions, to avoid duplication of effort and ensure the State legislature and funding agencies see well-organized and unified support for funding requests on an ongoing basis;
- Providing information to the public on Plan implementation and resulting improvements in watershed conditions;
- Providing early warning systems and joint responses to changing conditions, including physical conditions in the watershed; new regulatory developments; and new project proposals that may emerge from time to time;
- Monitoring of watershed conditions across jurisdictional boundaries, data management, and providing data access;
- Facilitating the development of interlocal agreements to coordinate water use and allocation decisions affecting adopted land use plans; and
- In coordination with adopting counties, conduct periodic plan reviews, and provide recommendations for necessary updates.

Lower Columbia Fish Recovery Board:

Example:

- Soliciting and administering funds for support of Planning Unit activities;
- Providing staff resources to support and facilitate Planning Unit activities described above;
- Coordinating integration of watershed plan implementation with salmon recovery plan implementation;
- Providing technical assistance to entities involved with Plan implementation; and
- Facilitating and coordinating development of “Six-year Implementation Work Schedules” that identify Plan actions accepted for implementation, based upon the DIP.

Entity (County, City, Utility District, Ecology, etc.)

Example:

Providing technical and staff resources; developing work schedules; soliciting funds; implementing programmatic and specific actions; conducting periodic plan reviews; coordinating activities; etc. Note: these will vary by entity.

6. Severability:

Example: (Include standard severability language)

7. Conclusion:

Example:

In signing this agreement, the decision making authority of each participating entity reaffirms the importance of coordinated implementation of the WRIA 27/28 Watershed Management Plan, and support for local watershed management and restoration as mandated by the Watershed Management Act, Chapter 247, Laws of 1998 (ESHB 2514) and Section 90.82 Revised Code of Washington; and the Salmon Recovery Planning Act, Chapter 246, Laws of 1998 (ESHB 2496), and commits that entity to support these efforts as outlined above.

8. Signatures:

_____

Name, Affiliation, Title, Date

_____

Name, Affiliation, Title, Date

_____

Name, Affiliation, Title, Date

Appendix K
Salmon-Washougal and Lewis Watersheds RM&E Program Description

Research, Monitoring & Evaluation Program For Lower Columbia Salmon & Steelhead

Lower Columbia Fish Recovery Board
Cramer Fish Sciences
May 2008 Draft

Preface

This comprehensive research, monitoring, and evaluation program for lower Columbia River salmon and steelhead was developed under the leadership of the Washington Lower Columbia Fish Recovery Board (LCFRB). The Board was established by state statute (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington state agencies, regional organizations, local governments, and members of the public participated in the planning process. Participation was achieved through a steering committee, work groups, watershed planning units, and public meetings, workshops, and comment periods.

Program development was funded by the WA Departments of Ecology and the Salmon Recovery Funding Board. The program was developed under the direction of Jeff Breckel, Steve Manlow, and Melody Tereski of the LCFRB with assistance from R. Beamesderfer, J. Brauner Lando, K. Arendt, and C. Ackerman of Cramer Fish Sciences. Oversight was provided by a steering group of representatives from implementing agencies and organizations including:

Mark Bagdovitz, USFWS	Frank Shrier, PacifiCorp
Pat Connolly, USGS	Dan Rawding, WDFW
Blaine Ebberts, USACE	Joel Rupley, Clark County
Rex Hapala, WDNR	Rod Swanson, Clark County
Mike Kohn, Lewis PUD	Ron Rhew, USFWS
Steve Lanigan, USFS	Robert Plotnikoff, WDOE
Steve Leider, GSRO	Russell Scranton, NOAA Fisheries
Scott McEwen, LCREP	Steve Waste, NPCC
Erik Netherlin, WDFW	Shannon Wills, Cowtliz Tribe
Guy Norman, WDFW	Jeff Wittler, CPU

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1.0 Overview

This document details the monitoring, research, and evaluation (RM&E) elements of a coordinated regional program supporting recovery efforts for Lower Columbia salmon and steelhead. The RM&E program described herein integrates and complements other state and regional planning and RM&E efforts for salmon and steelhead recovery. The area addressed by this plan includes Washington Columbia River subbasins from the Chinook River near the ocean, upstream to and including the Little White Salmon River in the gorge. The goal of this program is to provide a template for action and overall guidance to an extensive group of participants involved in implementation of the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (Recovery Plan). Preliminary RM&E guidance was provided in the Recovery Plan and the program presented herein is consistent with those overall objectives and actions. This RM&E program strives to provide a flexible and collaborative structure, developed with stakeholder involvement, for tracking, evaluating and responding to new information. Implementation of this RM&E Program will be achieved through a regional partnership of local, state, federal and tribal interests. This program does not serve as a regulatory document, nor does it obligate any party; however, it does establish specific responsibilities for actions that have been identified as important to fish recovery.

This program details the full spectrum of information needed for monitoring and evaluation of salmon recovery in Washington lower Columbia River subbasins, inventories what information and data are available from existing sources, and identifies critical information needs and priorities. The program includes six key elements: 1) biological status and trend monitoring, 2) habitat status and trend monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. Program elements were designed to address salmon status and threats consistent with ESA listing and recovery planning criteria and goals. Risk status is addressed through a combination of biological and habitat monitoring related to the Viable Salmonid Population concept[1]. Threats are evaluated based on habitat status, implementation/compliance, and action effectiveness monitoring. For the purposes of this program, action effectiveness refers to salmonid life-cycle based effects of habitat, harvest, habitat, hatchery, and ecological actions on biological status.

For each program element, we identify: A) objectives, B) indicators, C) sampling and analytical design, D) information gaps and priorities in available information, and E) implementation actions. Implementation actions identify specific projects or programs that will address the RM&E needs and priorities in this program.

[1] McElhany, 2000, NOAA Technical Memorandum NMFS-NWFSC-42

2.0 Introduction

2.1 Program Goals

This document describes the coordinated regional research, monitoring, and evaluation (RM&E) program supporting recovery efforts for Lower Columbia salmon and steelhead. The goal is to provide a template for action and overall guidance to an extensive group of participants involved in implementation of the Lower Columbia Salmon Recovery & Fish and Wildlife Subbasin Plan. Preliminary RM&E guidance was provided in the Recovery Plan and the program presented herein is consistent with those overall objectives and actions as well as the listing status decision framework identified by NMFS (Figure 1). The best available science outlined in the Recovery Plan identified a reasonable course of action. Although the Recovery Plan provided clear direction and purpose, uncertainties persist and course corrections are inevitable. Existing information is not adequate to predict with precise certainty whether a prescribed set of actions will be sufficient to meet objectives. The RM&E program is an explicit acknowledgement of uncertainties and the likely need for course adjustments along the way.

This RM&E program strives to provide a flexible and collaborative structure, developed with stakeholder involvement and capable of tracking, for evaluating and responding to new information. This program is the product of a collaboration facilitated by the LCFRB and involving federal and state agencies, tribes, local governments, and the public. Recognizing that recovery of fish and wildlife is a shared responsibility; it can only be achieved through the cooperative and combined efforts of federal, tribal, state, and local interests. Implementation of this RM&E Program will be achieved through a regional partnership of local, state, federal and tribal interests. This program does not serve as a regulatory document, nor does it obligate any party; however, it does establish specific responsibilities for actions that have been identified as important to fish recovery. It focuses on achieving outcomes and allows implementing agencies and other entities the flexibility to craft innovative, yet scientifically sound, approaches that best fit local conditions and values.

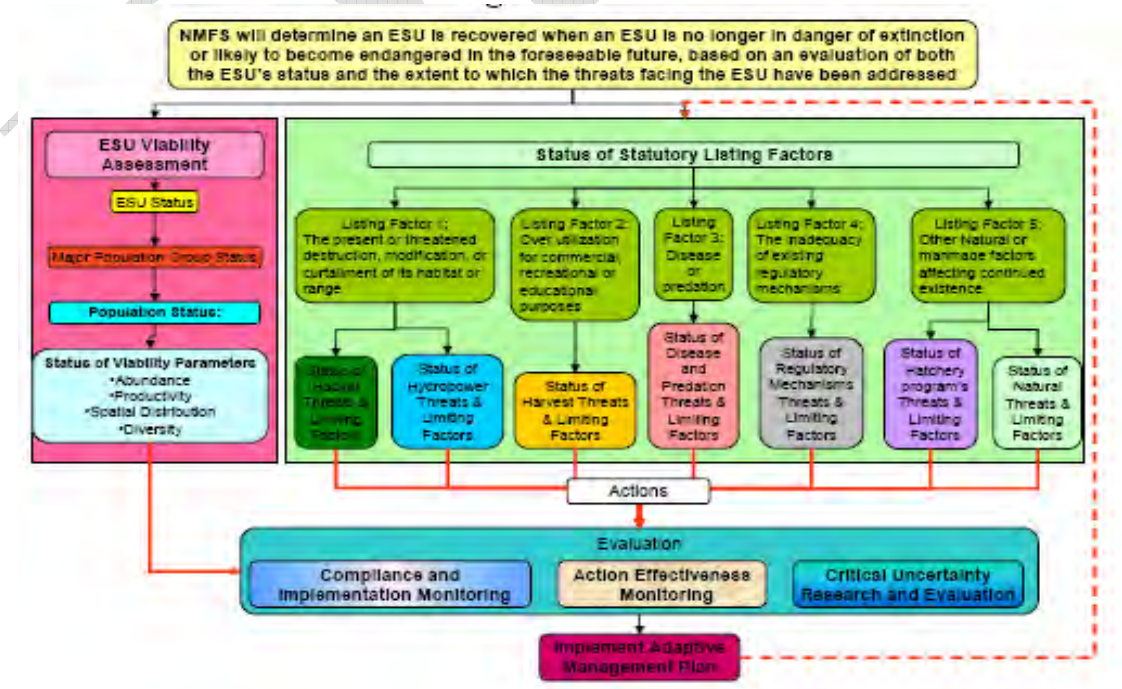

Figure 1. NMFS Listing Status Decision Framework.

2.2 Program Scope

The area addressed by this program includes Washington Columbia River subbasins from the Chinook River near the ocean to and including the Little White Salmon River in the gorge (Figure 2). A Willamette/Lower Technical Recovery Team (TRT) convened by NMFS has divided this area into three ecoregions (Coast, Cascade, and Gorge) for recovery planning purposes. Species addressed by this RM&E program include Chinook salmon, chum salmon, coho salmon, and steelhead (Table 1). Listed bull trout also occur in a few areas of this region but are addressed in detail by a separate plan (USFWS 2002). Estuary monitoring, research, and evaluation is also the subject of a separate RM&E plan (LCREP 2004).

Table 1. Federally listed salmonid species endemic to Washington lower Columbia River subbasins.

Species	ESU	Status	Initial listing date
Chinook salmon	Lower Columbia	Threatened	March 24, 1999
Chum salmon	Lower Columbia	Threatened	March 25, 1999
Steelhead	Lower Columbia[1]	Threatened	March 19, 1998
Coho	Lower Columbia	Threatened	June 28, 2005
Bull trout	Columbia Basin	Threatened	June 10, 1998

[1] *Grays, Elochoman, Skamokawa, Abernathy, Mill, and Germany populations are in the Southwest Washington ESU and are not listed under the ESA but are addressed within the Lower Columbia RM&E program.*

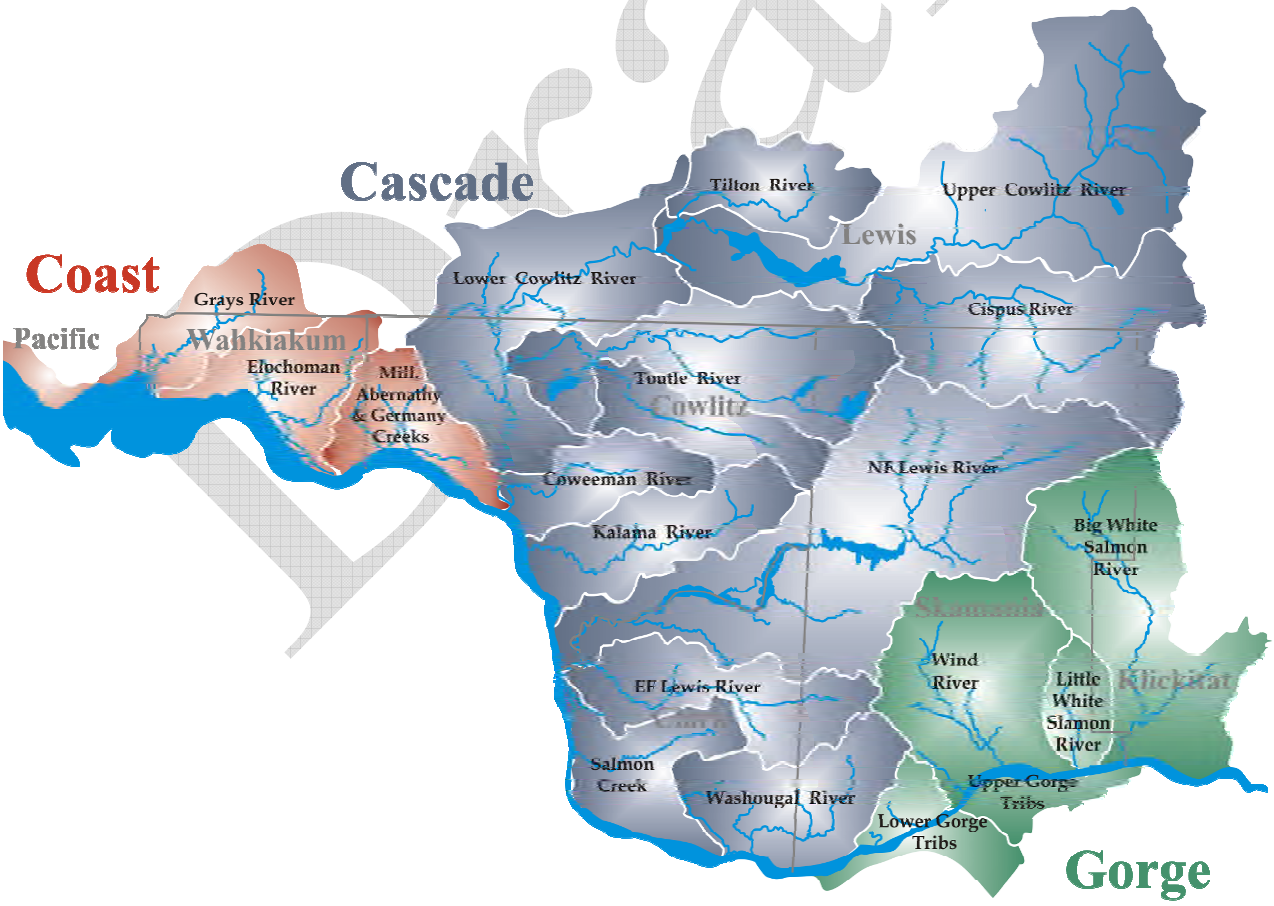

Figure 2. Map of basins in the Lower Columbia region and Coast, Cascade, and Gorge strata designations identified by the Technical Recovery Team.

2.3 Relation to Other Recovery Planning Efforts

The Recovery Planning process has integrated four interrelated initiatives to produce a single Recovery/Subbasin Plan for the lower Columbia:

- U.S. Endangered Species Act recovery planning for listed salmon, steelhead and trout is overseen by NOAA's National Marine Fisheries Service (NMFS).
- Northwest Power and Conservation Council (NPCC) subbasin planning for eight full and three partial subbasins which guide Bonneville Power Administration's funding of projects to implement the fish and wildlife program.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90.82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach promotes consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement actions.

The program presented herein directly reflects objectives, actions and priorities set forth in the Recovery Plan, individual subbasin plans, WRIA-based watershed plans, and subbasin habitat work schedules. Integrated recovery and subbasin plans were completed by the LCFRB in 2004 and subsequently adopted by NMFS on December 15, 2004 and NPCC in 2005. The Recovery Plan set forth a 25-year target in which to reverse long term declining trends and establish a trajectory leading to recovery with course adjustments made as needed. Watershed Management Plans, including detailed assessments of water resource conditions, with a wide-ranging set of policies and recommendations, were completed for WRIAs 25/26 (Grays-Elochoman and Cowlitz) and 27/28 (Salmon-Washougal and Lewis) by the in 2006 (LCFRB 2006b, 2006c). Habitat Work Schedules, compiled pursuant to the Washington Salmon Recovery Act, have been completed for each of the major subbasins in the lower Columbia region (LCFRB 2006a). These schedules augment information found in the Recovery Plan and focus implementation efforts by identifying and ranking salmon and steelhead habitat protection and restoration priorities and potential activities to be accomplished during the next six years.

2.4 Relation to Other RM&E Programs

A variety of regional RM&E reviews and programs have been implemented by various parties with many interrelated objectives. For instance NOAA, working with the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, has developed a detailed research, monitoring, and evaluation plan for implementing the 2000 Federal Columbia River Power System Biological Opinion (NOAA 2003). A Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) has also been implemented by the Columbia Basin Fish and Wildlife Authority to answer key monitoring and evaluation questions relevant to major fish and hydropower management decisions in the Columbia Basin. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP 2004) has reviewed existing plans to provide strategic guidance for subbasin planners on monitoring objectives, monitoring indicators, data reporting, coordination and management. Guidance documents have also been developed by the Washington Governor's Forum on Monitoring Salmon Recovery and Watershed Health

(Crawford 2007), Washington Salmon Recovery Funding Board (SRFB 2002), the Northwest Power and Conservation Council's Independent Scientific Advisory Board (ISAB 2003), and the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). More extensive descriptions of regional monitoring-related programs can be found in Appendix A.

In addition, many agencies conduct local monitoring programs focused on their specific areas of responsibility. For instance, the Washington Department of Fish and Wildlife conducts extensive annual surveys of fish status. Similarly, habitat conditions on State and National forest lands are monitored by the Washington Department of Natural Resources and the U.S. Forest Service, respectively. Streamflow and temperature at selected sites are monitored by the U. S. Geological Survey and Washington Department of Ecology. Information on habitat and water quality conditions is also collected by some Counties, conservation districts, and utility companies. The Lower Columbia River Estuary Partnership (LCREP) also funds and conducts monitoring, research, and evaluation work related to the Columbia River Estuary, in accordance with a separate RM&E plan (LCREP 2004). Numerous other local, state and federal programs also exist.

Appendix B provides a summary of existing biological and habitat status monitoring efforts currently underway within the area addressed by this program. However, it should be noted that biological and habitat status monitoring efforts vary over time given regulatory, budgetary and logistical constraints, as well as changes in management emphasis.

The RM&E program described herein integrates and complements other state and regional planning efforts for salmon. It details the full spectrum of information needed for monitoring and evaluation of salmon recovery in Washington lower Columbia River subbasins, inventories information and data available from existing sources, identifies necessary information that is not currently being collected, and describes an approach to filling informational and data gaps. Some or much of the needed information is currently being collected at various scales or purposes. In many or most cases, information being applied to other applications also has direct application to salmon recovery applications. The program identified in this plan is intended to integrate the application of available information to salmon recovery questions, and to fill in key gaps as needed to support successful implementation of the Recovery Plan.

Successful implementation of this RM&E program will require the coordination and integration of efforts by implementation partners throughout the lower Columbia region. This program recognizes that RM&E efforts are often constrained by logistical and budgetary considerations. This program is intended to guide, prioritize and focus the efforts of implementation partners to achieve recovery objectives and goals, in light of these constraints.

2.5 Implementation Strategy

This RM&E Program is based on Recovery Plan guidance in the form of A) strategies that provide overarching approaches for achieving plan objectives and B) working hypotheses or assumptions that underlie selection and definition of strategies.

Working hypotheses outlined in the Recovery plan include:

1. Successful implementation of this recovery/subbasin plan is predicated on an effective monitoring, research, and evaluation plan. Working hypotheses upon which the recovery plan is based provide clear direction but many hypotheses are uncertain. Future course corrections will be required based on RM&E.
2. Programmatic "top-down" and project "bottom up" monitoring, research, and evaluation approaches each provide useful guidance and an effective plan will incorporate elements of both approaches.
3. Existing programs meet many but not all RM&E needs of this plan.
4. There are direct tradeoffs in time and resource costs between RM&E and recovery actions that more directly affect species of interest.
5. It is not feasible to fund and implement projects to monitor, research, or evaluate every focal fish population, uncertainty or action.

RM&E strategies include:

1. Develop a programmatic regional framework for monitoring, research and evaluation to address ecosystem and ESU-wide concerns of fish recovery.
2. Define monitoring, research, and evaluation elements necessary to address both status and threats as identified by the National Marine Fisheries Service for listing considerations.
3. Recognize different spatial and temporal scales appropriate to a variety of programmatic and project-specific applications of RM&E with a framework that incorporates routine and statistical status monitoring, action effectiveness monitoring, implementation monitoring, and critical uncertainty research.
4. Optimize efficiencies by incorporating and adapting existing monitoring, research, and evaluation activities into the plan.
5. Utilize other Columbia Basin ecosystem and oceanographic monitoring, research, and evaluation efforts.
6. Identify information gaps that need to be addressed with new monitoring and evaluation activities while also balancing a recognition that the available resources limit implementation to the highest priorities and that tradeoffs exist between RM&E activities and measures that more directly contribute to fish recovery.
7. Focus selected monitoring and research activities in intensively monitored watersheds (IWAs) to optimize opportunities for identifying cause and effect relationships while also providing cost efficiencies.
8. Focus research on the effective implementation of recovery measures rather than detailed mechanistic studies of relationships between fish and limiting factors.
9. Incorporate provisions for regional coordination and data distribution to maximize accessibility and applicability.
10. Incorporate an adaptive evaluation framework with clear decisions points and direction to guide future actions.

2.6 Program Elements

Monitoring evaluations of recovery plan implementation and effects revolve around a series of fundamental questions that address salmon and steelhead status and threats (Figure 3). This document includes six fundamental elements of a comprehensive monitoring, research, and evaluation program organized around these questions. Elements include: 1) biological status and trend monitoring, 2) habitat status and trend monitoring, 3) implementation/compliance monitoring, 4) action effectiveness monitoring, 5) uncertainty and validation research, and 6) programmatic evaluation. For each of these elements, this program identifies: A) objectives, B) indicators, C) available information, D) sampling and analytical design, E) information gaps and priorities, and F) implementation actions.

Biological status and trend monitoring - Characterizes the existing salmon and trout populations for evaluation of progress toward ESU recovery goals and objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Reflects temporal and spatial variability of the resource.

Habitat status and trend monitoring - Characterizes the physical, chemical and water quality conditions to evaluate the cumulative effect of human activity trends and recovery measures on critical limiting factors. Reflects temporal and spatial variability of the resource. Provides information on status of salmonid habitat factors and threats as well as cumulative effects of habitat protection and restoration actions. Habitat status and trends monitoring is focused on subbasin conditions. Monitoring of out-of-subbasin natural factors is being conducted on a system-wide scale and will be incorporated into evaluations of data provided by this regional program.

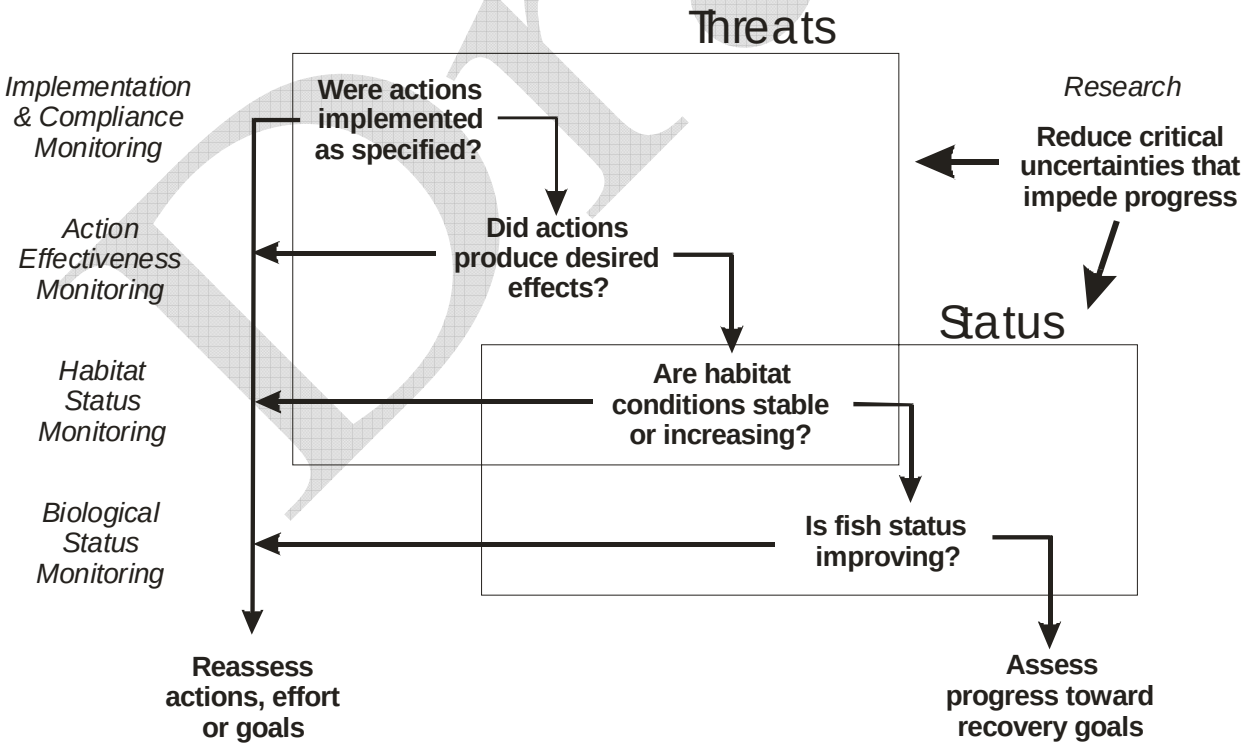

Figure 3. Monitoring, research and evaluation program elements.

Implementation/Compliance Monitoring - Determines if recovery actions were implemented as planned.

Action Effectiveness Monitoring - Determines if actions had the desired functional effects (i.e. site-specific conditions or physical watershed processes). This program defines action effectiveness monitoring to include measurements of specific habitat, hydropower, hatchery, harvest, and ecological interaction effects. A key element is the evaluation of status and trends in threats. Monitoring and evaluation plans in other regions have sometimes adopted a more narrow definition of action effectiveness monitoring specifically focused on research on cause and effect relationships.

Uncertainty, Effectiveness, and Validation Research - Characterizes unknown ecological relationships and evaluates whether the hypothesized cause and effect relationships between restoration action and response (physical or biological) were correct. Research identified in this program targets specific issues that constrain effective recovery plan implementation including evaluations of cause and effect relationships between fish, limiting factors, and actions that address specific threats related to limiting factors.

Evaluation - Evaluation includes interpretation of monitoring and research results, assessing the deviation from particular target goals or anticipated results, and recommending appropriate modifications to recovery strategies, measures, and actions. For the purposes of this plan, evaluation also includes gathering of diverse information available from a wide range of sources, processing and synthesis into common scales and formats required for analysis, and reporting of results and findings.

RM&E program elements are designed specifically to address NOAA's listing/delisting criteria based on an evaluation of both an ESU's viability and the extent to which the threats facing the ESU have been addressed. Delisting or downlisting of threatened or endangered species will ultimately depend of achievement of biological and threat-related criteria. Viability is addressed through a combination of biological and habitat status monitoring. Threats are addressed through a combination of habitat status monitoring, implementation/compliance and action effectiveness monitoring. Research provides guidance for evaluations of both status and threats. Note that habitat status monitoring applies to both biological status and habitat threat evaluations. Inferences from habitat conditions are useful in biological status monitoring because comprehensive biological assessments of every population are not feasible. Habitat status also reflects the cumulative effectiveness of all habitat actions and impacts in aggregate.

Biological monitoring in the Lower Columbia is population based whereas habitat monitoring is comprehensive in spatial coverage. The objective for habitat monitoring is to fully characterize, directly and inferentially, the baseline and changing habitat conditions over time. This distinction in monitoring biological populations versus habitat conditions is an important and purposeful strategy that supports the long-term assessment of viability. It allows the MRE program to focus biological monitoring on listed populations, but simultaneously recognize possible changes in habitat use over time. For example, if currently impassible barriers are removed, additional spawning and rearing habitat may be colonized. In such a situation, habitat status data would be available and likely incorporated into the restoration planning process. As such the Lower Columbia monitoring program has chosen to characterize all habitat types, rather than focus on those currently associated with threatened fish populations. Sections 3.0 and 4.0 of this report detail the biological and habitat monitoring design strategies. Both forms of monitoring are

subject to the adaptive management process and time tables. Habitat conditions, rated relative to properly functioning conditions (PFC) benchmarks, will be incorporated into the ESU's viability assessments.

Definitions in this plan are generally consistent with, but not always exactly equivalent to, those similar elements in other regional RM&E plans. For instance, we define action effectiveness monitoring to include status and trends of threats whereas other plans sometimes define effectiveness monitoring in terms of a specific research on cause and effect relationships. Although definitions may vary from plan to plan, each regional plan typically includes the same fundamental categories and elements.

3.0 Biological Status Monitoring

3.1 Objectives

Biological status monitoring is intended to characterize the likelihood of long term persistence (and conversely the risk of extinction) relative to the baseline condition at listing, periodic checkpoints in recovery plan implementation, and recovery goals. In addition to describing progress toward ESU recovery objectives, biological status monitoring also provides data necessary for action effectiveness monitoring and research to resolve critical uncertainties.

Null hypothesis:	**Fish status is unchanged or has continued to decline since listing.**
Alternative:	**Fish status has improved since listing.**

3.2 Strategy

This monitoring program identifies target sample numbers for strata by sampling intensity level based on the following guidelines:

1. ***Biological monitoring needs to address both ESU and population level viability recovery criteria and population parameters related to viability (abundance, productivity, spatial structure, and diversity).***

Evaluations of biological status are based on a series of indicators that are measured or derived variables defined at different hierarchical scales. Status and trends are evaluated at ESU, strata, and population levels. Each ESU is comprised of multiple geographical strata delineated to consider ecological differences among different geophysical regions within an ESU. Each stratum includes one or more populations. Recovery criteria defined by the technical recovery team are detailed in the Recovery Plan.

2. ***Status of every population needs to be assessed but all populations don't need to be monitored.***

Assessments of progress toward recovery require information on the status each population. Recovery plan goals developed based on Technical Recovery Team criteria prescribe population levels consistent with ESU viability. Goals are based on average viability levels exceeding moderate for each strata as well as at least two populations per strata at high levels of viability. Ideally every population would be independently monitored. A combination of Indicator, Inventory, and intensive monitoring will provide an appropriate basis for inferring the status of every population. More comprehensive analysis for a representative subset of population will provide a valid basis for inference. However, status of some populations might be inferred from monitoring of other like-populations or habitat conditions, particularly for small unproductive populations targeted only for stabilization by the recovery strategy.

3. ***Highest priorities for monitoring are assigned to populations targeted in recovery strategies for high viability or large improvements.***

A fundamental recovery strategy involves protection and restoration of key populations to high levels of viability. These populations also provide the best opportunities for effective implementation of an intensive monitoring program which represents a full suite of population dynamics information. Ideally, monitoring programs would be allocated across a representative range of population types but resource limitations will constrain the feasibility of conducting comprehensive monitoring programs for multiple populations within a species. Because only a

subset of populations will ultimately drive recovery, the monitoring program is focused on identifying the status of that subset rather than of all populations in the ESU. The recovery plan identifies population priorities based on Primary, Contributing, and Stabilizing categories. Primary populations are those targeted for restoration to high or very high levels of viability. Contributing populations are those for which significant restorations will be needed to achieve a strata wide average of medium viability. Stabilizing populations are those that would be maintained at current levels.

4. ***Representative samples are needed for primary and contributing populations for every species/life and strata (major population group) based on intensive or inventory monitoring.***

Recovery will depend on improvements in both strong and weak populations. Status varies significantly among populations within a stratum. Different populations are subject to different limitations and can be expected to respond in varying to recovery actions. Not every primary or contributing population needs to be monitored at an Intensive or Inventory level but those that are rigorously monitored must be representative of those that are monitored at a lesser intensity.

5. ***Intensive monitoring of juveniles and adults should occur for at least one population of every species/life history type (major population group).***

It is not realistic to expect to intensively monitor every population to assess status of each at the highest levels of precision and accuracy. A full suite of abundance, productivity, distribution, and diversity information based in intensive monitoring will provide a basis for analysis of fundamental relationships and assumptions of the monitoring program. This monitoring should include intensive monitoring of both adults (fish in) and juveniles (fish out) to provide life stage-specific information on production and factors affecting production. High levels of monitoring will include one intensively monitored population per species. Very high levels of monitor occur when one population per strata is intensively monitored.

6. ***Higher priority is assigned to additional coverage of populations at intensive or inventory sampling intensity than coverage of multiple populations within a species/life history (major population group) at an intensive sampling level.***

There is a tradeoff between the intensity of monitoring of a limited number of populations and the depth of monitoring of a greater number of populations. This plan prioritizes monitoring more populations at an intensive or inventory levels rather than monitoring fewer populations at in intensive level.

3.3 Indicators

3.3.1 Attributes & Metrics

We have categorized indicators as attributes, metrics, and statistics. Attributes of biological status include viability and Viable Salmonid Population (VSP) characteristics including abundance, productivity, distribution, and diversity (Figure 4). Box 1 describes the general approach to monitoring of each attribute. Table 2 details specific metrics that can be statistically quantified for each attribute. For instance, mathematical persistence probabilities (and conversely extinction risks) can be estimated using population trend or life cycle models parameterized with attribute data on abundance and productivity. In addition, the Willamette Lower Columbia Technical Recovery Team (TRT) has identified a categorical scoring approach that infers biological viability levels from quantitative and qualitative information for each VSP attribute. Figure 4 illustrates examples of VSP metrics with fish data.

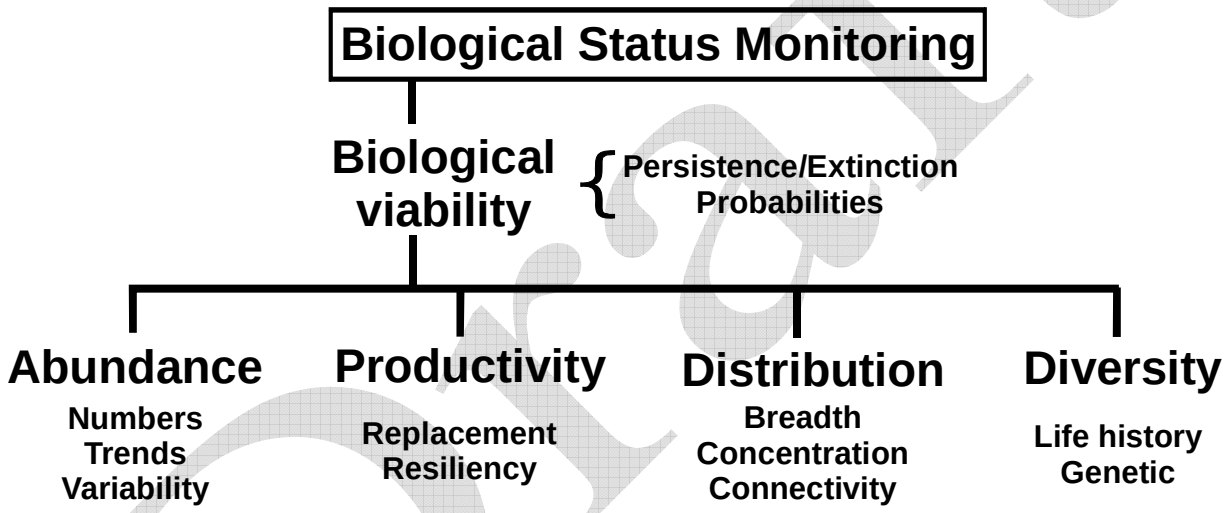

Figure 4. Elements for biological status monitoring of salmon recovery.

Box 1. Generalized description of biological monitoring approach for viable salmonid population attributes.

1. ***Monitor adult spawning abundance of representative populations of Chinook, chum, coho, and steelhead.***

   Questions: What is the current population size and trend relative to the recovery objective?

   Data: Estimates of absolute or relative abundance from counts of live fish, carcasses, or redds

   Sampling: Representative long term index sites (dams, weirs, snorkel, ground or aerial surveys)

   Analysis: Geometric mean number of spawners and annualized population growth rate.

2. ***Monitor juvenile abundance of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: What is current juvenile abundance and trend relative to the recovery objective?

   Data: Juvenile migrant population estimates or indices of abundance, size, age, migration dates.

   Sampling: Collection of migrating juveniles at representative index sites (traps, mark-recapture, catch per unit effort).

   Analysis: Annualized population growth rate, juveniles per spawner.

3. ***Monitor productivity of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: What is current productivity and trend in productivity relative to the recovery objective?

   Data: Numbers, ages, hatchery/wild origin.

   Sampling: Annual size, age, marks, tags from trapped fish, carcasses, and juvenile tagging in conjunction with adult escapement data.

   Analysis: Natural juvenile and/or adult recruits per spawner based on cohort run reconstructions.

4. ***Monitor distribution/spatial structure of representative populations of Chinook, chum, coho, and steelhead in each recovery strata.***

   Questions: How many reaches are used for spawning and how has distribution of spawners among reaches varied in relation to abundance, accessibility and historical use?

   Data: Indices of relative abundance of adults from counts of live fish, carcasses or redds and/or juveniles based on snorkel, electrofishing, or seining surveys.

   Sampling: Replicate random samples stratified by time period and area in one or more years, repeated at periodic intervals.

   Analysis: Relative abundance, range, patchiness, used vs. available area, representation of index sites identified in routine sampling.

5. ***Monitor trends and variation in diversity of representative populations of Chinook, chum, coho, steelhead and bull trout in each recovery strata.***

   Questions: Do all life history patterns continue to be represented and are traits changing relative to objective descriptions?

   Data: Sex, size, fecundity, migration timing, hatchery influence, genetic characteristics.

   Sampling: Representative individual samples from adult or juvenile fish or carcasses in conjunction with adult or juvenile abundance and distribution sampling.

   Analysis: Averages and frequency distributions over time.

Table 2. Attributes, metrics, and example statistics for use as indicators of biological status. (Every statistic not expected to be available for every population.)

Attributes	Metrics	Example statistics
Biological viability	Persistence probability	Extinction risk Categorical scores based on benchmarks
Abundance (adults or juveniles)	Numbers	Geometric mean (4-, 12-, 20-yr) Median (4-, 12-, 20-yr) Stock-recruitment equilibrium abundance
	Trends	Time series slope (4-, 12-, 20-year) Median annual population growth rate (λ)
	Variability	Range (4-, 12-, 20-year) Variance (4-, 12-, 20-year) Coefficient of variation
Productivity	(Adult spawners)	
	Replacement	Spawner recruits per spawner (averages)
	Resiliency	Geometric mean recruits per spawner at low spawner nos. Stock-recruit function intercept parameter
	(Juveniles)	
	Replacement	Smolts per spawner (averages)
	Resiliency	Juvenile production function intercept
Distribution	(Spawning & rearing habitat)	
	Breadth	Miles accessible
	Concentration	Spawners per mile
	Connectivity	Miles occupied, % of historical usage
Diversity	Life History	% hatchery origin spawners & origin (pHOS), % natural origin broodstock (pNOB) % natural influence (PNI) Age at migration (frequency distribution) Age at maturation (frequency distribution) Run timing (mean & range) Fecundity (by size)
	Genetic	Frequency of population bottlenecks (generational geometric mean < threshold) Heterozygosity Frequency of rare types

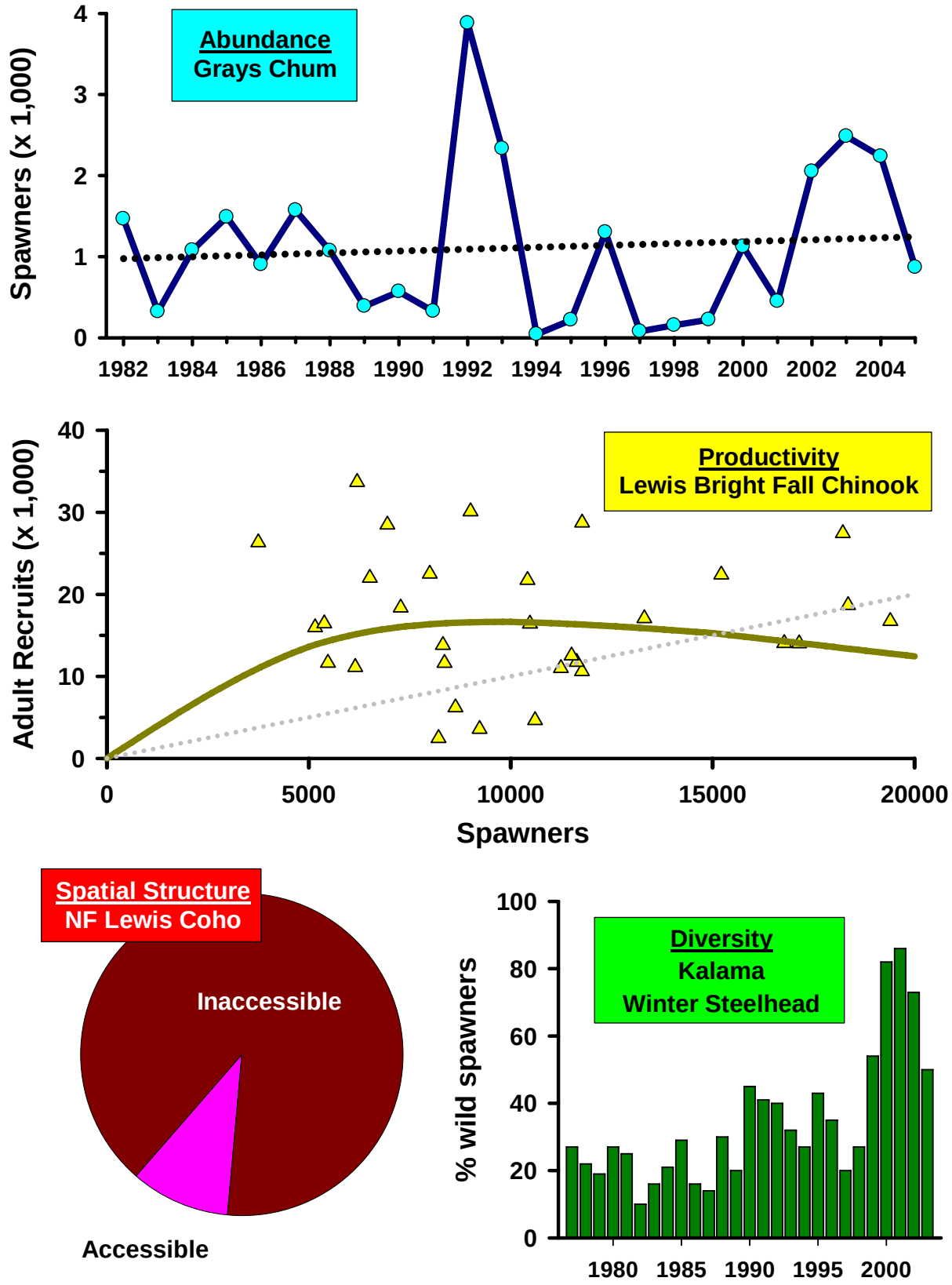

Figure 5. **Examples of Viable Salmonid Population data and metrics as applied to several lower Columbia River populations.**

3.3.2 Status Benchmarks

Assessments of progress toward biological viability goals will rely on quantitative and qualitative interpretations of attribute metrics and statistics. Interpretations will be based on changes in indicators over time as well as comparisons with benchmark values. Benchmarks do not represent goals but are goal-related reference points or standards against which to compare performance achievements. Many different combinations of attribute conditions might satisfy recovery goals. Benchmarks provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level.

The recovery plan identifies goals based on ESU and population-specific criteria. ESU scale benchmarks (Table 3) were developed by the Willamette/Lower Columbia TRT. For instance, the TRT describes a high persistence probability for an ESU strata where the average population persistence probability is significantly greater than moderate and at least two populations are at high levels of persistence (e.g. <5% risk of extinction). All strata must achieve high persistence levels to meet recovery goals. Population-scale benchmarks (Table 4) were developed by the LCFRB and WDFW to address criteria developed by the Willamette/Lower Columbia Technical Recovery Team. Population-scale benchmarks identify attribute values generally corresponding with population persistence levels. The current TRT approach to rating status calculates persistence category for a population based on a weighted average of the attribute scores (TRT 2003).

Table 3. ESU strata-level benchmarks for evaluating fish status relative to recovery criteria guidelines (TRT 2003).

Persistence probability	Average of population persistence	Populations at high persistence
Low (<75%)	Less than moderate (<2.0)	none
Moderate (75-95%)	Moderate (2.0 – 2.25)	at least 2
High (>95%)	Above moderate (>2.25)	at least 2

Based on a qualitative population score where persistence probability is 0 = very low (≤40%), 1 =low (40-75%), 2 = moderate (75-95%), 3 = high (95-99%), and 4 = very high (>99%).

Table 4. Population-level benchmarks for evaluating fish status relative to recovery criteria guidelines.

Category	Description	Values[1]
	Population Persistence	
0	Either extinct or very high risk of extinction	Very low (0-40%) probability of persistence for 100 years
1	Relatively high risk of extinction	Low (40-75%) probability of persistence for 100 years
2	Moderate risk of extinction	Medium (75-95%) probability of persistence for 100 years
3	Low (negligible) risk of extinction	High (95-99%) probability of persistence for 100 years
4	Very low risk of extinction	Very High (>99%) probability of persistence for 100 years
	Adult Abundance and Productivity	
0	Numbers and productivity consistent with either functional extinction or very high risk of extinction	Extinction risk analysis estimates 0-40% persistence probability.
1	Numbers and productivity consistent with relatively high risk of extinction	Extinction risk analysis estimates 40-75% persistence probability.
2	Numbers and productivity consistent with moderate risk of extinction	Extinction risk analysis estimates 75-95% persistence probability.
3	Numbers and productivity consistent with low (negligible) risk of extinction	Extinction risk analysis estimates 95-99% persistence probability.
4	Numbers and productivity consistent with very low risk of extinction	Extinction risk analysis estimates >99% persistence probability.
	Juvenile Out-Emigrants	Evaluated based on the *occurrence* of natural production, whether natural production was *self sustaining* or supplemented by hatchery fish, *trends* in numbers, and *variability* in numbers.
0	Consistent with either functional extinction or very high risk of extinction[3]	No significant juvenile production either because no natural spawning occurs or because natural spawning by wild or hatchery fish occurs but is unproductive.
1	Consistent with relatively high risk of extinction[3]	Long term trend in wild natural production is strongly negative. Also includes the case where significant natural production occurs in many years but originates primarily from hatchery fish.
2	Consistent with moderate risk of extinction[3]	Sample data indicates that significant natural production occurs in most years and originates primarily from naturally-produced fish. No trend in numbers may be apparent but numbers are highly variable with only a small portion of the variability related to spawning escapement.
3	Consistent with low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. No long term decreasing trend in numbers is apparent. Juvenile numbers may be variable but at least some of this variability is related to fluctuations in spawning escapement.
4	Consistent with very low risk of extinction[3]	Sample data indicates significant natural production by wild fish occurs in all years. Trend is stable or increasing over extended time period. Variability in juvenile production is low or a large share of the observed variability is correlated with spawning escapement.

Category	Description	Values[1]
	Within-Population Spatial Structure	
0	Spatial structure is inadequate in quantity, quality[2], and connectivity to support a population at all.	*Quantity* was based on whether all areas that were historically used remain accessible. *Connectivity* based on whether all accessible areas of historical use remain in use. *Catastrophic risk* based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.
1	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population far below viable size	The majority of the historical range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.
2	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population of moderate but less than viable size.	The majority of the historical range is accessible but fish are currently concentrated in a small portion of the accessible area.
3	Spatial structure is adequate in quantity, quality[2], and connectivity to support population of viable size, but subcriteria for dynamics and/or catastrophic risk are not met	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.
4	Spatial structure is adequate to quantity, quality, connectivity, dynamics, and catastrophic risk to support viable population.	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.
	Within-Population Diversity	
0	All four diversity elements (life history diversity, gene flow and genetic diversity, utilization of diverse habitats, and resilience and adaptation to environmental fluctuations) are well below predicted historical levels, extirpated populations, or remnant populations of unknown lineage	*Life history diversity* was based on comparison of adult and juvenile migration timing and age composition. *Genetic diversity* was based on the occurrence of small population bottlenecks in historical spawning escapement and degree of hatchery influence especially by non local stocks. *Resiliency* was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.
1	At least two diversity elements are well below historical levels. Population may not have adequate diversity to buffer the population against relatively minor environmental changes or utilize diverse habitats. Loss of major presumed life history phenotypes is evident; genetic estimates indicate major loss in genetic variation and/or small effective population size. Factors that severely limit the potential for local adaptation are present.	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.
2	At least one diversity element is well below predicted historical levels; population diversity may not be adequate to buffer strong environmental variation and/or utilize available diverse habitats. Loss of life history phenotypes, especially among important life history traits, and/or reduction in genetic variation is evident. Factors that limit the potential for local adaptation are present.	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.

Category	Description	Values[1]
3	Diversity elements are not at predicted historical levels, but are at levels able to maintain a population. Minor shifts in proportions of historical life-history variants, and/or genetic estimates, indicate some loss in variation (e.g. number of alleles and heterozygosity), and conditions for local adaptation processes are present.	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.
4	All four diversity elements are similar to predicted historical levels. A suite of life-history variants, appropriate levels of genetic variation, and conditions for local adaptation processes are present.	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.
	Habitat	
0	Habitat is incapable of supporting fish or is likely to be incapable of supporting fish in the foreseeable future	*Unsuitable habitat.* Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historical range are addressed by spatial structure criteria[2].
1	Habitat exhibits a combination of impairment and likely future conditions such that population is at high risk of extinction	*Highly impaired habitat.* Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur in only in favorable years.
2	Habitat exhibits a combination of current impairment and likely future condition such that the population is at moderate risk of extinction	*Moderately impaired habitat.* Significant degradation in habitat quality associated with reduced population productivity.
3	Habitat in unimpaired and likely future conditions will support a viable salmon population	*Intact habitat.* Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)
4	Habitat conditions and likely future conditions support a population with an extinction risk lower than that defined by a viable salmon population. Habitat conditions consistent with this category are likely comparable to those that historically existed.	*Favorable habitat.* Quality is near or at optimums for salmon. Includes properly functioning through pristine historical conditions.

[1] *Rules were derived by the LCFRB and WDFW staff for attribute descriptions from McElhany et al. 2003. Application rules do not represent assessment by the Technical Recovery Team which is currently in the process of refining benchmarks.*

[2] *Because recovery criteria are closely related, draft category descriptions developed by the Technical Recovery Team often incorporate similar metrics among multiple criteria. For instance, habitat-based factors have been defined for diversity, spatial structure, and habitat standards. To avoid double counting the same information, streamline the scoring process, and provide for a systematic and repeatable scoring system this application of the criteria used specific metrics only in the criteria where most applicable. This footnote denotes these items.*

[3] *This is a modification of the interim JOM criteria identified by the TRT for consistency with other criteria.*

3.3.3 Sample Summary Reports

Example reporting templates for biological status data are depicted in Table 5. Examples were included to illustrate how biological status data might begin to be organized and used. Many alternative depictions might ultimately be developed.

Table 5. Sample reporting templates.

Population viability data

Species		Washington	Current viability (No. of pop.)				Viability goal (No. of pop.)			
Type	Strata	Populations	Low	Med	High	Avg.	Low	Med	High	Avg.
Chinook										
Spring	Cascade Gorge	6	6	0	0	Low	1	3	2	Med+
Fall	Coast Cascade Gorge									
Late Fall	Cascade									

Abundance data

Species			Numbers (avg.)					Trends (avg.)			Viability
Type	Strata	Population	Goal	Base	4-yr	10-yr	25-yr	4-yr	10-yr	25-yr	category
Chinook											
Spring	Cascade	U. Cowlitz Cispus									

Productivity data

Species			Observed spawner/spawner				Normalized values					Viability
Type	Strata	Population	Base	4-yr	10-yr	25-yr	Goal	Base	4-yr	10-yr	25-yr	category
…												

Distribution data

Species			Accessibility			Occupancy				Viability
Type	Strata	Population	Hist. (Miles)	Base (%)	Current (%)	Base	4-yr	10-yr	25-yr	category
…										

Diversity data

Species			Hatchery fraction (avg.)					Bottleneck freq.			Viability
Type	Strata	Population	Goal	Base	4-yr	10-yr	25-yr	4-yr	10-yr	25-yr	category
…											

3.4 Sampling & Analytical Design

3.4.1 Framework

This program identifies a stratified, representative, multi-level sampling framework for monitoring the biological status at a population unit scale. It is simply not realistic to monitor every VSP parameter for every population in every year at a high level of precision due to costs of intensive biological monitoring, other monitoring and research needs, and tradeoffs in funding priorities between monitoring and other recovery actions. Instead, this plan identifies a biological sampling program that provides information on every population, but samples different populations at different intensities, and employs a stratified subsampling distribution of effort among populations to ensure representative coverage of all ESUs. The design incorporates existing activities and identifies priorities for addition biological monitoring efforts necessary to address identified gaps. This program is designed to provide the information necessary to assess progress toward achieving recovery goals and objectives. The stratified, representative, multi-level sampling design addresses the following four elements:

1) Population strata (Species, Stock & Region)
2) Intensity (Intensive, Inventory, Index)
3) Life stage (Juveniles, Adults)
4) Frequency (Annual, Periodic)

Sample strata are major population groups described by the WLC TRT based on species, life history characteristics, and geographical proximity. A total of 102 populations of four species and seven species/life history types have been delineated by the TRT for this region (Table 6). Of these, 72 (71%) occur wholly or partly in Washington. Geographical strata reflect common spatial and ecological influences. The Coast stratum includes Columbia tributary subbasins downstream from the Cowlitz River. These subbasins are comprised of small rain-driven systems draining forestlands of the southern Willapa Hills. The Cascade stratum includes Cowlitz, Lewis, and Washougal subbasins, draining the West slope of the Cascades. These are typically larger rainfall and snow-driven systems in a mixture of forest and developed lands. The Gorge stratum includes systems from upstream of the Washougal River, to the White Salmon River. Gorge subbasins are typically small to moderate-sized, steep, forested Cascade systems.

Table 6. Numbers of Washington and Oregon Lower Columbia populations occurring in sample strata consisting of geographical/ecological regions and species/life history types (Washington populations are in parentheses).

Strata	Chinook			Chum	Steelhead		Coho
	Spring	Fall (tule)	Late Fall (bright)		Winter	Summer	
Coast	**0 (0)**	**7 (3)**	**0 (0)**	**7 (3)**	**7 (3)** [1]	**0 (0)**	**7 (3)**
Cascade	**7 (6)**	**10 (8)**	**2 (1)**	**7 (5)**	**14 (12)**	**4 (4)**	**14 (12)**
Gorge	**2 (1)**	**4 (3)**	**0 (0)**	**2 (2)**	**3 (2)**	**2 (1)**	**4 (3)**
Total	***9 (7)***	***21 (14)***	***2 (1)***	***16 (10)***	***24 (17)***	***6 (5)***	***25 (18)***

[1] ***Not listed***

Figure 6. Tradeoffs in benefits among sampling protocols of varying intensity.

Three levels of sampling intensity are identified, reflecting tradeoffs between the precision provided and effort required for implementation (Figure 6). Levels are distinguished by the depth and breadth of adult and juvenile sampling activities. Any given sampling activity typically addresses multiple VSP parameters. Therefore sampling activities intended to estimate VSP parameters are bundled for the purposes of this program. Rather than repeating descriptions of the sampling activities needed to address each individual VSP parameter, this program identifies integrated suites of activities that address complementary VSP elements at a given level of accuracy and precision.

The ***Intensive*** sampling level provides the most comprehensive and detailed information on abundance, distribution, productivity, and diversity based on adult or juvenile direct census, marking or tagging, and individual fish sampling. Intensive sampling is distinguished by direct empirical measurements of attribute metrics and critical assumptions of the sampling method. For instance, intensive sampling would include comprehensive time and area surveys or mark-recapture programs to determine census accuracy. The high depth, accuracy, and precision of an Intensive sampling program can be costly and has most effectively been implemented as part of a large-scale research program. Intensive sampling efforts have not been widely implemented in the lower Columbia.

The ***Inventory*** sampling level provides similar information on VSP attributes but with less rigorous testing of assumptions and greater uncertainty. For instance, expansions of adult index counts into estimates of absolute abundance might rely on historical or periodic rather than annual estimates of the proportional representation of index areas and periods. Similarly, spawner surveys might include index and extensive reaches that account for the large majority of the spawning distribution, but might be limited in occasional use areas. Tradeoffs in detailed assessments of assumptions can allow a much broader coverage of populations using Extensive sampling than could be accomplished for the same cost and effort with Intensive sampling. Faced with limited resources, the choice is between more detailed information for a few populations with Intensive sampling or coverage of more populations at a lesser depth using an Extensive protocol. Extensive sampling has been widely implemented in the lower Columbia, particularly for Chinook and steelhead.

Indicator sampling is the least rigorous of the proposed sampling levels but provides key information on relative abundance and distribution at a population scale for a modest cost. It provides a means for status assessment of many populations where the available resources are not adequate to support Intensive or Inventory sampling. On the lower Columbia, limited sampling is commonly used to assess steelhead, coho and chum populations.

Intensive, Inventory, and Indicator sampling may be focused on adult and juvenile samples. Intensive sampling protocols typically involve both adult and juveniles sampling. Comparisons of adult and juvenile numbers provide very powerful information for interpreting patterns of variation in abundance as well as driving factors. Adult and juvenile sample levels are allocated independently. For instance, an extensive juvenile sampling program might be implemented for the same population as an intensive adult sampling program.

Sampling may be either annual (every year) or periodic (multi-year intervals). Annual sampling is generally intended to provide a detailed time series of status information to assess trends and variability. Periodic samples are primarily intended to evaluate status of less-intensively

monitored populations relative to more-intensively monitored populations. Intervals for periodic sampling depend on the information objective.

3.4.2 Methods

Sampling methods associated with different sampling intensities for adult and juvenile salmonids are summarized below and in (Table 7). The table also describes how the sampling relates to the VSP parameters.

Intensive Sampling - Adults

Intensive adult sampling typically estimates absolute annual numbers of fish based on counts of fish at dams or weirs, or counts of live fish, carcasses, or redds in spawning or staging areas by ground, aerial, or snorkel surveys. Effective sampling methods are determined by the species and habitat type circumstances. In some cases, particularly at dams or weirs, counts may represent a near-absolute census of the population. However, in many cases, counts represent a subsample of the total population. An intensive sampling protocol estimates total annual numbers of fish from subsample data using expansion factors calculated from comprehensive time and area sample surveys, or mark-recapture data. Intensive surveys generally include multiple samples throughout the spawning period to accommodate temporal differences in abundance as well as individual fish that are present at different times. Intensive surveys also include all spawning areas or a stratified random approach including major spawning areas with subsamples of areas of limited use. In some cases, annual sampling is based on a subsample of representative index sites and times, while periodic sampling is conducted to develop expansion factors.

Intensive adult sampling provides detailed information on abundance, productivity, and diversity. Detailed information is also provided on distribution where based on spawning ground surveys. Census data from adult abundance sampling generally provides the most accurate and precise data available for estimating annual patterns and trends in spawner numbers. Adult abundance sampling also often provides detailed information on distribution, productivity, and diversity in addition to abundance. Costs of adult abundance sampling can be significant, particularly where couple with collection of data on ages or size, hatchery fractions, and tag recovery.

Table 7. Description of representative multi-level sampling design components of biological status monitoring.

Level, Life stage	Attribute	Information type	Sampling activities[1]	Frequency
1. Intensive				
Adults	Abundance	Spawner census (total abundance)	Weir/dam counts, mark-recapture, or comprehensive time & area spawner surveys	Annual
	Distribution	Core & dispersed production areas	Spawner surveys of index & extensive reaches (e.g. EMAP style design)	Annual
	Productivity	Spawner recruits per spawner	Hatchery origin & age samples for brood year reconstructions	Annual
	Diversity	Hatchery fraction, age composition	Individual fish or carcass sampling for marks, CWTs, and scales	Annual
Juveniles	Abundance	Migrant census (total numbers)	Migrant trap counts, trap efficiencies from mark-recapture	Annual
	Distribution	Mainstem & ocean occurrence, timing	CWT of juveniles, ocean fishery recoveries	Periodic
	Productivity	Parr or smolts per spawner	Brood year comparisons with adult data	Annual
	Diversity	Run timing, size/age distribution	Seasonal trap catch rates, individual fish subsampling at traps	Annual
2. Inventory				
Adults	Abundance	Spawner no. (estimated abundance)	Spawner index surveys (standardized expansions for time & area)	Annual
	Distribution	Core & dispersed production areas	Spawner surveys of extensive reaches	Periodic
	Productivity	Spawner recruits per spawner	Hatchery origin & age samples for brood year reconstructions	Annual
	Diversity	Hatchery fraction, age composition	Individual fish or carcass sampling for marks, CWTs, and scales	Annual
Juveniles	Abundance	Migrant index (relative numbers)	Migrant trap, seine, or electrofishing catch per unit effort	Annual
	Distribution	Core & dispersed production areas	Surveys of index & extensive reaches (e.g. EMAP style design)	Periodic
	Productivity	Index migrants per spawner	Brood year comparisons with adult data	Annual
	Diversity	Run timing or seasonal abundance	Seasonal catch rates	Periodic
3. Indicator				
Adults	Abundance	Spawner index (relative abundance)	Index area fish, carcass, or redd peak surveys (ground, aerial or snorkel)	Annual
	Distribution	Adult presence/absence	Reconnaissance surveys of non-index areas	Periodic
	Productivity	NA	NA	
	Diversity	NA	NA	
Juveniles	Abundance	Parr presence/absence	Snorkel or electrofishing surveys in rearing areas	Periodic
	Distribution	Parr presence/absence	Distributed sampling regime	Periodic
	Productivity	NA	NA	
	Diversity	NA	NA	

[1] *Representative activities. Variations can result from different cases.*
NA = not available.

Inventory Sampling - Adults

Inventory sampling of adults involves estimates of annual patterns and trends based on counts of live fish, carcasses, or redds made by ground, aerial, or snorkel surveys for a representative subsample of the available spatial and temporal distribution. Total population size might be estimated from index counts expanded for time and area by the assumed proportion of the total represented by the index area and period. The approach may be similar to intensive sampling except that expansions of index samples are based on more limited data (assumed values or non-replicated estimates).

Index sample sites are standardized from year to year to eliminate site effects on fish density that might confound interpretations of annual trends. The tradeoff is that differences in distribution between sampled and unsampled areas can affect annual patterns. For this reason, sampling areas are often selected to represent core production areas. Index sampling provides a systematic means of monitoring fish status at a moderate cost, accuracy, and precision.

Adult Inventory sampling is designed to provide information on trends in abundance. Unlike intensive adult abundance sampling programs, Inventory sampling programs typically provide limited information on distribution and diversity. Relative productivity data may be developed from index samples where coupled with age and mark sampling.

Figure 7. Salmon redd and carcass surveys are often the basis for inventory or intensive sampling of adults.

Indicator Sampling - Adults

Indicator sampling of adults describes annual patterns and trends based on unexpanded or partially-expanded relative numbers. Indicator sites typically include a subset of potential spawning areas. Counts might be made only once per year on historic peak spawning activity dates. Data is often represented on a unit basis (e.g. counts per mile). Representative sites and times are ideally selected during program development based on an initial survey of all potential spawning areas. Indicator samples might be made every year or in periodic years.

Indicator sampling may also involve adult presence/absence sampling involving low intensity reconnaissance grade surveys to determine if significant numbers of spawners may be present in any given area or time. They may be based on ground, aerial, or snorkel counts and are often

periodic in nature. The primary purpose of the reconnaissance sampling is to track sporadic patterns of occurrence and distribution in cases where more formal rigorous sampling programs are not in place. Presence/absence sampling provides limited information on distribution but little or no statistical information on abundance, productivity or diversity.

Intensive Sampling - Juveniles

Intensive juvenile sampling provides absolute estimates of juvenile numbers, typically smolt or presmolt migrants. Absolute estimates are generally based on subsamples from the total population collected in migrant traps or dam fish passage facilities. Subsample numbers are then expanded based on sample rates that are best estimated from recovery rates of marked fish released upstream from the sample site. Juvenile abundance sampling is useful for estimating capacity and productivity of freshwater habitats, relationships between spawner and juvenile numbers, and annual population status. Juvenile surveys are particularly useful for population status assessments where spawner surveys are difficult. Juvenile sampling programs often provide information on size, age, and timing of outmigration. Juvenile sampling programs are often conducted in conjunction with other programs such as migration and survival studies. Juvenile abundance sampling is labor intensive and costly. As a result, juvenile sampling programs in streams are not widespread. Juvenile census sampling can provide extensive information on abundance and productivity, and more limited information on distribution and diversity.

Figure 8. Intensive sampling of juveniles often relies on migrant trapping with a rotary screw trap. Where coupled with releases of mark groups to estimate trap efficiency, smolt trapping can provide estimates of absolute abundance of juveniles.

Coded wire tagging is a component of some intensive juvenile sampling programs. Coded wire tags are typically implanted in juveniles provide critical information on fish origins when recovered in fishery, hatchery, or spawning samples. CWTs are a critical element of fishery index stock programs designed to monitoring catch distribution patterns and to limit fishery

harvest and impacts of specific stocks to desired levels. CWTs also important in hatchery evaluations of fishery contributions and relative survival rates of different hatchery treatments. CWTs are batch marks that are implanted in large numbers for representative subsamples of most hatchery stocks. Lesser numbers of wild fish are marked with CWTs owing to the cost and difficulty of capturing and marking a large enough sample to provide useful information from the typically small fraction of marked fish that reach adulthood and are sampled. As a result, hatchery samples have often been used as surrogates for wild stocks in the past.

Inventory Sampling - Juveniles

Inventory juvenile sampling provides information on relative rather than absolute abundance. It is typically based on index counts per unit of sampling effort from catches in juvenile migrant traps, catches in seine or electrofishing samples, or numbers observed in snorkel surveys. Inventory sampling is often similar to abundance sampling but without the time, area, or sample rate expansions for a total census. Inventory sampling can be useful for estimating relative capacity and productivity of freshwater habitats, relationships between spawner and juvenile numbers, changes in population status, distribution, or size, age and timing of outmigration.

Indicator Sampling - Juveniles

Indicator sampling of juveniles involves presence/absence consisting of low intensity reconnaissance grade surveys typically intended to determine if significant numbers of juveniles may be present in any given area or time. They may be based on catches in juvenile migrant traps, catches in seine or electrofishing samples, or numbers observed in snorkel surveys are often periodic in nature. Presence/absence information is most valuable for identifying gross patterns of distribution and has limited utility for monitoring temporal abundance patterns. However, presence/absence surveys can provide valuable information for addressing the TRT's spatial distribution criterion.

Figure 9. Snorkel surveys are often utilized for indicator or inventory surveys of juveniles or adults,

3.4.3 Sampling Benchmarks

Based on these guidelines, benchmarks were established for evaluation of the adequacy of current efforts, information gaps, and priorities to fill gaps in biological status monitoring. Benchmarks are based on general statistical principles rather than prescribed statistical power analyses. Benchmarks are most useful as descriptive reference points to highlight differences in relative effort of biological monitoring programs for different species and strata. Benchmarks include both Oregon and Washington populations.

Benchmarks were established at MPG and population levels. MPG-level benchmarks were identified based on numbers of populations at low, moderate, and high sampling coverages corresponding to the relative degree of certainty in the biological status assessment (Table 8). The MPG criteria involve: 1) sampling depth based on intensive sampling of adults and juveniles of the same population for explicit estimates of life stage productivity and survival, 2) sampling breadth based on sampling of multiple populations to provide minimum levels of replication within an MPG, and 3) sampling breadth based on representative fractions of populations in each MPG that are monitored.

Table 8. Major Population Group-level sampling guidelines at low, moderate, and high levels of coverage for biological monitoring (number of populations monitored by sampling intensity).

Relative certainty	Sampling depth Intensive	Sampling breadth Inventory or Intensive	Sampling coverage Indicator or Inventory or Intensive
Low	<1 per species/life history (juveniles & adults)	<2 per species/life stage & strata (adults or juveniles)	<33% of populations (adults or juveniles)
Moderate	1 per species/life history (juveniles & adults)	2 per species/life stage & strata (adults or juveniles) [1]	≥33% of populations (adults or juveniles)
High	>1 per species/life history & strata (juveniles & adults)	>2 per species/life stage & strata (adults or juveniles)[2]	>50% of populations (adults or juveniles)

[1] *Or two populations if only two in the strata.*
[2] *Or two or three populations in strata with only two or three, respectively.*

Population-level benchmarks were identified for sampling levels consistent with population priorities for recovery (primary, contributing, stabilizing categories). The sampling strategy directs that populations slated for recovery to high viability or large improvements will require significant sampling efforts to determine with some certainty whether goals are met. Thus, primary populations will require more intensive sampling than contributing populations, and contributing populations will require more intensive sampling than stabilizing populations. Population priority benchmarks are based on a relative data quality scale related to the depth and breadth of sampling efforts for each population (Table 9). This plan targets sampling of Primary populations at an A or B data quality standard, and contributing populations at a data quality standard of C or above.

Table 9. Population-level data quality criteria for Primary and Contributing populations based on adult and juvenile sampling intensity. Quality ratings as based on a subjective relative scale (A to D.

Data quality	Adult sampling		Juvenile sampling	Adequate for primary?	Adequate for contributing?
A	Intensive	and	Intensive	Yes	Yes
	Intensive	and	Extensive	Yes	Yes
B	Intensive	or	Intensive	Yes	Yes
	Extensive	and	Extensive	Yes	Yes
C	Extensive	or	Extensive	No	Yes
D	Indicator	or	Indicator	No	No
--	none		none	No	No

3.5 Current Monitoring Activities

Biological status of salmon populations is currently being monitored for a subsample of populations and attributes. Some level of monitoring is currently being conducted in a majority of watersheds for most species (Table 1). Intensive adult monitoring is currently conducted for all significant Spring Chinook and summer steelhead populations and many winter steelhead populations (Table 1). Adult Fall Chinook are widely monitored at an inventory level. An Inventory program including many chum populations has been initiated in recent years. Adult abundance sampling for coho in Washington has been largely been limited to reintroduction efforts above Cowlitz Dams. Oregon has recently implemented an intensive coho monitoring program in lower Columbia streams to supplement long term intensive coho monitoring activities in the Clackamas and Sandy rivers.

Intensive juvenile monitoring includes hydro-related studies in Upper Cowlitz, a research program in the Kalama, the intensive watershed monitoring program in Mill, Abernathy, and Germany Creeks, and a restoration program in the Hood River. Juvenile inventory sampling programs involving migrant traps have recently been conducted or are currently underway for multiple species in Mill, Abernathy, and Germany creeks (Coast strata) as part of the intensively monitored watershed program funded by the State of Washington, Coweeman River (Cowlitz tributary, Cascade Strata), Cedar Creek (N. Lewis tributary, Cascade strata), Wind River (Gorge strata), and Hood River (Gorge strata). Juvenile inventory sampling also occurs at Cowlitz and Clackamas hydropower facilities. Juvenile indicator programs include presence/absence surveys conducted under the Forest and Fish Rules for stream typing purposes, project-related surveys conducted under local ordinances (e.g., critical areas, wetlands protection, etc), and surveys associated with research projects.

Monitoring of tributary populations is primarily conducted by WDFW and ODFW, respectively. Mainstem population monitoring activities are conducted by WDFW, ODFW, NOAA, and the USFWS. Monitored populations and attributes reflect a variety of needs and are also closely related to funding sources. For instance, inventory fall Chinook escapement information is collected to support inter-jurisdictional fishery management activities. Similarly, adult and juvenile data is collected in the upper Cowlitz as part of hydro mitigation activities. The current program was not specifically designed to provide representative samples for the purposes of salmon recovery assessments. Note that the same information collected for the analysis of biological status can have a variety of applications in action effectiveness monitoring as well as uncertainty, effectiveness, and validation research.

Table 10. Current biological status monitoring types by subbasin and species. Dashes denote subbasins where stock is not present. Asterisks (*) are populations where significant monitoring is not conducted. Multiple subbasins comprising a single population are denoted with boxes.

		Fall Chinook		Spring Chinook	Chum	Steelhead		Coho	Data source
		Tule	Bright			Winter	Summer		
COA S T[2]	Grays/Chinook (WA)	A2[1]	--	--	A1/J3[5]	A1[2]	--	A3[10]	WDFW
	Elochoman/Skamokawa (WA)	A2[1]	--	--	A3	A1[2]	--	A3[10]	WDFW
	Mill/Abernathy/Germany (WA)	AI/JI	--	--	A1/J1	A1/J1[72]	--	A1/J1	WDFW
	Youngs Bay (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Big Creek (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Clatskanie (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
	Scappoose (OR)	A1	--	--	A3	A2[2]	--	A1	ODFW
CA S CADE	Lower Cowlitz (WA)	A2[1]	--	A1	A3	A2	--	A3[10]	WDFW
	Upper Cowlitz (WA)	*	--	A1/J1[3]	*	A1/J1	--	A1/J1	WDFW
	Cispus (WA)	*	--	A1/J1[3]	*	A1/J1	--	A1/J1	WDFW
	Tilton (WA)	*	--	--	*	A2/J2	--	A2/J2	WDFW
	SF Toutle (WA)	A2[1]	--	--	*	A1	--	A3[10]	WDFW
	NF Toutle (WA)	A2[1]	--	--	*	A2[8]	--	A3[10]	WDFW
	Coweeman (WA)	A2[1]/J3	--	--	A3	A1/J3	--	A3[10]/J3	WDFW
	Kalama (WA)	A2[1]	--	A1/J2	A3	A1/J1	A1/J1	A3[10]	WDFW
	Lewis NF (WA)	A2[1]	A1/J1/JT	A2/J2[4]	A3	A2/J2[9]	A1	A2/J2	WDFW, PacifiCorp
	Lewis EF (WA)	A2[1]	--	--	A3	A1	A1	A3[10]	WDFW
	Salmon (WA)	*	--	--	A3	*	--	A3[10]	WDFW
	Washougal (WA)	A2[1]	--	--	A3	A1	A1	A3[10]	WDFW
	Sandy (OR)	A1	A1	A1	*	A2/A2	--	A2/J2	ODFW, PGE, USFS
	Clackamas (OR)	A3	--	A1/J2	*	A2/J2	--	A1/J2	ODFW, PGE, USFS
GORGE	Lower Gorge (WA/OR)	A2[1]	A2[2]	--	A2/J2[6]	*	--	A3[10]	WDFW, USFWS
	Upper Gorge (WA/OR)	A2[1]	A2[2]	A2	A1	*	A2/J2	A3/J2[10]	WDFW, USGS
	White Salmon (WA)	A2[1]	A2[2]	*	--	--	--	*	WDFW, USFS
	Hood (OR)	A3	--	A1/J1	--	A1/J1	A1/J1	AI/J1	ODFW, CTWSRO, USFS

A1 = Adult intensive monitoring (annual abundance based dam/weir counts or expanded survey counts), A2 = Adult Inventory monitoring (Annual relative measure of numbers typically reported as redds/mile for the sample area), A3 =Adult indicator monitoring (periodic). J1 = Annual juvenile abundance, J2 = Juvenile Inventory monitoring, J3 = Juvenile indicator monitoring, JT = Juvenile coded-wire tagging.

WDFW = Washington Department of Fish and Wildlife, ODFW = Oregon Department of Fish and Wildlife, PGE = Portland General Electric, CTWSRO = Warm Springs Tribe, USFWS = U.S, Fish and Wildlife Service, USGS = U. S. Geological Survey, US Forest Service.

[1] *Adult abundance estimates may not include entire spawning area or time and area replicates.*

[2] *Not part of lower Columbia ESU.*

[3] *Juvenile accounting at Cowlitz Falls Dam. Does not separate Upper Cowlitz and Cispus production.*

[4] *Juvenile abundance monitoring will likely begin in new license period*

[5] *Juvenile migration timing only*

[6] *Juvenile abundance monitoring for Hamilton, Hardy, and Duncan Creeks. Juvenile Inventory monitoring for mainstem Columbia near Ives Island.*

[7] *Adult monitoring does not include Mill Creek. Juveniles monitored in all three streams.*

[8] *Adult monitoring for NF Toutle. Adult index for Green River.*

[9] *Includes Cedar Creek only. Adult and juvenile monitoring will likely begin in new hydro license period.*

[10] *Coho adult monitoring is incidental to Chinook and chum monitoring.*

3.6 Information Gaps

Current sampling efforts were evaluated based on major population group- and population-level sampling benchmarks to highlight species, life history types, and strata where information may be incomplete. The gap analysis indicates that existing programs fall far short of adequate coverage necessary to provide the biological data needed to evaluate progress toward recovery objectives with moderate or high levels of certainty.

MPG-level gaps where identified based on depth, breadth, and coverage in the number of populations currently sampling. Some information is available for all major population groups, but moderate and high certainty MPG benchmarks are met only for Cascade spring Chinook and Cascade winter steelhead (Table 11). However, most of this monitoring in the Cascade strata is focused on reintroduction efforts in the Cowlitz basin which is not be representative of other populations in the strata. Moderate certainty MPG benchmarks are met for all spring Chinook, summer steelhead, and coho MPGs but at least one MPG falls short for fall Chinook, winter steelhead, and chum. Significant monitoring gaps are identified at the moderate certainty level for fall Chinook in the Cascade and Gorge strata (lack of intensive adult monitoring and juvenile monitoring), Gorge winter steelhead (adults and juveniles), Cascade and Gorge chum (adults and juveniles), and Washington populations of coho (adults and juveniles).

Table 11. Summary of current sample sizes (adults/juveniles) at intensive, inventory, and indicator sampling intensities and assessment of whether moderate or high certainty sample size benchmarks are met by current sampling efforts (combined Washington and Oregon sampling efforts).

Type	Strata	# pop	Intensive	Inventory	Indicator	Moderate	High
Chinook							
Spring	Cascade	7	5/2	1/2	0/0	Yes	Yes
	Gorge	2	1/1	1/0	0/0	Yes	**No**
Fall	Coast	7	5/1	2/0	0/0	Yes	**No**
	Cascade	10	1/0	6/0	1/1	**No**	**No**
	Gorge	4	0/0	3/0	1/0	**No**	**No**
Late Fall	Cascade	2	2/1	0/0	0/0	Yes	**No**
Steelhead							
Winter	Coast	7	3/1	4/0	0/0	Yes	**No**
	Cascade	14	7/3	6/4	0/1	Yes	Yes
	Gorge	3	1/1	0/0	0/0	**No**	**No**
Summer	Cascade	4	4/1	0/0	0/0	Yes	**No**
	Gorge	2	1/1	1/1	0/0	Yes	**No**
Chum							
	Coast	7	2/1	1/0	4/1	Yes	**No**
	Cascade	7	0/0	0/0	5/0	**No**	**No**
	Gorge	2	0/0	2/1	0/0	**No**	**No**
Coho							
	Coast	7	5/1	0/0	2/0	Yes	**No**
	Cascade	14	3/2	3/4	8/1	Yes	**No**
	Gorge	4	1/1	0/1	2/0	Yes	**No**

Population-level monitoring gaps were identified where sampling intensity and corresponding data quality were inconsistent with population recovery priorities. Based on the sampling strategy, this analysis assumed that populations targeted for high levels of viability or significant improvements would require significant sampling efforts to confirm status. Significant discrepancies between recovery targets and current sampling efforts were identified for multiple populations of tule fall Chinook, Chum, and coho. Shortcomings were particularly pronounced for chum and coho. Tule fall Chinook concerns were generally limited to the need for more intensive monitoring of several primary populations, particularly where hatchery influence was significant. Sampling efforts for bright fall Chinook and summer steelhead met population-level benchmarks for all populations. Sampling efforts for spring Chinook and winter steelhead met population-level benchmarks except for the contributing Toutle River spring Chinook population and the primary lower gorge winter steelhead population.

Assessments of gaps in current monitoring programs and additional sampling needs to meet sampling benchmarks are described in further detail for each species in the following sections. These sections also identify additional sampling needed by population based on MPG and population-level needs, population-specific sampling feasibility, opportunities to meet multiple needs by focused sampling in specific subbasins, and other opportunities based on planned action effectiveness monitoring. These priorities highlight several subbasins where more intensive sampling programs may produce economies of scale by providing information on multiple species. Oregon priorities are placeholders for consideration by the Oregon recovery planning process.

Table 12. Summary of current data quality (A = very high, B = high, C = medium, D = low) relative to population-level sampling benchmarks by population recovery targets (Primary, Contributing, Stabilizing).[1] Populations where additional sampling is needed to meet population-level benchmarks are denoted by black shading. (Oregon information is a placeholder).

		Fall Chinook (tule)	Fall Chinook (bright)	Spring Chinook	Chum	Winter steelhead	Summer steelhead	Coho
COAST	Grays/Chinook	**Primary (C)**	--	--	Primary (B)	na	--	**Primary (D)**
	Elochoman/Skamokawa	**Primary (C)**	--	--	**Primary (D)**	na	--	**Primary (D)**
	Mill/Abernathy/Germany	Contributing (A)	--	--	Primary (A)	na	--	Contributing (A)
	Youngs Bay (OR)	Stabilizing (B)	--	--	**Primary (D)**	na	--	Stabilizing (B)
	Big Creek (OR)	Stabilizing (B)	--	--	**Contributing (D)**	na	--	Stabilizing (B)
	Clatskanie (OR)	Primary (B)	--	--	**Contributing (D)**	na	--	Primary(B)
	Scappoose (OR)	Stabilizing (B)	--	--	**Contributing (D)**	na	--	Primary(B)
CASCADE	Lower Cowlitz	Contributing (C)	--	--	**Contributing (D)**	Contributing (C)	--	**Primary (D)**
	Upper Cowlitz	Stabilizing (--)	--	Primary (A)	--	Contributing (A)	--	Contributing (A)
	Cispus	--	--	Primary (A)	--	Contributing (A)	--	Contributing (A)
	Tilton	--	--	Stabilizing (--)	--	Contributing (C)	--	Contributing (B)
	Toutle SF	--	--	**Contributing (--)**	--	Primary (B)	--	**Primary (D)**
	Toutle (NF)	Stabilizing (C)	--	--	--	Primary (B)	--	**Primary (D)**
	Coweeman	**Primary (C)**	--	--	--	Primary (B)	--	**Primary (D)**
	Kalama	**Primary (C)**	--	Primary(A)	**Contributing (D)**	Primary (A)	Primary (A)	**Contributing (--)**
	Lewis NF	--	Primary (A)	Primary (B)	--	Contributing (B)	Stabilizing (B)	Contributing (B)
	Lewis EF	**Primary (C)**	--	--	**Primary (D)**	Primary (B)	Primary (B)	**Primary (D)**
	Salmon	--	--	--	**Stabilizing (D)**	Stabilizing (--)	--	Stabilizing (D)
	Washougal	**Primary (C)**	--	--	**Primary (D)**	Contributing (B)	Primary (B)	**Contributing (D)**
	Sandy (OR)	Contributing (B)	Primary (B)	Primary (B)	**Primary (--)**	Primary (B)	--	Primary (B)
	Clackamas (OR)	Stabilizing (D)	--	na	**Contributing (--)**	Primary (B)	--	Primary (A)
GORGE	Lower Gorge	Contributing (C)	--	--	Primary (B)	**Primary (--)**	--	**Primary (D)**
	Upper Gorge	Stabilizing (C)	--	--	Contributing (B)	Stabilizing (--)	Primary (B)	**Primary (D)**
	White Salmon	Contributing (C)	--	Contributing (C)	--	--	--	**Contributing (--)**
	Hood (OR)	Stabilizing (D)	--	Primary (A)	--	Primary (A)	Primary (A)	Contributing (A)

[1] *Benchmarks are A or B data quality for primary populations and C or higher for Contributing populations.*

3.6.1 Spring Chinook

Spring Chinook are well represented by current programs due to their occurrence in upper portions of large subbasins upstream of hydro facilities where regulatory commitments and obligations require monitoring. Intensive or inventory monitoring programs are underway in the Cowlitz, Lewis, and Sandy systems, which account for the majority of lower Columbia spring Chinook production. Long-term viability of spring Chinook depends largely on the success of reintroduction efforts into the upper Cowlitz, Lewis, and Hood systems, which makes monitoring of those populations a high priority. The Sandy population is also key and a high priority for monitoring. More intensive monitoring of juvenile and adult Lewis River spring Chinook will also be appropriate as part of experimental reintroduction evaluations. Adult and juvenile monitoring in the Big White Salmon subbasin would increase if passage is restored over Condit Dam, or the dam is breached. Because spring Chinook monitoring needs are generally being met by existing programs and priorities, management emphasis should be placed on maintenance of existing efforts. However, action effectiveness monitoring will require additional information also pertinent to biological status evaluations.

Table 13. Assessment of current monitoring data for lower Columbia River spring Chinook populations and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	State	Ad.	Juv.	quality[2]	designation[3]	Ad.	Juv.	Ad.	Juv.
Cascade									
Cowlitz	W	1	1	A	Primary	--	--	--	--
Cispus	W	1	1	A	Primary	--	--	--	--
Tilton	W	--	--	--	Stabilizing	--	--	--	--
Toutle	W	--	--	--	Contributing	X	--	X	--
Kalama	W	1	2	A	Primary	--	--	--	--
Lewis NF	W	2	2	B	Primary	--	--	1[5]	1[5]
Sandy	O	1	--	B	Primary	--	--	--	--
Gorge									
Upper	W	2	--	C	Contributing	--	--	1[5]	1[5]
Hood	O	1	1	A	Primary	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Index.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of potential reintroduction efforts will be needed. Current sampling is not adequate for evaluation.*

3.6.2 Fall Chinook

Most lower Columbia tule fall Chinook populations are intensively monitored for adults for use in ocean and in-river fishery management. Fall Chinook status and trends are effectively monitored using adult spawner surveys because spawning distribution is limited, redds and fish are conspicuous, and carcasses are easily sampled. Juvenile data on fall Chinook is limited to the Mill/Abernathy/Germany Intensively Monitored Watershed (IMW) program, which has only recently been implemented. Juvenile fall Chinook are difficult to monitor due to their small size, protracted timing of outmigration, and occurrence in the lower portions of large systems. Fall Chinook monitoring meets high coverage guidelines for adults but additional monitoring of juveniles would be needed for the Cascade and Gorge strata in order to clarify differences in in-basin and out-of-basin productivities. Maintenance of existing sampling levels for adults is also

of high priority. More intensive sampling of selected parameters for several representative populations would also clarify the accuracy and precision of current survey methods to meet population-level sampling benchmarks. These include time and area expansion assumptions and relative contributions of hatchery spawners to recruitment. In order to more effectively evaluate effects of hatchery interactions at a high level of certainty, more intensive periodic sampling of primary populations of adults should include watersheds that have both natural and hatchery fall Chinook populations (e.g. Kalama, and Washougal), areas where fall Chinook hatchery production occurred for many years but was recently eliminated (Grays), and watersheds with only natural fall Chinook populations (East Fork Lewis and Coweeman).

Table 14. Assessment of current monitoring data for lower Columbia River fall (tule) Chinook and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Coast									
Grays/Chinook	W	2	--	C	Primary	**1**	--	**1**	**1**
Eloch/Skam	W	2	--	C	Primary	**1**	--	**1**	--
Mill/Aber/Germ	W	1	1	A	Contributing	--	--	--	--
Youngs Bay	O	1	--	B	Stabilizing?	--	--	--	--
Big Creek	O	1	--	B	Stabilizing?	--	--	--	--
Clatskanie	O	1	--	B	Primary?	--	--	--	--
Scappoose	O	1	--	B	Stabilizing?	--	--	--	--
Cascade									
Lower Cowlitz	W	2	--	C	Contributing	--	--	--	--
Upper Cowlitz	W	--	--	--	Stabilizing	--	--	--	--
Toutle	W	2	--	C	Stabilizing	--	--	--	--
Coweeman	W	2	3	C	Primary	**1**	**1**	**1**	**1**
Kalama	W	2	--	C	Primary	**1**	--	**1**	--
Lewis (EF)	W	2	--	C	Primary	**1**	--	**1**	**1**
Salmon	W	--	--	--	Stabilizing	--	--	--	--
Washougal	W	2	--	C	Primary	**1**	--	**1**	--
Clackamas	O	3	--	D	Contributing?	**2**	--	**2**	--
Sandy	O	1	--	B	Stabilizing?	--	--	--	--
Gorge									
L. Gorge	W/O	2	--	C	Contributing	--	--	--	--[5]
U. Gorge	W	2	--	C	Stabilizing	--	--	--	--[5]
White Salmon	W	2	--	C	Contributing	**1**[6]	**1**[6]	**1**[6]	**1**[6]
Hood	O	3	--	D	Stabilizing	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, 3 = Index.*

[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity)*

[3] *Priority designation in WA recovery plan.*

[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*

[5] *Intensive monitoring of gorge tule fall Chinook is problematic. The lower gorge population spawns primarily in the mainstem Columbia River. Wind River tule Chinook fish largely spawn downstream from any suitable sampling site. Production also includes non-listed bright fall Chinook, hence will require DNA analysis to distinguish.*

[6] *The USFWS is planning to initiate monitoring on the White Salmon River. Estimation of White Salmon tule fall Chinook production will require DNA analysis to distinguish the contribution of non-listed bright fall Chinook stocks.*

3.6.3 Late Fall Chinook

Bright fall Chinook are intensively monitored in the NF Lewis with an existing WDFW/PacifiCorp program. Monitoring of NF Lewis fish also includes a long term CWT program that provides detailed productivity and fishery information. The Sandy population is intensively monitored for adults. This represents 100% coverage of populations for adults and 50% for juveniles. LR bright fall Chinook populations are currently at high or very high levels of viability. The priority for bright fall Chinook monitoring is to maintain current levels of effort. Intensive sampling of Sandy juveniles would be required to reach high certainty monitoring benchmarks for this MPG.

Table 15. Assessment of current monitoring data for lower Columbia River late fall (bright) Chinook and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Cascade									
Lewis NF	W	1	1	A	Primary	--	--	--	--
Sandy	O	1	--	B	Primary	--	--	--	**1**

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Index.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*

3.6.4 Summer steelhead

Summer steelhead are currently being monitored with moderate levels of coverage in both strata where they occur. Intensive monitoring of adults and juveniles occurs in the Kalama and Hood rivers. Additional intensive monitoring of juveniles in both strata would be required to meet high status certainty benchmarks. The Wind River indexing program is a critical monitoring component for the gorge strata and more intensive sampling of selected parameters for this population would increase accuracy and precision of current survey methods (time and area expansions and relative contributions of hatchery spawners to recruitment).

Table 16. Assessment of current monitoring data for lower Columbia River summer steelhead and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Cascade									
Kalama	W	1	1	A	Primary	--	--	--	--
N.F. Lewis	W	1	--	B	Stabilizing	--	--	--	--
E.F. Lewis	W	1	--	B	Primary	--	--	--	**1**
Washougal	W	1	--	B	Primary	--	--	--	--
Gorge									
Wind	W	2	2	B	Primary	--	--	**1**	**1**
Hood	O	1	1	A	Primary	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Index.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*

3.6.5 Winter steelhead

Almost all winter steelhead populations are monitored at some level with intensive sampling efforts represented in Coast and Cascade strata. Sampling efforts in the Cascade strata meet high coverage benchmarks. Note that coast strata winter steelhead are not listed under the ESA, but are addressed in the WA Recovery Plan. Monitoring efforts for Oregon lower Columbia steelhead populations have been bolstered by Oregon's implementation of a statistical sampling program. Intensive juvenile and adult programs are associated with reintroduction efforts in the upper Cowlitz and from a long-term research effort on the Kalama, although these populations may not be entirely representative of other areas. Excellent adult data is also available from dam counts in the Clackamas and Sandy systems. Dam count data in the Clackamas is also supported with intensive surveys in lower basin streams. One of three gorge populations is monitored (Hood), but this monitoring involves an intensive sampling program. Other gorge winter steelhead populations are small and difficult to sample. The priority for winter steelhead is to maintain existing sampling efforts. More intensive sampling of several Cascade populations is needed to ensure representative sampling of this large MPG and to support potential reintroduction efforts. Additional monitoring of gorge winter steelhead populations would also be required to meet moderate or high levels of coverage.

Table 17. Assessment of current monitoring data for lower Columbia River winter steelhead and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Coast									
Grays/Chinook	W	1	--	B	Not listed	--	--	--	--
Eloch/Skam	W	1	--	B	Not listed	--	--	--	--
Mill/Ab/Germ	W	1	1	A	Not listed	--	--	--	--
Youngs Bay	O	2	--	C	Not listed	--	--	--	--
Big Creek	O	2	--	C	Not listed	--	--	--	--
Clatskanie	O	2	--	C	Not listed	--	--	--	--
Scappoose	O	2	--	C	Not listed	--	--	--	--
Cascade									
Lower Cowlitz	W	2	--	C	Contributing	--	--	--	--
Coweeman	W	1	--	B	Primary	--	--	--	**1[5]**
NF Toutle	W	2	2	B	Primary	--	--	--	--
SF Toutle	W	1	--	B	Primary	--	--	--	--
Upper Cowlitz	W	1	1	A	Contributing	--	--	--	--
Cispus	W	1	1	A	Contributing	--	--	--	--
Tilton	W	2	--	C	Contributing	--	--	--	--
Kalama	W	1	1	A	Primary	--	--	--	--
N.F. Lewis	W	2	2	B	Contributing	--	--	**1[6]**	**1[6]**
E.F. Lewis	W	1	--	B	Primary	--	--	--	--
Salmon	W	--	--	--	Stabilizing	--	--	--	--
Washougal	W	1	--	B	Contributing	--	--	--	--
Clackamas	O	1	2	A	Primary?	--	--	--	--
Sandy	O	2	2	B	Primary?	--	--	--	--
Gorge									
L. Gorge	W/ O	--	--	--	Primary	**2**	--	**1**	**1**
U. Gorge	W/O	--	--	--	Stabilizing	--	--	--	--
Hood	O	1	1	A	Primary?	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Index.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*

[4] *Additional monitoring needed to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring needed for other species will also provide steelhead data.*
[6] *Intensive monitoring of potential reintroduction efforts will be needed. Current sampling is not adequate for evaluation.*

3.6.6 Chum

Annual chum salmon adult monitoring programs are largely restricted to the two significant remaining populations in the Grays River and the lower gorge. Adult and juvenile chum are sampled by the intensive monitoring program of Mill, Abernathy, and Germany salmon populations. Washington recently completed a project indexing numbers of chum in remnant populations throughout the lower Columbia region. Oregon collects indicator-level information on chum occurrence in systematic fall salmon surveys. Significant juvenile monitoring of chum is limited to the intensive monitoring program at Mill, Abernathy, and Germany, and index monitoring of migrants in the lower gorge population (Duncan, Hardy, Hamilton, and mainstem Ives Island areas) by WDFW and USFWS. The small size of age 0 juvenile chum migrants makes them very difficult to sample effectively.

Additional sampling efforts will be required to adequately monitor chum salmon populations for ESA recovery purposes. Chum are perhaps the least monitored ESU in the lower Columbia Region. Chum sampling priorities include continuation of current sampling, implementation of systematic annual intensive and inventory sampling efforts for adults and juveniles in multiple populations. This proposed program generally focuses on adult sampling because of sampling difficulties for juvenile chum. Much of this sampling will likely be associated with effectiveness monitoring of intensive chum restoration efforts.

Table 18. Assessment of current monitoring data for lower Columbia River chum and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Coast									
Grays/Chinook	W	1	3	B	Primary	--	--	--	**1**
Eloch/Skam	W	3	--	D	Primary	--	--	--	--
Mill/Ab/Germ	W	1	1	A	Primary	--	--	--	--
Youngs	O	3	--	D	Primary?	**2?**	--	**1?**	--
Big Creek	O	3	--	D	Contributing?	**2?**	--	**2?**	--
Clatskanie	O	3	--	D	Contributing?	**2?**	--	**2?**	--
Scappoose	O	3	--	D	Contributing?	**2?**	--	**2?**	--
Cascade									
Cowlitz	W	3	--	D	Contributing	**2**	--	**2**	--
Kalama	W	3	--	D	Contributing	**2**	--	**2**	--
Lewis (EF)	W	3	--	D	Primary	**1**	**1**	**1**	**1**
Salmon	W	3	--	D	Stabilizing	--	--	--	--
Washougal	W	3	--	D	Primary	**1**	--	**1**	**1**
Clackamas	O	--	--	--	Contributing?	**2?**	--	**2?**	--
Sandy	O	--	--	--	Primary?	**1?**	--	**1?**	--
Gorge									
Lower Gorge	W/O	2	2	B	Primary	**1**	--[5]	**1**	--[5]
Upper Gorge	W/O	1	--	B	Contributing	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of chum in the mainstem Columbia would be costly relative to the value.*

3.6.7 Coho

Status assessments of wild coho are hampered by a lack of monitoring data, particularly long-term time series of data. Washington samples are limited to reintroduction efforts in the upper Cowlitz and juvenile migrant sampling of a few populations. Long term dam count data is available for the Clackamas and Sandy rivers. The Clackamas data includes juvenile indices from downstream passage monitoring at North Fork Dam as well as systematic sampling of tributaries downstream from the dam. Oregon has recently implemented a systematic statistical sampling program in Coast strata tributaries. Adult coho are difficult to survey because of their run timing during fall freshets and wide dispersion throughout a subbasin. Current effort levels for coho are not adequate to meet MPG or population-level monitoring benchmarks. Additional intensive and inventory surveys of coho will be required in many areas, particularly in Washington tributaries.

Table 19. Assessment of current monitoring data for lower Columbia River coho and additional needs to achieve moderate and high levels of certainty in MPG status assessment as well as population priority benchmarks.

		Sampling now[1]		Data	Recovery	@ moderate[4]		@ high[4]	
Population	**State**	**Ad.**	**Juv.**	**quality[2]**	**designation[3]**	**Ad.**	**Juv.**	**Ad.**	**Juv.**
Coast									
Grays/Chinook	W	3	--	D	Primary	--	**1**	**1**	**1**
Eloch/Skam	W	3	--	D	Primary	--	**1**	--	**1**
Mill/Ab/Germ	W	1	1	A	Contributing	--	--	--	--
Youngs	O	1	--	B	Stabilizing?	--	--	--	--
Big Creek	O	1	--	B	Stabilizing?	--	--	--	--
Clatskanie	O	1	--	B	Primary?	--	**2?**	--	**1?**
Scappoose	O	1	--	B	Primary?	--	**2?**	--	**2?**
Cascade									
Lower Cowlitz	W	3	--	D	Primary	**2**	**2**	**2**	**2**
Coweeman	W	3	--	D	Primary	**2**	**1**	--	**1**
NF Toutle	W	3	--	D	Primary	**2**	**2**	**2**	**2**
SF Toutle	W	3	--	D	Primary	**2**	**2**	**2**	**2**
Upper Cowlitz	W	1	1	A	Contributing	--	--	--	--
Cispus	W	1	1	A	Contributing	--	--	--	--
Tilton	W	2	2	B	Contributing	--	--	--	--
Kalama	W	3	--	--	Contributing	--	**2**	--	**2**
NF Lewis	W	2	2	B	Contributing	**1**[5]	**1**[5]	**1**[5]	**1**[5]
EF Lewis	W	3	--	D	Primary	**1**	**1**	**1**	**1**
Salmon	W	3	--	D	Stabilizing	--	--	--	--
Washougal	W	3	--	D	Contributing	--	**2**		**2**
Clackamas	O	1	2	A	Primary?	--	--	--	--
Sandy	O	2	2	B	Primary?	--	--	--	--
Gorge									
L Gorge	W/O	3	--	D	Primary	**2**	**2**	**2**	**2**
U Gorge	W/O	3	2	D	Primary	**2**	**2**	**2**	**2**
White Salmon	W	--	--	--	Contributing	**1**[6]	**1**[6]	**1**[6]	**1**[6]
Hood	O	1	1	A	Contributing?	--	--	--	--

[1] *Monitoring intensity: 1 = Intensive, 2 = Inventory, C = Indicator.*
[2] *Data quality: A = very high, B = high, C = medium, D = low. (Based on sampling history & intensity.)*
[3] *Priority designation in WA recovery plan.*
[4] *Additional monitoring need to reach prescribed level of certainty based on benchmarks: 1 = Intensive, 2 = Inventory.*
[5] *Intensive monitoring of potential reintroduction efforts will be needed. Current sampling is not adequate for evaluation.*
[6] *The USFWS is planning to initiate monitoring on the White Salmon River.*

3.7 Implementation Actions

M.M-1. Maintain current biological sampling efforts for representative priority populations of all species and strata.

Lead: WDFW, ODFW

Funding source: WA Salmon Recovery Funding Board, NOAA/Mitchell Act, Tacoma Public Utility District, Northwest Power and Conservation Council/Bonneville Power Administration, OR Watershed Enhancement Board, Portland General Electric

Rationale: Current biological monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments, recovery plans, and ongoing harvest management. Current programs are adequate for some recovery plan applications but fall short in other areas. Thus, effective monitoring and evaluation will require more funding, not less. This RM&E program seeks a balance in commitments between monitoring, protection, and restoration activities. This plan does not prescribe intensive monitoring of every parameter in all populations of every stratum. However, this approach places a premium value on information and data provided by existing programs. The long-term nature of many programs provides particularly valuable information for distinguishing real trends from sampling noise or normal variation. Current monitoring activities have been implemented with a mixture of hard and soft funds. In many cases, long term funding of key programs is not assured. Loss of significant components of current biological monitoring programs would significantly reduce the accuracy and precision of evaluations of progress or lack thereof to recovery goals. Table 12 identifies priorities for maintaining current biological sampling efforts for representative populations in each stratum.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

M.M-2. Implement additional intensive biological monitoring for juveniles and/or adults in all strata to meet representative monitoring needs of multiple species.

Lead: WDFW

Funding source: State of Washington, PacifiCorp (contingent on licensing).

Rationale: Intensive biological monitoring activities of adults and juveniles in one subbasin can provide critical information for multiple species with significant economy. For instance, juvenile migrant trapping during spring can provide abundance, productivity, and diversity information on both coho and steelhead. Fall spawner surveys can index overlapping distributions and timing of chum, fall Chinook, and coho in different portions of a subbasin. Current Intensive Watershed Monitoring efforts in Mill, Abernathy, and Germany subbasins are an example of a comprehensive intensive

monitoring program that meets numerous biological sampling moderate sampling level needs for species in the Coast Strata while also providing valuable information on habitat action effectiveness and uncertain linkages in fish and habitat relationships. Intensive biological monitoring activities in the cascade strata are primarily associated with spring Chinook, coho, and steelhead reintroduction efforts above tributary hydro facilities. This is critical information for both basic biological status assessment and hydro action effectiveness monitoring. However, these intensive reintroduction monitoring efforts do not adequately represent other species and subbasin types in the cascade strata. Intensive monitoring of tule Fall Chinook, chum, and coho is currently inadequate to reach moderate certainty MPG benchmarks in the Cascade strata. Intensive monitoring in all strata is does not meet high certainty MPG benchmarks. East Fork Lewis and Coweeman subbasins are recommended candidates for an intensive biological sampling program of adult and juveniles in the Cascade strata to include Fall Chinook, chum, coho, winter steelhead and summer steelhead. Grays and Elochoman/Skamokawa subbasins are recommended candidates for additional intensive sampling in the Coast strata.

Activities**:**

f. Identify appropriate opportunities and funding sources.

g. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules

h. Identify constraints and uncertainties

i. Identify coordination considerations

M.M-3. Implement a comprehensive natural coho sampling program in Washington in all strata.

Lead: WDFW

Funding source: NPCC/BPA.

Rationale: Adult and juvenile coho monitoring efforts in all watersheds are currently insufficient to adequately assess population status and viability parameters. A comprehensive coho monitoring program consisting of a combination of intensive, Inventory, and Indicator adult and juvenile sampling is among the highest of priorities for recovery monitoring in the lower Columbia River domain. A cost effective program can be implemented in conjunction with additional monitoring of winter steelhead. Table 12 identifies priority coho populations' inclusion in a comprehensive sampling effort.

Activities**:**

j. Identify appropriate funding sources

k. Develop, submit, and support a detailed sampling proposal, work plan.[2], and data reporting schedules

l. Identify constraints and uncertainties

m. Identify coordination considerations

[2] WDFW has proposed this work for funding by the Bonneville Power Administration's Fish and Wildlife Program. The proposal is currently under consideration.

M.M-4. Expand current chum salmon sampling efforts to include more intensive and extensive monitoring of adults and juveniles.

Lead: WDFW

Funding source: NPCC/BPA.

Rationale Chum adult spawning and juvenile surveys are currently funded with "soft funds" and continued funding will need to be solidified. Moreover, the current funding provides the minimum resources needed to count fish and redds and does not include monies to conduct a thorough investigation of the accuracy of the methods used to estimate total adult spawning escapement, adult or juvenile productivity, or diversity, in all watersheds. Priority populations for expanded chum sampling efforts are identified in Table 12.

Activities**:**

n. Identify appropriate funding sources.

o. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.

p. Identify constraints and uncertainties.

q. Identify coordination considerations.

M.M-5. Augment current sampling programs for fall Chinook and winter steelhead with more intensive adult and juvenile sampling levels in selected areas.

Lead: WDFW

Funding source: To be determined.

Rationale: Although, existing monitoring programs for fall Chinook and winter steelhead provide significant data on a majority of populations of all strata, much of this information is based on Intensive or Inventory surveys which do not adequately evaluate critical assumptions of current sampling and evaluation. Supplemental sampling is needed to validate the accuracy of the existing approach.

Activities**:**

r. Complete inventory of specific limitations of existing approach.

s. Identify appropriate funding sources.

t. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.

u. Identify constraints and uncertainties.

v. Identify coordination considerations.

4.0 Habitat Status Monitoring

Habitat monitoring provides critical information for salmon-related decision making at a variety of institutional levels and scales. Adaptive plan implementation, in the face of uncertainties in future trends and recovery efforts, mandates regular check points on habitat conditions relative to recovery benchmarks in order to identify the need for course corrections. Without effective habitat protection and a means to distinguish long-term habitat trends, benefits of investments in recovery activities will not be realized or recognized. Without demonstrable improvements in critical habitat conditions, recovery goals for most species will not be achieved.

Habitat information addresses a multitude of critical questions including long-term cumulative effects of recovery measures and other human activities, inferences of fish potential where biological data is incomplete, identification of key limiting factors and functional relationships, and site-specific effects of specific recovery measures. This chapter focuses primarily on habitat status monitoring of cumulative effects of recovery measures and human activities in order to assess related listing factors identified by NOAA. However, much of this same information will have application to biological status monitoring, effectiveness monitoring of specific habitat measures, and uncertainty or validation research. These linkages are highlighted in this chapter.

Habitat monitoring, more than any other element of this program, is complicated by issues of multiple and overlapping objectives, scales, information needs, and jurisdictional responsibilities. Each of these elements implies a specific set of information needs and sampling regimens. This program identifies a comprehensive set of habitat monitoring activities designed to address this hierarchy of needs. The program identifies sampling components at three habitat scales: 1) watershed, hillslope/upland, and wetland conditions which are referred to in this plan as “landscape,” 2) stream, riparian, and floodplain characteristics which are referred to in this plan as “stream corridor”, and 3) water quality and quantity. Monitoring components are identified for each of the three habitat scales.

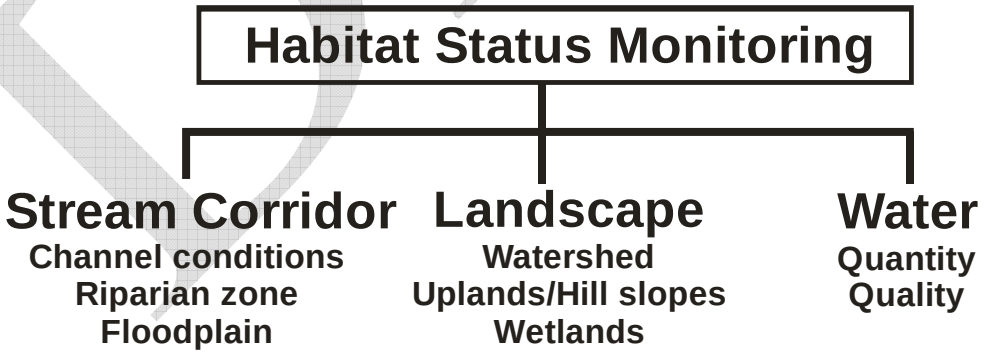

Figure 10. Elements for habitat status monitoring of fish recovery.

4.1 Stream Corridor – Channel, Riparian & Floodplain Conditions

4.1.1 Objectives

Habitat status monitoring at the stream scale is primarily intended to characterize conditions for salmon relative to a baseline at listing and improvements consistent with recovery. Stream habitat conditions serve as an evolving record of aquatic ecosystem health that in turn affects the viability of fish populations. Stream conditions reflect the direct effects of actions at the stream habitat scale as well as watershed-scale actions and conditions that influence stream habitat forming processes. Monitoring of stream conditions will identify long-term trends and cumulative effects of recovery measures and other human activities at the stream and watershed scale (Box 2).

Stream habitat information has a variety of applications critical to effective salmon recovery. A primary application will be to evaluate the status of habitat-related statutory listing factors identified by the NMFS listing status decision framework (NOAA 2007). Stream habitat information is also useful for comparisons of observed and benchmark habitat conditions based on favorable values for salmon to identify critical limiting factors and help focus actions for maximum effect and efficiency. Comparisons of habitat suitability and potential for fish among stream reaches and subbasins guide prioritization of areas for preservation and restoration. Stream habitat information may be used to infer fish status in areas where biological data is incomplete. Stream habitat information is also used to evaluate the effectiveness of site-specific habitat actions. Finally, comparisons of landscape, stream, water, and biological information are the basis for uncertainty and validation research designed to identify key functional relationships and to reduce fundamental uncertainties which might constrain effective recovery plan implementation.

Figure 11. Typical habitat conditions in a west Cascade headwater stream.

Box 2. Questions and hypotheses addressed by stream habitat monitoring.

Question #1. Are habitat conditions stable or changing as a result of fish protection and restoration actions, and other factors?

Null hypothesis: Stream habitat conditions are unchanged since listing.
Alternative: Stream habitat conditions have changed since listing.

Question #2. How are fish limiting factors affected by stream habitat status and trends?

Null hypothesis: Stream habitat limitations for fish are unchanged.
Alternative: Changes in stream habitat have affected critical fish limiting factors such that improvements in fish status are likely.

Question #3. Which streams and stream reaches are most important to fish protection and/or restoration?

Null hypothesis: All streams and stream reaches are of equal importance to fish.
Alternative: Some streams and stream reaches are more important than others.

Question #4. What is the fish production and abundance capacity of the stream habitat and how has it changed?

Null hypothesis: There are no significant differences in habitat productivity and capacity for fish among areas or trends over time.
Alternative: There are significant differences in habitat productivity and capacity for fish among areas and/or trends over time.

Question #5. Have specific stream habitat improvement actions achieved the desired physical and biological effects? (see action effectiveness monitoring section)

Null hypothesis: Actions resulted in no change in physical or biological conditions.
Alternative: Physical or biological conditions changes as a result of the action.

Question #6. How is fish status related to stream conditions and how are stream conditions affected by landscape/watershed factors and stream flow patterns? (see uncertainty and validation research section

Null hypothesis: Stream conditions do not affect fish status and are unaffected landscape/watershed factors or stream flow patterns.
Alternative: Stream conditions affect fish status and are affected landscape/watershed factors or stream flow patterns.

4.1.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For stream habitat monitoring, these include:

1. ***Complete comprehensive assessments of stream habitat status and significance to salmon at 12 year intervals as prescribed by the Recovery Plan.***

A 12 year assessment interval is identified by the recovery plan for the assessment of stream habitat status relative to baseline conditions and benchmarks. The assessment will require a rotating panel of habitat samples to be repeated in a 12-year cycle. The relatively long interval between assessments provides the opportunity to distribute sampling efforts in the region across

multiple years so that a massive effort does not need to be completed within a short time period. The interval also recognizes the gradual or episodic nature of change at the habitat scale and provides enough time for potential changes to accrue before reassessment.

2. ***Utilize a multi-level stream habitat sampling approach to address the multitude of objectives and applications of this information.***

Stream habitat information is needed for a wide variety of purposes including characterizing conditions across the region, detecting trends, identifying problems and restoration opportunities, evaluating action effectiveness, and characterizing linkages with fish. No single stream habitat sampling design, level, or protocol is adequate for all of these purposes.

3. ***Assess stream habitat status of every subbasin in a representative fashion (although every subbasin doesn't need to be monitored at the same sampling level).***

Listing factor criteria identified by NOAA are evaluated at the population scale. Therefore, stream habitat monitoring must occur at the subbasin scale. Stream habitat sampling meets a variety of needs including providing some indication of changes in habitat suitability or potential for salmon populations where biological data is sparse. Habitat assessments can be a much more cost-effective alternative to evaluating the freshwater production potential, particularly for populations existing at very low levels in degraded habitats. Habitat information also provides a systematic means of inferring relative status of less intensively-monitored populations from more intensively-monitored populations.

4. ***Stratify habitat monitoring in order to represent the full range of conditions and to maximize sampling power to detect changes.***

Statistical power of tests for differences over time is increased by a spatial stratification scheme which reduces the error variation among samples by removing between-strata differences. Given the geographic extent of the Lower Columbia and the complexity of habitat conditions, acquiring habitat data for all locations in the region is unrealistic. Given the very large habitat variation across the region among strata, lack of a stratified design would greatly inflate the number of samples needed to characterize conditions throughout the basin and to detect even moderate-sized changes in habitat conditions.

5. ***Replicate samples within each stratum in order to provide a statistical basis for evaluating differences.***

There can be substantial variation in stream habitat conditions among streams and among reaches in a stream within any given strata. Replication (collecting data from more than one reach or site) is needed for statistical analysis of differences and trends. Differences among strata or within strata over time can only be demonstrated by comparison to differences within strata (Green 1979).

6. ***Employ both a probabilistic sampling scheme designed to representatively survey conditions across the landscape and an index site sampling scheme designed for sensitivity to detect significant changes in salmon habitat threats over time.***

The two primary habitat sampling objectives require fundamentally different approaches to sample site selection. Survey sampling to describe the average and range of conditions within a stratum requires random (probabilistic) sampling in order to provide representative coverage. Index sampling for characterizing long term trends is most efficient where sample sites are selected based on sensitivity to likely changes and value to fish. Given the large size and diversity of the monitoring region, the resources are simply not available to collect a sufficient

number of samples in a completely stratified random design to evaluate habitat changes with any reasonable degree of efficiency.

7. Employ a range of sampling intensities consistent with the multiple objectives.

A multi-level habitat monitoring approach is the best avenue for providing adequate coverage of stream habitat information. Inventory sampling provides a big picture context for evaluating habitat patterns across the region. Indicator monitoring will provide representative breadth across the region and also representative index sites for periodic resampling. Intensive monitoring of selected reaches that are significant to fish recovery will provide more sensitive indications of temporal changes. Reconnaissance sampling provides a means of rapidly assessing problems not reflected in habitat subsampling sites as well as restoration or preservation opportunities.

8. Monitor subbasins that are a higher priority for recovery at a greater intensity.

This habitat monitoring program is specifically designed to address salmon recovery needs. A fundamental recovery strategy involves protection and restoration of key populations to high levels of viability. These populations will be the focus of the most intensive stream habitat monitoring efforts. Ideally, monitoring programs would be allocated across a representative range of population types but resource limitations will constrain the feasibility of conducting comprehensive monitoring programs for multiple populations within a species.

9. Design stream habitat monitoring for salmon recovery evaluations to make maximum use of other regional monitoring where consistent.

Scale of habitat monitoring required for salmon recovery applications is very large. Information collected for specific purposes is often useful for a variety of applications and opportunities to utilize this information should not be overlooked. An economical habitat monitoring program takes advantage of all potential sources of information even where they were not specifically intended for the desired application. Stream habitat assessments should make optimum use of all available information rather than relying on completely new and dedicated sampling efforts. The design will also need to be flexible in order to recognize and qualify potential limitations in other sampling. The key is understanding the limitations and applicability of each type of information.

10. Adopt habitat monitoring protocols for dedicated salmon recovery habitat monitoring that are compatible with other regional monitoring efforts.

There is no need to reinvent the wheel if the mouse trap is not broken. Most of the current baseline habitat information has been collected with relative standard protocols in wide use for salmon habitat monitoring. Unless existing protocols fall significantly short of monitoring needs for salmon recovery or a critical mass of standard methodology have not been applied, any new work undertaken should attempt to emulate past protocols as much as possible. It is also likely that regular protocols will have to be supplemented with additional methods or metrics in order to meet all information needs.

4.1.3 Indicators

4.1.3.1 Attributes & Metrics

Stream habitat conditions are characterized through a set of habitat indicators including attributes, metrics, and statistics that reflect the suite of conditions that are relevant to salmonid protection and recovery (Table 20). Channel morphology and complexity, riparian condition and function, and habitat access are included as stream habitat attributes for the purposes of this monitoring program. Metrics include attributes such as channel morphology, substrate, woody debris, riparian cover, and bank stability.

The program recognizes the subjectivity of defining a boundary between stream and watershed attributes due to the complexity of connectivity and functional relationships. These attributes were grouped under the stream habitat category because they lend themselves to common sampling and analysis protocols. Specific metrics and example statistics are also identified for each attribute. Indicators are consistent with those identified in NOAA's listing status decision framework for the habitat category and with other diagnostic methods implemented in the region including the Ecosystem Diagnosis and Treatment model (EDT) (LCFRB 2004).

4.1.3.2 Benchmarks

Assessments of habitat suitability for fish and the effects of habitat changes will rely on quantitative and qualitative interpretations of indicators. Interpretations will be based on changes in indicators over time as well as comparisons with benchmark values. Benchmarks do not represent goals but are goal-related reference points or standards against which to compare performance achievements.

Given the inherent variability and complexity of natural systems, it is impractical to establish broadly-applicable goals for habitat conditions. A more effective approach for stream and watershed characteristics is to develop relative measures of trends over time. Many different combinations of attribute conditions might satisfy recovery goals. Benchmarks provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level. The recovery plan identifies habitat benchmarks based on Properly Functioning Conditions (PFCs) identified by NOAA to reflect freshwater habitat conditions generally favorable for salmonids spawning and rearing (NMFS 1996b). PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes.

Table 20 Attributes, metrics, and example statistics for use as indicators of stream habitat status.

Attribute	Metric	Example statistics	Relevance to Fish
Channel conditions	Channel cross-section form	Width-to-Depth ratio, entrenchment, artificial confinement	Quality of physical habitat
	Channel gradient & channel form	Channel gradient, length & sinuosity	Suitable hydraulics and channel dynamics for habitat formation and maintenance
	Erosion and sedimentation	Percent fines, embeddedness, bed-material composition	Adequate substrate for spawning, egg incubation, and early rearing
	Habitat types	Percent & frequency pools, riffles, glides, off-channel areas, etc...	Spawning and rearing habitat availability
	Large Woody Debris	Abundance, size, and distribution	Availability of cover and complexity
Riparian zone	Vegetative Cover	Percent cover by vegetation type	Food source production, nutrient exchange, LWD recruitment, bank stability
	Shade	Percent shade	Stream temperature moderation
	Invasive Species	Presence/Absence and mapping	Natural riparian function
	LWD recruitment potential	Buffer width, tree size, stand density	Large woody debris recruitment
	Stream bank stability	Stream bank stability indices	Stream bank stability and sedimentation
Floodplain and channel migration processes	Channel migration zone encroachment Floodplain connectivity	Width of channel migration zone Extent of connected floodplains	In-channel habitat formation and maintenance, Off-channel habitat creation, Nutrient exchange, Flood abatement, Flood refuge, Temperature moderation
Accessibility	Anthropogenic & Natural Barriers	Miles/acreage of blocked habitat by type Barrier characteristics - location (GPS), type, width, length, gradient, drop, bedload, % passability etc.)	Fish Passage, Spawning habitat, Juvenile rearing, Outmigrant survival, Adult migration timing

Table 21 Salmonid freshwater benchmarks for stream habitat based on the Matrix of Pathways and Indicators (NMFS 1996b).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Stream channel & habitat units:	Pool Frequency	meets pool frequency standards (below) and large woody debris recruitment standards for properly functioning habitat (above) channel width (ft): pools/mi[1] (5:164, 10:96,15: 70, 20: 56, 25: 47, 50: 26, 75: 23, 100: 18)	meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	does not meet pool frequency standards
	Pool Quality	pools >1 meter deep (holding pools) with good cover and cool water[3], minor reduction of pool volume by fine sediment	few deeper pools (>1 meter) present or inadequate cover/ temperature[3], moderate reduction of pool volume by fine sediment	no deep pools (<1 meter) and inadequate cover/ temperature[3], major reduction of pool volume by fine sediment
	Substrate	dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20%[3]	gravel and cobble is subdominant, or if dominant, embeddedness 20-30%[3]	bedrock, sand, silt or small gravel dominant, or if gravel and cobble dominant, embeddedness >30%[2]
	Sediment	< 12% fines (<0.85mm) in gravel[1]	12-I7% (west-side)[1], 12-20% (east-side)[1]	>17% (west-side)[1], >20% (east side)[1] fines at surface or depth in spawning habitat[2]
	Large Woody Debris	Coast: >80 pieces/mile >24"diameter >50ft. length[1]; and adequate sources of woody debris recruitment in riparian areas	currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	does not meet standards for properly functioning and lacks potential large woody debris recruitment
	Off-channel Habitat	backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.) [3]	some backwaters and high energy side channels[3]	few or no backwaters, no off-channel ponds[3]
	Refugia (important remnant habitat)	habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations[1]	habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations[1]	adequate habitat refugia do not exist[1]
	Width/Depth Ratio	<10[2,4]	10-12 (we are unaware of any criteria to reference)	>12 (we are unaware of any criteria to reference)
	Streambank Condition	>90% stable; i.e. on average, less than 10% of banks are actively eroding[1]	80-90% stable	<80% stable
	Floodplain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian	reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
		vegetation and succession	evidenced by moderate degradation of wetland function, riparian vegetation/ succession	reduced and riparian vegetation/ succession altered significantly
Riparian Zone	Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%[12]	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (≈70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[12]	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition <25%[12]
Habitat Access:	Physical Barriers	any man-made barriers present in watershed allow upstream and downstream fish passage at all flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows

[1] Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.

[2] Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.

[3] Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.

[4] Biological Opinion on Implementation of Interim Strategies for Managing Anadromous Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). National Marine Fisheries Service, Northwest Region, January 23, 1995.

[5] A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.

[6] USDA Forest Service, 1994. Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.

[7] Frissell, C.A., Liss, W.J., and David Bayles, 1993. An Integrated Biophysical Strategy for Ecological Restoration of Large Watersheds. Proceedings from the Symposium on Changing Roles in Water Resources Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.

[8] Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.

[9] e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.

[10] Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional Species and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management.

[11] USDA Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.

[12] Winward, A.H., 1989. Ecological Status of Vegetation as a Base for Multiple Product Management. Abstracts 42nd Annual Meeting, Society for Range Management, Billings MT, Denver, CO: Society for Range Management: p. 277

4.1.3.3 Example Information

Example reporting templates for stream habitat data are depicted below. This data may be represented in terms of site or reach-specific physical conditions or can be represented relative to benchmark fish values. Spatial stream habitat data is well suited to presentation in a map format and this application is facilitated by use of Geographical Information Systems. Examples are included to illustrate how stream habitat data can be organized and used. The data included in examples also represents baseline conditions for comparison with results of future monitoring. Many alternative depictions might ultimately be developed.

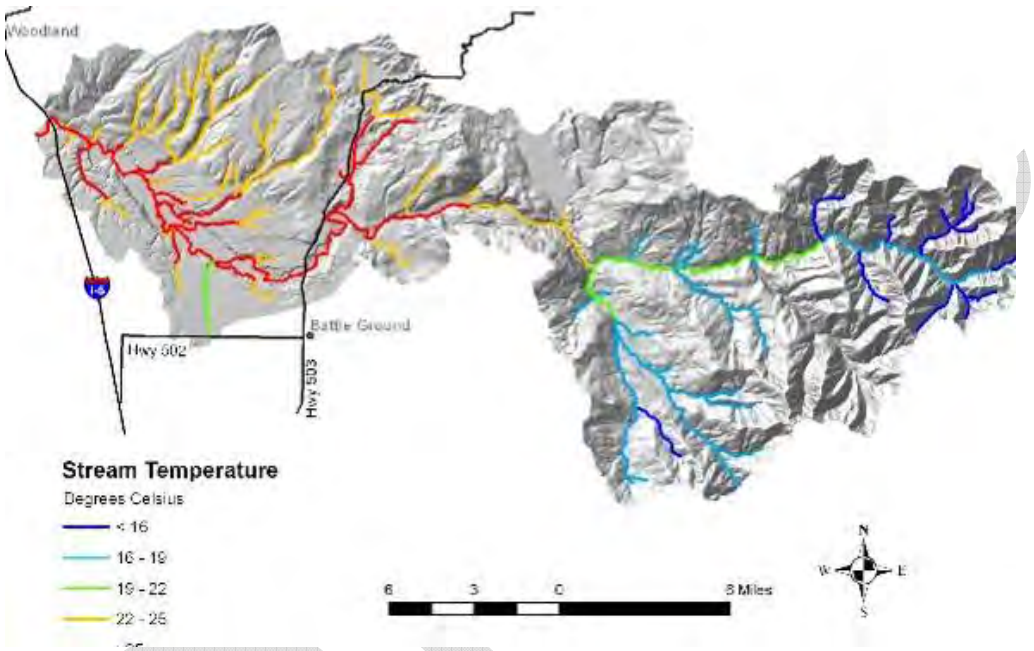

Figure 12. Map example depicting stream habitat data.

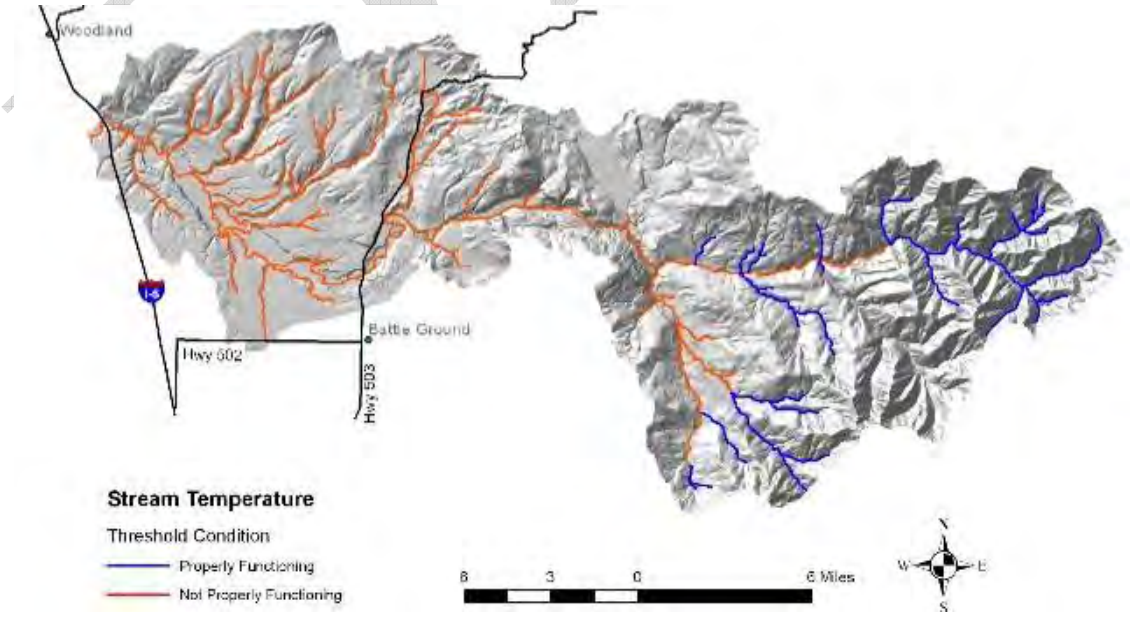

Figure 13. Map example illustrating stream habitat data relative to the Properly Functioning Condition benchmark.

4.1.4 Sampling and Analytical Design

4.1.4.1 Framework

This program identifies a stratified, representative, multi-level sampling framework for monitoring stream habitat to meet multiple needs including characterization of habitat status, habitat trends, habitat action effectiveness, and fish status inferences. Elements of the design framework are identified in Figure 14.

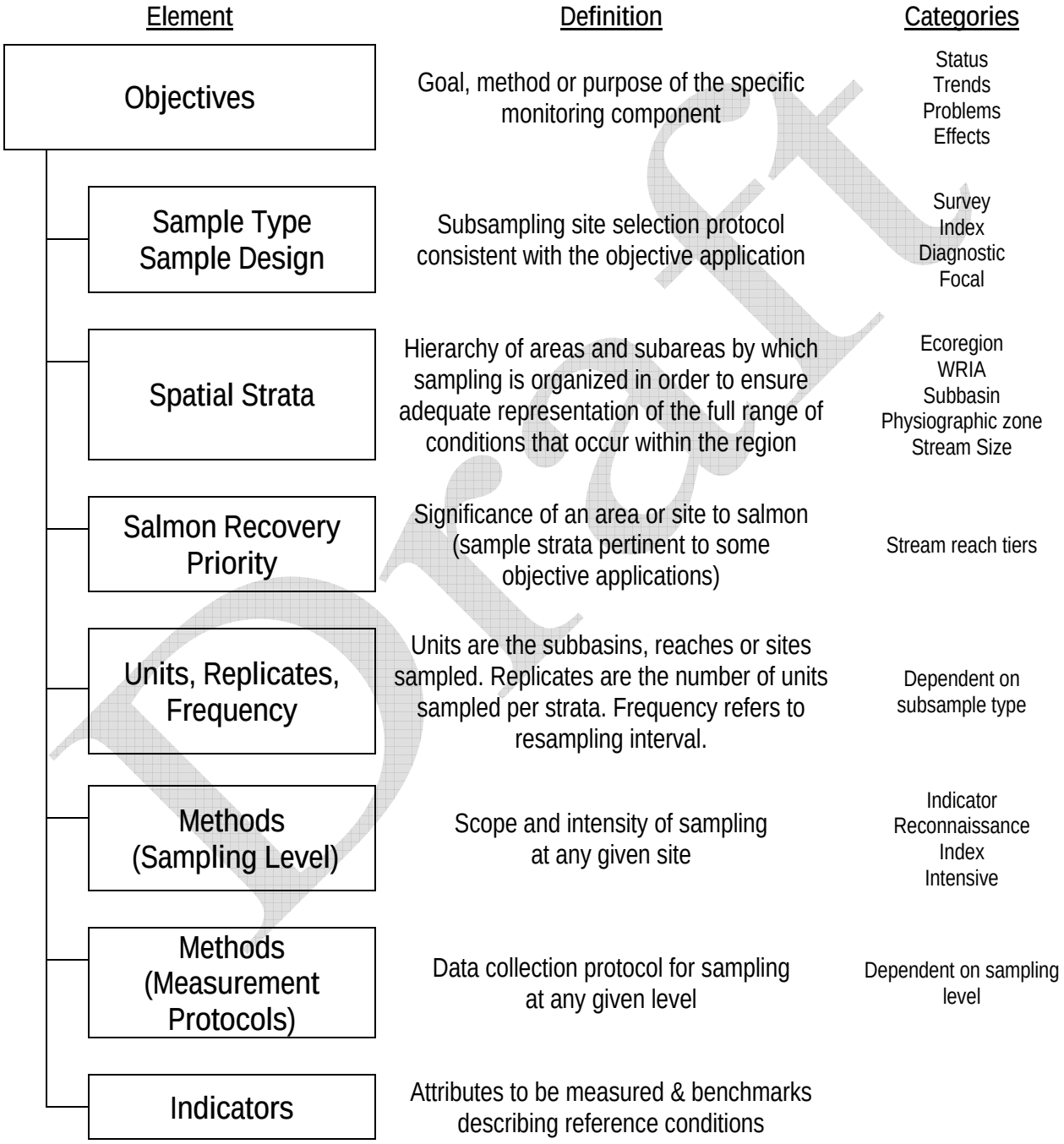

Figure 14. Elements of a systematic stream habitat sampling framework.

Objectives

Stream habitat monitoring addresses a variety of objective applications for salmon recovery evaluations and different applications will require slightly different but overlapping sampling strategies and protocols. Any given habitat sample can be used in one or more of several applications. This program labels and bundles suites of related sampling activities based on objective applications. Labels are based on objectives but also imply different subsample site selection, stratification, sampling intensity, and sampling protocols.

Status is a characterization of conditions across the region within and among sampling strata at any given point in time.

Trends are changes in status over time.

Problems are specific habitat features or sites potentially targeted for action (e.g. hydromodifications, habitat impairments, or fish barriers.)

Effects refers to specific habitat information needs for action effectiveness evaluation or research into linkages between habitat and fish.

Sample Type

Sample type is categorized by site selection protocols dictated by the corresponding objective application. Different applications require fundamentally different site selection protocols.

Conditions across the landscape are evaluated using ***Survey Samples***. Survey samples are collected in a randomly-distributed (probabilistic) manner within a sampling stratum in order to represent average conditions and variation in conditions within that stratum. The principle characteristics of a probabilistic design are 1) the population being sampled is clearly described; 2) every element in the population has the opportunity to be sampled with a known probability; and 3) sample selection is carried out by a random process. Following these guidelines allows statistical confidence levels to be placed on the estimates. Washington's Watershed Health and Salmon Recovery Quality Assurance Monitoring Plan (WDOE) and EPA's EMAP program are examples of a probabilistic sampling approach in a stratified random sampling design intended to describe spatial patterns in conditions.

Trends over time are evaluated using ***Index Samples***. Index samples involve periodic resampling of specific sites. Index samples may be randomly selected from a stratum in order to describe conditions representative of that strata or they can be specifically selected to represent a specific set of conditions. Sampling power to detect modest incremental habitat changes is maximized when among-site variability is controlled by concentrated periodic sampling of the same index sites. Small incremental changes in stream conditions that result from long term trends in habitat-forming processes can be difficult to distinguish from randomly selected sites. Thus, index sampling will be most effective where it is focused on sites that are most sensitive to change. Examples might include reaches in areas where development is expected to occur or critical areas that are in limited supply. These non-randomly selected sites are not expected to be indicative of average conditions throughout a subbasin or larger area. Therefore, index sampling must be complemented with survey samples in order to characterize the relationship between sensitive index and representative survey sites. Index sites are also selected to facilitate access which improves sampling efficiency and to include areas of particular significance to fish in order to maximize applicability to biological analyses.

Diagnostic samples are typically used to evaluate the distribution and significance of specific conditions or problems. Examples of diagnostic sampling might include a roving survey of selected stream reaches to identify hydromodifications, habitat impairments, fish accessibility or potential restoration project opportunities. Diagnostic samples are typically focused on a few key metrics intended to guide implementation or evaluate effectiveness of specific actions or regulations. Diagnostic sampling programs may also involve specific agencies or jurisdictions and limited areas.

Focus samples are collected for other specific purposes such as project site planning, action effectiveness monitoring, and uncertainty and validation research. Efforts are often limited in scale and can involve tests of specific hypotheses or project-level planning and monitoring. They include attempts to define cause-effect linkages between land use and habitat. Monitoring intensity can be frequent. The cause-effect processes discovered in these studies can also be used to relate watershed condition trends to stream habitat trends. Focal sampling methods depend on the specific objectives. Paired treatment-control or before-and-after evaluations are examples of focused sampling. These activities can involve intensive habitat sampling which can also have survey or index applications.

Spatial Strata

Stream habitat monitoring is organized by a nested series of regions and watersheds including ecoregions, WRIAs, subbasins, and physiographic zones.

Ecoregions are areas of similar geographical, climate, and habitat conditions used by NOAA to identify major population groups of salmon which together comprise an ESU. Three ecoregions (Coast, Cascade, and Gorge) have been identified in the lower Columbia Region (Figure 15).

Watershed Resource Inventory Areas (WRIAs) are major watershed basins identified by Washington for administrative and planning purposes. The lower Columbia Region includes 5 WRIAs including the Grays-Elochoman, Cowlitz, Lewis, Salmon-Washougal, and Wind-White Salmon basins.

Subbasins are smaller watershed areas within each WRIA, generally corresponding to salmon populations identified by the TRT.

Physiographic zones reflect topographic, watershed condition, land use patterns of significance to fish habitat (Figure 15). Boundaries of the physiographic zones do not align with watershed boundaries but do distinguish different areas within each watershed subject to different activities and watershed processes which translate into fish habitat effects. Four physiographic strata are defined (Table 22). Physiographic zones are also related to land use and management patterns and authorities. These include Federal and Industrial/Commercial Forest Lands USFS and DNR regulation), mixed rural, transitional and agricultural lands (County and State regulation), and urban lands (City, County, and State regulation).

Stream size varies throughout the region from small headwater tributaries to large river mainstems. This monitoring program includes representative sampling and analysis across the available range of stream sizes. Stream size is often categorized by stream order which is a systematic number scheme ranging from headwater streams (1st order) though large mainstems (4th order or above).

Figure 15 Spatial and physiographic strata within the Lower Columbia Basin.

Table 22. Definitions of physiographic zones used to in stream habitat sampling strata.

Zone	Definition
Developed	Large urban and residential zones in lower elevation valley floor areas along the Columbia River and I-5 corridor from Vancouver to Longview. Developed areas were distinguished based on population densities of greater than 100 persons per square mile using 2004 census data. (Small developed areas were eliminated from the Coast and Gorge ecoregions and were incorporated into other classifications.) Fish habitat in these areas, typically including river mainstems and small low gradient streams has been severely impacted by development.
Valley and foothill	Undeveloped low elevation areas, typically in rural, agricultural, managed forest, or mixed use. This zone was derived from the lowland classification in the Washington Department of Natural Resources rain-on-snow GIS layer, with the exception of small developed areas as described above. These areas are expected to absorb much of the future population growth expected in the region. These areas include most of the historically-productive habitat for fall Chinook and chum salmon.
Rain Dominated	Low to mid elevation areas, typically in mixed or managed forest use. The zone was identified from the WDNR Rain Dominated area classification, with the exception of small developed areas as described above. These areas historically produced significant numbers of coho, spring Chinook, and winter steelhead.
Highland	Higher elevation areas, typically forest lands. This zone was derived from WDNR rain-on-snow area classifications (highlands, snow dominated, and peak rain-on-snow). Small areas of highlands in the Coast Strata were lumped into the Rain Zone. Highlands areas, where still accessible to fish, are among the most productive or potentially-productive salmon habitats in the region, particularly for summer steelhead and coho.

Table 23. Sample stratification scheme for representative surveys of stream habitat conditions at an inventory sampling level across the Washington lower Columbia River salmon recovery area.

Ecoregion (n=3)	WRIA (n=5)	Subbasin (n=18)	Physiographic zone (n=4) [3]	Stream order (n=4) [3]
Coast	25 Grays – Elochoman	Grays/ Chinook[1]	Developed Valley & Foothills Rain dominated Highlands	1, 2, 3, 4 or higher
		Elochoman/Skamokawa	"	"
		Mill/Abernathy/Germany	"	"
Cascades	26 Cowlitz	Lower Cowlitz	"	"
		Upper Cowlitz	"	"
		Tilton	"	"
		Cispus	"	"
		Toutle NF	"	"
		Toutle SF	"	"
		Coweeman	"	"
	27 Lewis	Kalama	"	"
		Lewis NF	"	"
		Lewis EF	"	"
	28 Salmon – Washougal	Salmon	"	"
		Washougal	"	"
Gorge	29 Wind – White Salmon	Bonneville tributaries[2]	"	"
		Gorge tributaries	"	"
		Wind River	"	"

[1]Chinook River is part of WRIA 24 (Willapa) but is included for salmon habitat monitoring purposes with the Grays River
[2]Part of WRIA 28 (Salmon-Washougal) but included for salmon habitat monitoring purposes in the gorge strata.
[3] Not every physiographic zone or stream order may be represented in every strata.

Salmon Recovery Priority

Salmon recovery priorities at the subbasin and stream reach level are a sample stratum pertinent to some habitat monitoring applications. The salmon recovery plan categorized stream reach in each subbasin into one of four reach tiers based on the number of fish populations that utilize habitat in that reach, the importance of each fish population relative to regional recovery objectives, and the significance of the reach to the specific fish populations. Reach tiers thus represent the areas where recovery measures would yield the greatest benefits towards accomplishing the biological objectives.

Tier 1 includes reaches with significant production or restoration potential for one or more primary populations. Primary populations are those targeted for restoration to high or very high levels of viability.

Tier 2 has reaches not included in Tier 1 that are of medium priority for one or more primary species and/or high priority reaches for one or more contributing populations. Contributing populations are those for which significant restoration will be needed to achieve a strata wide average of medium viability.

Tier 3 includes other reaches which are medium priority for contributing populations and/or high priority reaches for stabilizing populations.

Tier 4 includes medium priority reaches for stabilizing populations and/or low priority reaches for all populations.

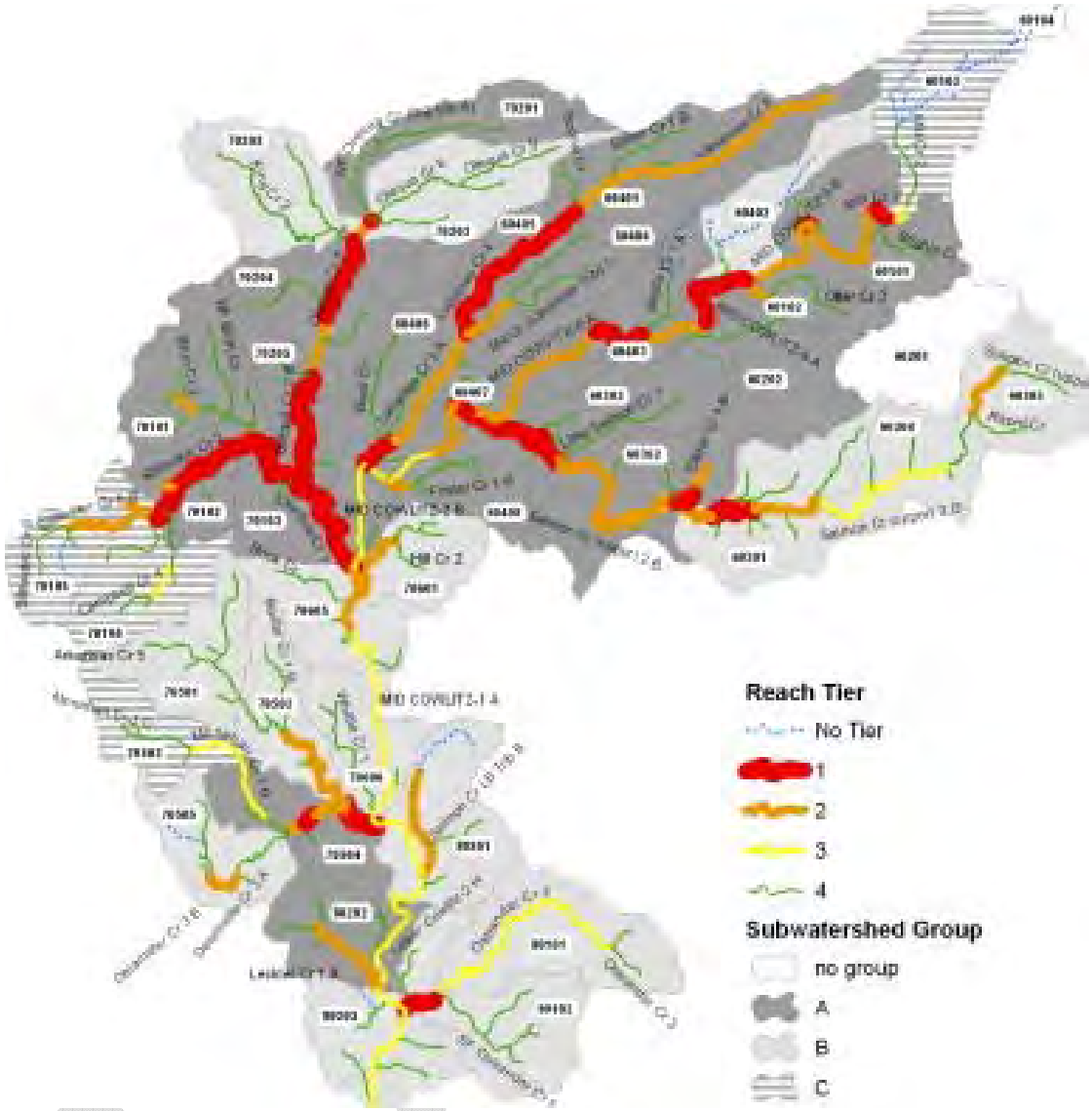

Figure 16. Examples of reach tiers representing the areas where recovery actions would yield the greatest benefits with respect to species recovery objectives. Example also includes subwatershed groups are based on Reach Tiers.

Units, Replicates and Frequency

Samples might be collected at multi-year, annual, seasonal, or even daily intervals depending on the scale of examination, the intended application, and the variability in the conditions being characterized. Longer sampling intervals are appropriate for large-scale landscape level features where changes are gradual or periodic and changes tend to be persistent. Thus, indicator level sampling based on remote sensing information is effectively applied at multi-year or even decadal intervals. In contrast, local site-specific conditions are more likely to display discernable changes at shorter time intervals which may warrant more frequent sampling. Sampling frequencies must consider the inherently dynamic nature of streams and sample at a sufficient frequency to distinguish short term local variability from longer term changes and trends. Most stream habitat surveys are typically designed to determine the pulse or condition of the stream during low flow conditions.

4.1.4.2 Sampling Level Protocols and Methods

This program describes four sampling levels of varying scope and intensity (Table 24). Any given sampling level might be applied to any given objective or involve a variety of stratification, site selection, or sampling protocol. However, each of these monitoring program elements is closely related and different sampling levels are generally suited to different applications. Sampling level is generally related to certainty of results with more intensive sampling expected to provide more precise and accurate information. However, tradeoffs exist between certainty and cost of sampling.

Standardized operating procedures (SOPs) or methods are identified in protocol manuals for the collection of stream habitat data are essential for quality assurance/quality control (QA/QC), for consistent implementation by disparate entities, and for the integration of independently sampled data. Sampling and reporting methods provide a transparent and defensible source of information that can be accessed by interested parties. Several recent publications address the importance of protocols. The *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest Directory and Synthesis of Protocols for Management/Research and Volunteers* (Johnson et al, 2001) provides detailed recommendations of specific sample protocols for habitat metrics. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is also currently finishing an initial side by side test of different protocols (www.pnamp.org). A result of the PNAMP work is that the Washington Governor's Forum on Monitoring endorsed four sampling methods in their 2007 Salmon and Watershed Monitoring Guidance; these included: the USFS AREMP and PIBO programs, the USEPA EMAP protocols, and the 2007 Upper Columbia Monitoring Strategy by Tracy Hillman.

Protocols with measurement methods and sampling levels are typically closely related. A variety of sampling protocols have been associated with habitat status sampling efforts throughout the region. This summary describes typical protocols for each sampling level. These descriptions also are the basis for additional sampling needs identified in this program.

Table 24. Features of different stream habitat sampling levels.

Feature	Sampling Level			
	Indicator	Reconnaissance	Inventory	Intensive
Metrics	Limited	Limited	Moderate to Many	Typically Many
Activity	Remote / office	On-the-ground	On-the-ground	On-the-ground
Focus	Stream, reach or site	Stream or reach	Reach & habitat unit	Site-specific
Data type	Quantitative or Qualitative	Typically Qualitative	Quantitative or Qualitative	Typically Quantitative
Repeatability	Moderate	Low	Moderate	High
Cost per area sampled	Very Low	Low	Moderate	High
Example protocols	USFS Level I Remote sensing	USFS Visual Assessment EPA Rapid Assessment	USFS Level II LCFRB Watershed Assessments Oregon Stream Inventories	USFS Level III EPA EMAP
Example application	Survey, Index, Focal	Diagnostic, Survey	Survey, Index	Survey, Index, Focal

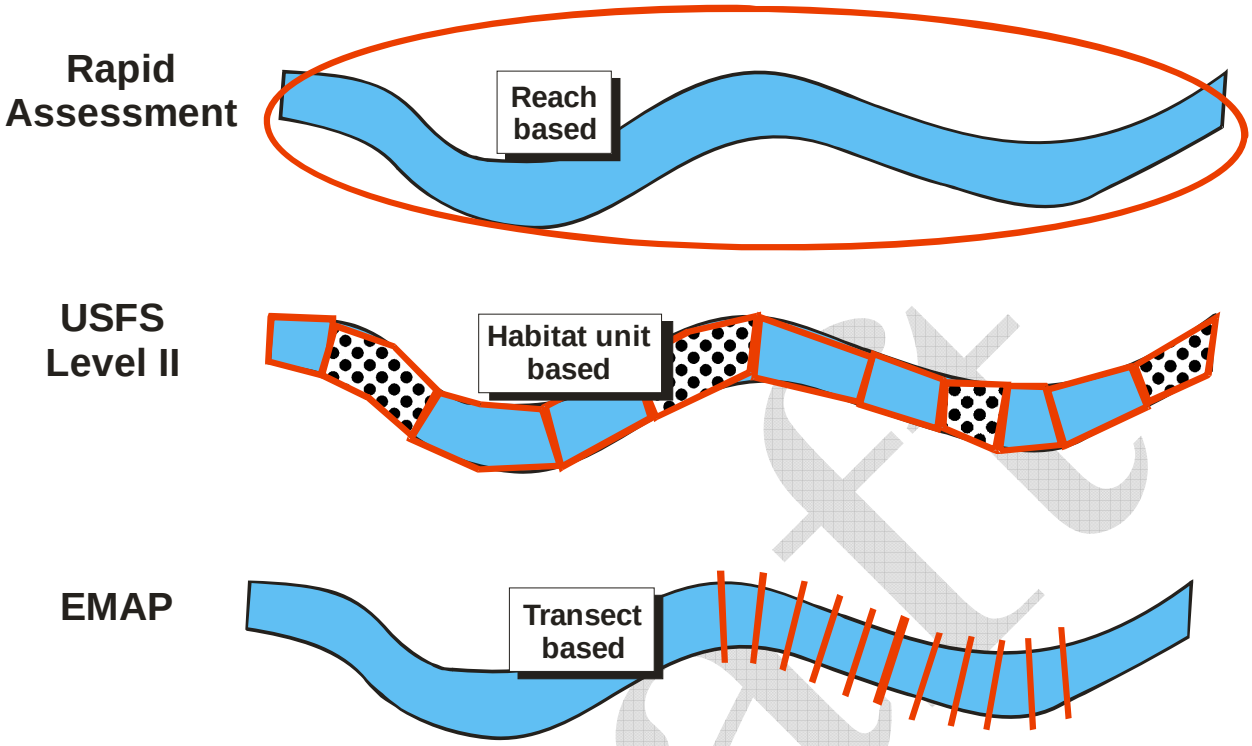

Figure 17. Examples of stream habitat measurement protocols.

Indicator-Level Sampling

Indicator level sampling identifies standard attributes of a stream based on a synthesis or analysis of available remote sensing and GIS information. Indicator level sampling generally involves summary and interpretation of existing information while sitting in an office at a computer. Indicator sampling does not require on-the-ground sampling but can provide broad coverage of selected indicators at a modest cost. Indicator level sampling is readily applicable across the region or can be concentrated on a particular focal area. Remote sampling is best suited to provide broad-scale geographic coverage and reflect large-scale patterns in space and over time. Satellite imagery provides low cost answers to large scale habitat questions and also avoids intrusion onto private property (Crawford 2007).

Remote sensing data is obtained from satellite imagery or aerial photos. Regional GIS coverages include things like stream hydrography, watershed areas, elevation, land use, vegetation, roads, etc. Stream scale metrics that can be derived from remote sampling include elevation, gradient, reach length, stream width, channel confinement, tree canopy, hydromodifications, and passage barriers. Metrics can include riparian vegetation type and cover, roads, stream crossings, river channel morphology, and large woody debris. Measurement protocols depend on the metrics of interest and the information available.

The U.S. Forest Service Level I inventory falls in this category. Ecosystem Diagnosis and Treatment (EDT) parameterization can also be considered to be an indicator level sampling/analysis exercise based on a synthesis of map and GIS data, inferences from existing

surveys, expert observations and inferences. Indicator sampling is generally a complement to more intensive sampling types.

Reconnaissance-Level Sampling

Reconnaissance level sampling involves field sampling based on rapid assessment or visual assessment protocols. The prototypical activity would be walking or floating sections of stream and categorizing what you see. This level of sampling effort is most effective for providing general descriptions of stream habitat conditions across broad areas based on qualitative descriptions or criteria. Qualitative assessments and conditions can be somewhat subjective, depending on the training and experience of the surveyors. Thus reconnaissance level sampling is most effective for providing descriptions of general habitat features. It is also particularly effective for identifying problem sites such as potential fish migration barriers, restoration opportunities, and the upstream extent of suitable fish habitat. Diagnostic sampling is often based on reconnaissance-level activities.

Recent surveys by WDFW to validate EDT inputs for selected stream habitat parameters and watershed assessments by the LCFRB to identify restoration project opportunities in key salmon production reaches (R2 Resource Consultants 2004; SPCA 2005) are examples of reconnaissance level surveys.

Reconnaissance sampling as described in this plan is based on rapid or visual assessment protocols. A variety of protocols can be adopted depending on the focus of the reconnaissance. The method involves fairly rapid coverage of large areas for data validation, future data interpretation, ecological value assessment, development of associations, and verification of stressor data. Visual observations are documented, typically at the reach level, based on qualitative categories for key sample metrics. Example protocols include EPA's Rapid Bioassessment Protocol (Plafkin et al. 1989; Barbour et al. 1999) and NRCS's Stream Visual Assessment Protocol (NRCS 1998). Reconnaissance sampling can also include broad surveys targeting specific conditions. For instance, on-the-ground visual surveys may be used to rapidly assess the prevalence of site-specific habitat problems or restoration opportunities such as migration barriers, sediment sources, or hydromodifications across large stream sections in significant fish production areas.

Inventory-Level Sampling

Inventory level sampling involves on the ground (or on the water) sampling of stream and riparian characteristics at the stream reach and the habitat unit scale. It can also involve detailed analysis of remote sensing information (e.g. aerial photos) for some metrics. This level involves a systematic sampling regime and measurements or estimates of habitat metrics at multiple subsample sites within a reach at the habitat unit scale. Inventory sampling can occur at a range sampling scopes and depths depending on the objectives and resources available. It can include a standard set of core metrics and a variety of optional attributes. Where it involves a rigorous subsampling scheme and a full suite of metrics, inventory sampling can be costly and time consuming. U.S. Forest Service Level II inventories (USFS 2007), Oregon Department of Fish and Wildlife aquatic inventories (ODFW 2006), and LCFRB Watershed Assessments (R2 Resource Consultants 2004; SPCA 2005) are examples of inventory level sampling.

Inventory sampling as described in this plan is based on ground surveys of stream habitat conditions at the reach scale based on classification and characterization of habitat units (pool,

rifle, etc.) and riparian conditions. U.S. Forest Service Level II inventories (USFS 2007), Oregon Department of Fish and Wildlife aquatic inventories (ODFW 2006), and LCFRB Watershed Assessments (R2 Resource Consultants 2004; SCPA 2005) are examples of inventory level sampling protocols. Common protocols identify every habitat unit and collect a mixture of quantitative and qualitative stream and riparian zone metrics at every n^{th} unit within a prescribed reach. Reaches are identified based on the extent of common habitat characteristics.

Intensive-Level Sampling

Intensive sampling as described in this plan is based on ground surveys of stream habitat conditions at the site scale based on detailed quantitative measurements at specified points or transects. EMAP sampling protocols are an example of an intensive sampling method (Kaufmann et al. 1999). This protocol defines reaches as a distance 40 times the low flow wetted width and collects measurements at systematically spaced transects. Note that we distinguish EMAP site selection protocols from EMAP data collection protocols at a specified site. Washington's Intensively Monitored Watersheds project is an example of an EMAP sampling protocol.

Intensive level sampling is a detailed and concentrated field survey focused on a specific area or application. It is distinguished from inventory sampling by more rigorous sampling protocols and use of quantitative rather than qualitative metrics. It can incorporate all of the elements of indicator and inventory sampling as well as additional rigor specific to its intended purpose. Purposes can include action effectiveness monitoring of a stream restoration project for instance, or the information needed for project level planning and design. The U.S. Forest Service Level III inventory and the EMAP sampling protocol generally fit in this category.

4.1.4.3 Program Targets

Sampling targets outline the requirements necessary to carry out the monitoring program and will be used to measure progress toward accomplishing program objectives. Targets were defined based on minimum requirements or benchmarks necessary to address all monitoring objectives consistent with the prescribed strategy. Targets are based on a systematic multi-tiered stratified statistical sampling design to address survey, index, diagnostic, and focal applications (Table 25). It is expected that some of these targets will be met by existing monitoring programs and some will require additional sampling effort.

Survey sampling is intended to represent conditions at the subbasin level across the region. Minimum targets for survey sampling are based on a 12-year sample rotation, probabilistic design, indicator and inventory level surveys, sample strata including subbasins, physiographic zones, and stream sizes, replicates of 3 sites per strata combination (Table 23). A total of 648 reaches would be sampled using the combination of a modified USFS level II and remote sensing data collection protocol would meet this benchmark. Distribution of these samples over a 12 year period would require a sample rate of 54 reaches per year. Sample sites would initially be selected at random from each strata but repeat sampling of the same sites in the second 12-year rotation would also provide for an evaluation of average habitat changes across the region.

Table 25. Sampling targets for stream habitat monitoring by objective application and sampling type.

	Status / Survey	Trends / Index	Problems / Diagnostic	Effects / Focal
Objective	Represent conditions at the subbasin level	Detect trends in sensitive indicator sites	Identify significant habitat and passage problem sites & restoration opportunities	Design and evaluate site specific projects, action effectiveness, and fish linkages
Site selection criteria	Stratified Probabilistic	Non-random based on fish values & expected impacts	All high priority salmon habitat reaches	Action-specific
Sampling level	Indicator + Inventory	Indicator + Intensive	Indicator + Reconnaissance	As appropriate
Sample unit	Reach	Site	Reach	As appropriate
Subsample stratification	Subbasin x Zone x Order	Subbasin x Zone	Subbasin	As appropriate
Total # strata	18 x 3 x 4 = 216	18 x 3 = 54	18	As appropriate
Replicates / strata	3	1	variable	As appropriate
Samples total	648	54	360 (approx.)	As appropriate
Samples / subbasin	36	3	20 (approx.)	As appropriate
Sampling frequency	12-year rotation	3-year rotation	12-year rotation	As appropriate
Samples / year	54	18	30 (approx.)	As appropriate
Representation	>10% of available 1:100,000 scale reaches	not applicable	90% of tier 1 reaches 50% of tier 2 reaches	As appropriate
Example method	USFS level II or equivalent	EMAP or equivalent	Rapid / Visual Assessment	As appropriate
Approx allocation of total sampling effort	50%	20%	20%	10%

Index sampling is intended to detect trends in sensitive indicator stream reaches. Indicator sites are specifically selected to include areas that are particularly sensitive to habitat changes as well as significant to fish. These sites are selected independently from survey sample sites. Specified index sites will be repeat sampled at a three year interval in order to provide temporal replication needed to distinguish annual variation from long term trends and to characterize effects periodic disturbances which are critical habitat forming processes. Minimum targets for index sampling involve one reach per physiographic zone in each subbasin. The 18 subbasins typically include 3 zones each for a total of 54 sample sites. Where distributed throughout the three-year rotation, this would require 18 sites to be sampled per year. Index sampling would be based on an intensive indicator measurement protocol (e.g. EMAP) in order to minimize measurement error in qualitative metrics due to potentially subjective surveyor judgment. Measurement transects in each reach would be fixed and repeat sampled during each sample replicate.

Diagnostic sampling is intended to identify significant habitat and passage problem sites and potential protection and restoration opportunities. Diagnostic sampling is concentrated on stream reaches of high priority for salmon protection or restoration as identified by reach tiers defined in the recovery plan. Minimum benchmarks for diagnostic sampling include 90% of tier 1 reaches and 50% of tier 2 reaches. Sample numbers are based on desired benchmark coverage levels and the numbers of Tier 1 and Tier 2 reaches in the region. Numbers vary from subbasin to subbasin depending on the number and priority of fish populations in each as well as basin size and fish distribution. Diagnostic sampling is conducted using rapid/visual assessment methods targeting the features of interest.

Focal sampling is designed for a variety of specific evaluation including site specific projects, action effectiveness, and landscape, stream, and fish linkages. Sampling elements are specific to each evaluation and are identified as appropriate. Benchmarks also identify the relative time and effort expected to be expended for each of the four sampling types. Effort allocation is approximate and based on benchmark sample sizes and protocols for each type.

4.1.5 Current Monitoring Activities

There is currently no systematic and comprehensive stream habitat monitoring program in the Lower Columbia Region adequate for evaluations of status and trends necessary to inform the public and meet federal ESA recovery purposes (Crawford 2007). However, fish-related stream habitat survey information is available from a diverse mix of local, state, and federal entities and with various objectives (Table 26). Significant stream habitat sampling efforts in recent years are summarized by subbasin in Table 27. A detailed inventory of habitat-related monitoring activities is also presented in an Appendix.

Baseline stream and reach-level habitat conditions on the lower Columbia have been assessed and characterized using the Ecosystem Diagnosis and Treatment (EDT) methodology (MBI 1999). EDT is a database and mechanistic model that relates fish performance to aquatic habitat characteristics. Physical habitat conditions were described for each individual stream reach in the form of qualitative scores for 46 indicators, known as level 2 habitat attributes. These model inputs were then related through a set of rules to life stage specific survival in order to model fish potential and limiting factors for the current (patient), historical (template) and “Properly Functioning” conditions. This evaluation considered information from local experts, observations from reconnaissance-level stream habitat surveys conducted by several Conservation Districts in the late 1990s, and inventory-level surveys conducted periodically by

the U.S. Forest Service on National Forest lands WDFW also conducted supplemental indicator and reconnaissance-level assessments to support this effort. The EDT analysis was completed in 2004 for recovery and subbasin planning purposes and updated in 2007 with a more comprehensive dataset for small first order streams not included in the initial assessment.

A variety of stream habitat data on specific areas or selected metrics have also been collected by various parties in relation to project planning or evaluation, as well as for regulatory purposes. Examples include surveys in the Lewis River subbasin by PacifiCorp as part of hydro evaluations and relicensing activities and on private timberlands in the Coweeman subbasin by Weyerhaeuser as part of forest practice evaluations.

More detailed stream habitat assessments were conducted by the LCFRB in the Kalama, Lewis, Salmon, and Washougal subbasins during 2004 (R2 Resource Consultants 2004; SPCA 2005). These surveys subsampled reaches stratified by stream size and significance to fish recovery, followed a modified USFS Level II sampling protocol, collected data on stream habitat conditions, riparian conditions, sediment sources, and also inventoried hydromodifications and potential habitat restoration opportunities. The intent of these projects was to help fill data gaps, identify potential enhancement, restoration, or protection projects, and to evaluate previous EDT results.

More detailed stream habitat assessments have also been undertaken as part of Washington's Intensively Monitored Watershed (IMW) Project (Bilby et al. 2004). This project is a joint effort of the Washington Departments of Fish and Wildlife and Ecology, NOAA Fisheries, EPA, Lower Elwha Klallam Tribe and Weyerhaeuser Company and is funded by the Washington Salmon Recovery Funding Board (http://wdfw.wa.gov/hab/imw/index.htm). The IMW project focuses intensive fish and habitat monitoring efforts on a few locations in order to identify the complex relationships controlling salmon response to habitat conditions and restoration treatments. The IMW project includes Mill, Abernathy, and Germany creeks in the coast strata of the lower Columbia Region and cooperators have begun collecting a comprehensive suite of data in 2005 on water quantity, water quality, habitat, summer juvenile fish abundance, and smolt production. Stream habitat surveys in the IMW are based on EMAP protocols.

At the subbasin scale, significant habitat data has been collected from inventory or intensive level sampling efforts during the last 10-15 years in almost all of the Cascade and Gorge strata subbasins, with the exception of the lower Cowlitz subbasin. Intensive-level stream habitat sampling data is also available from the Mill, Abernathy, and Germany subbasin in the Coast strata and from the Wind subbasin in the Gorge strata. However, systematic ongoing monitoring efforts of a comprehensive suite of stream habitat conditions is currently limited to the IMW project in the coast strata.

Table 26. Key entities involved in significant habitat monitoring in the lower Columbia region.

Entity	Information type	Location
Federal		
U.S. Forest Service	Riparian condition and function, channel morphology and complexity, temperature, water quality, watershed conditions and hillslope processes, fish passage	Kalama, Wind, Cowlitz, Lewis, Washougal, Bonneville Tribs, Gorge Tribs, Little White Salmon
Bureau of Land Management	Water quality, stream/riparian surveys, channel morphology and complexity	Lower Columbia
U.S. Geological Survey	Stream flow, water quality, limited habitat complexity and cover	Throughout the region
U.S. Fish and Wildlife Service	Channel morphology and complexity, Stream flows	Gee Creek, Hamilton Creek, Gibbons Creek, Lewis River
U.S. Army Corps of Engineers	Water quality	Lower Columbia Mainstem
NOAA	Habitat conditions	Lower Columbia Mainstem
State		
WA Departments of Ecology and Fish and Wildlife	Stream/riparian surveys, temperature, channel morphology and complexity	Lower Columbia
WA Department of Natural Resources	Water quality, watershed conditions and hillslope processes, fish passage	Lower Columbia
Washington Department of Ecology	Extensive water quality in a limited number of basins, instream flows, floodplain and wetland function; channel migration processes	Lower Columbia
State Parks	Stream/riparian surveys, blocked habitat, channel morphology and complexity	Lower Columbia
WA Department of Health	Drinking water quality	Statewide
Local		
Clark PUD	Temperature, stream and riparian surveys	Salmon, East Fork Lewis, Washougal
Clark Conservation District	Water quality, fish passage, habitat conditions, fish barriers	Lewis, Salmon Creek, Washougal
Wahkiakum Conservation District	Instream, floodplain, riparian conditions, Water quality, temperature, fish passage	Grays, Skamokawa, Elochoman, Mill
Cowlitz Conservation District	Channel complexity and morphology, water quality, fish passage, riparian conditions	Lower Cowlitz, Coweeman, Toutle, Kalama, Lower NF Lewis, Mill, Abernathy, Germany
Clark County	Water quality (temp/flow/quality) channel morphology and complexity, stormwater	EF Lewis, Lake River, Salmon Creek, Lower NF Lewis, Washougal
LCFRB	all limiting factors	Lower Columbia region
Lower Columbia Fish Enhancement Group (LCFEG)	Water quality, habitat conditions, fish/habitat associations	Lower Columbia & tributaries
Lower Columbia Estuary Partnership (LCREP)	Water quality, habitat conditions, fish/habitat associations	Lower Columbia & tributaries
Columbia River Estuary Study Task Force	Project effectiveness, restoration feasibility	Lower Columbia
PacifiCorp	Temperature, stream flow, instream habitat conditions	NF Lewis Basin
Underwood Conservation District	Water Quality	Wind Basin, White Salmon Basin
Fish First	Channel morphology and complexity, temperature	Cedar Creek, East Fork Lewis

Table 27. Summary of significant fish-related habitat survey efforts in Washington Lower Columbia subbasins.

	Basin	Sampling level			
		Indicator	Recon.	Inventory	Intensive
Coast Strata	Grays	WDFW (2004-2006) [1]	WCD (1996)[3]	--	--
	Grays Bay Tribs		WCD (1996-1997)[3] WDFW (2002-2003)[2]	--	--
	Skamokawa	WDFW (2004-2006) [1]	WCD (1996-1997)[3] WDFW (2002-2003) [2]	--	--
	Elochoman	WDFW (2004-2006) [1]	CCD (1996)[3] WDFW (2002-2003) [2]	--	--
	Mill	WDFW (2004-2006) [1]	CCD (1996-1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
	Abernathy	WDFW (2004-2006) [1]	CCD (1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
	Germany	WDFW (2004-2006) [1]	CCD (1997)[3] WDFW (2002-2003) [2]	--	Washington (2005-)[4]
Cascade strata	Lower Cowlitz	WDFW (2004-2006) [1]	CCD (1996-1999)[3] LCCD (2000)[3]	--	--
	Coweeman	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	Weyerhaeuser (1995-1996)	--
	Toutle	WDFW (2004-2006) [1]	--	USFS (1993)	--
	Upper Cowlitz	WDFW (2004-2006)[1]	--	USFS (1987-2001)	--
	Cispus	WDFW (2004-2006)[1]	--	USFS (1987-2001)	--
	Tilton	WDFW (2004-2006)[1]	--	USFS (1993)	--
	Kalama	WDFW (2004-2006)[1]	--	USFS (1990) LCFRB (2004)	--
	Lower NF Lewis	PacifiCorp (2003)[1]	WDFW (2002-2003) [2]	PacifiCorp (1999-2000) LCFRB (2004)	--
	Upper Lewis	PacifiCorp (2003)[1]	PacifiCorp (1999-2000)	USFS (1989-2000) LCFRB (2004)	--
	EF Lewis	WDFW (2004-2006) [1]	WDFW (2003) [2]	USFS (1991-2001) LCFRB (2004)	--
	Salmon	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	LCFRB (2004)	--
	Washougal	WDFW (2004-2006) [1]	WDFW (2002-2003) [2]	LCFRB (2004)	--
	Lower Gorge	WDFW (2004-2006) [1]	--		--
Gorge strata	Upper Gorge	--	--	USFS (1997)	--
	Wind	WDFW (2004-2006) [1]	--	USFS (1988-2001)	--
	Little White Salmon	--	WDFW (2002-2003) [2]	USFS (1988-2001)	--

1 Part of EDT analysis
2 Subsampling for selected EDT Analysis inputs.
3 Qualitative surveys by stream reach for limiting factor assessments
4 Intensively monitored watershed program

WCD = Wahkiakum Conservation District
CCD = Cowlitz Conservation District
WDFW = Washington Department of Fish & Wildlife
USFS = US Forest Service
LCCD = Lewis County Conservation District
LCFRB = Lower Columbia Fish Recovery Board

4.1.6 Information Gaps

Current sampling efforts were evaluated based on sampling benchmarks to identify where information needed for salmon habitat recovery monitoring is lacking. Significant information gaps were identified in almost all subbasins at every level.

Survey samples to describe current habitat status meet sampling benchmarks in the Intensively Monitored Watershed project area including Mill, Abernathy, and Germany creeks. Status survey benchmarks are partially met in most Cascade and Gorge subbasins by the combination of LCFRB inventory surveys during 2004, periodic USFS surveys on Federal lands, and other efforts (Weyerhaeuser, PacifiCorp) in selected watersheds. However, survey sample coverage appears to fall short of benchmarks in some strata of Cascade and Gorge subbasins, particularly in representative small, low elevation streams on nonfederal lands. Survey sample data is limited for non IMW Coast subbasins, the Lower Cowlitz, and the lower Gorge tributaries.

Table 28 Summary of current availability of stream habitat information relative to sampling benchmarks by objective application and sampling type.

		Status / Survey	Trends / Index	Problems / Diagnostic	Effects / Focal
	Benchmark:	3 inventory samples per subbasin, zone & order	1 intensive sample per subbasin & zone	Reconnaissance samples of 90% of Tier 1 & 50% of Tier 2	Not specified
	Basin				
Coast	Grays	Low	Low	Moderate	Moderate
	Grays Bay Tribs	Low	Low	Moderate	Moderate
	Skamokawa	Low	Low	Moderate	Moderate
	Elochoman	Low	Low	Moderate	Moderate
	Mill	Very High	Very High	High	High
	Abernathy	Very High	Very High	High	High
	Germany	Very High	Very High	High	High
Cascade	Lower Cowlitz	Low	Low	Low	Moderate
	Coweeman	Moderate	Moderate	Moderate	Moderate
	Toutle	Moderate	Moderate	Moderate	Moderate
	Upper Cowlitz	Moderate	Low	Moderate	Moderate
	Cispus	Moderate	Low	Moderate	Moderate
	Tilton	Moderate	Low	Moderate	Moderate
	Kalama	Moderate	Low	Moderate	Moderate
	Lower NF Lewis	Moderate	Moderate	Moderate	Moderate
	Upper Lewis	Moderate	Moderate	Moderate	Moderate
	EF Lewis	Moderate	Moderate	Moderate	Moderate
	Salmon	Moderate	Low	Moderate	Moderate
	Washougal	Moderate	Low	Moderate	Moderate
	Lower Gorge	Low	Low	Low	Moderate
Gorge	Upper Gorge	Moderate	Low	Moderate	Moderate
	Wind	Moderate	Moderate	Moderate	Moderate
	Little White Salmon	Moderate	Moderate	Moderate	Moderate

Low: Benchmarks addressed primarily through Indicator level sampling.
Moderate: Benchmarks partially met by reconnaissance, inventory or intensive sampling within the prescribed period.
High: All benchmarks met by sampling within a period correspond to the prescribed sampling frequency (3 or 12 years)
Very High: Sampling exceeds all benchmarks
Effects / Focal monitoring assessed based on degree of miscellaneous habitat assessments associated with action-specific or regulatory activities by various parties.

Index samples needed to provide a solid baseline for evaluating habitat trends are available only from Mill, Abernathy, and Germany creeks which are part of the Intensively Monitored Watershed project area. Trend index benchmarks might be partially addressed in some Cascade and Gorge subbasins by LCFRB inventory surveys during 2004, periodic USFS surveys on Federal lands, and other efforts (Weyerhaeuser, PacifiCorp, Washington DNR) in selected watersheds. However, existing inventory data in these areas may be suitable only for detecting large changes in habitat conditions and may not be adequate for characterizing smaller incremental changes over time or distinguishing trends from periodic disturbances. Nor are all physiographic zones or stream sizes represented. Sampling benchmarks generally identify the need for more intensive sampling levels in sensitive areas in order to identify trends. Suitable trend index data is not available for several subbasins in each ecozone.

Diagnostic reconnaissance has been completed at some level in most subbasins but existing samples fall short of benchmark levels either for level of sampling or coverage of the majority of reaches identified by the recovery plan as significant or potentially significant to fish production. Reconnaissance level surveys in coastal and lower Cowlitz subbasins by the conservation districts provided broad coverage to identify limiting factors at a gross scale but did not provide adequate information on site-specific problems and opportunities to guide habitat protection and restoration efforts. Assessments by the LCFRB and Forest Service in many Cascade or Gorge subbasins provided detailed information but did not include a complete coverage of significant fish reaches.

In addition, a variety of project or action related habitat monitoring efforts are underway across the region. These can be expected to provide some useful habitat information on some metrics in some areas. In particular, the Mill, Abernathy and Germany IMW project is expected to provide excellent data on habitat effects on fish. However, existing efforts fall short of needs for focal monitoring related to action effectiveness monitoring throughout the region. Further discussion of effectiveness monitoring for habitat actions may be found in a subsequent section.

While a patchwork of stream habitat information has been provided by a variety of activities, few of these are part of a long-term systematic effort that can be expected to answer habitat monitoring needs for salmon recovery. Most continuing habitat monitoring efforts are project or action related. These can be expected to provide some useful information but will likewise fall short of the information needed to evaluate progress or lack thereof of recovery efforts to address habitat-related threats that contributed to listing of salmon and steelhead throughout the region.

4.1.7 Implementation Actions

M.M-6. Maintain current habitat monitoring efforts for representative priority areas.

Priority: Very High

Lead: USFS, WDFW, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Current habitat monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments and recovery plans. Current programs are adequate for some recovery plan applications but fall short in other areas. Thus, effective monitoring and evaluation will require more funding, not less. This RM&E plan seeks a balance in commitments between monitoring, protection, and

restoration activities. Current monitoring activities have been implemented with a mixture of hard and soft funds. In many cases, long term funding of key programs is not assured. Many previous habitat sampling efforts are not part of any ongoing program. Loss of significant components of current habitat monitoring programs would significantly reduce the accuracy and precision of evaluations of progress, or lack thereof, with respect to recovery goals.

6 Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules
d. Identify constraints and uncertainties
e. Identify coordination considerations.

M.M-7. Establish a baseline habitat characterization and database of current stream conditions in the Lower Columbia region based on existing data for use as a reference point in future analysis as well as specific guidance for additional sampling needed to fill information gaps.

Priority: High

Lead: USFS, WDFW, WDNR, WDOE, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Significant habitat information exists from current and past sampling programs by a wide variety of parties for a multitude of purposes. This information is identified in this plan and used to identify significant information gaps. Much of this information was also utilized in the recovery and subbasin plan to generally characterize existing conditions and to identify priorities for protection and restoration actions. A considerable amount of data has already been collected by federal, state, tribal, and local entities; however, a comprehensive baseline, extending down to the stream scale, has yet to be established. The existing information has not been synthesized and summarized for the purposes of clearly identifying baseline conditions for future reference. Existing information has been compiled from a variety of sources but source protocols and references have not always been effectively captured in metadata. Recovery planning analyses using Ecosystem Diagnosis and Treatment and Integrated Watershed Assessment methodologies relied primarily on readily available and easily summarized data sources and did not incorporate the full scope of the available data needed to characterize the baseline. More intensive synthesis, analysis, and documentation are needed than was required for recovery and subbasin planning purposes. Without this upfront work, future habitat monitoring evaluations will have difficulty discerning the baseline conditions, some current information may be lost, and gaps in current status information will be overlooked. The baseline habitat characterization will also provide an explicit template to guide future habitat evaluations at Recovery Plan implementation checkpoints.

Activities

a. Identify appropriate funding sources and implementation partners.
b. Develop and implement an appropriate plan of work.

c. Obtain existing data from regional entities, build a data library including documentation where available, and incorporate appropriate information into a georeferenced relational database suitable for use in future status, trend, and problem analyses.

d. Collectively analyze data to characterize baseline stream habitat conditions. Process and summarize data to produce regionally representative information (including extraction of level II information from the EDT analysis). This includes spatially locating data, and translation of diverse metrics, scales, and protocols to a common representation to the extent possible. Graphically and statistically characterize results.

e. Incorporate data quality assessments.

f. Identify specific sample data needs to fill information gaps in baseline conditions relative to sampling benchmarks.

M.M-8. Develop and implement an empirical sampling program to fill specific data gaps in the habitat baseline relative to sampling benchmarks identified by this program.

Priority: High

Lead: LCFRB with support from USFS, WDFW, PNAMP, NOAA conservation districts and counties

Rationale: Existing data is not adequate to clearly establish baseline habitat conditions. Lack of a clear description of baseline habitat status will preclude future determination of trends. Without clear evidence for trends, it will be impossible to determine the cumulative effect of recovery activities and other influences on habitat conditions, whether further actions are needed or whether past actions have achieved objectives. Even where actions produce significant benefits, due credit for results could not be given. In order to track progress with respect to the recovery plan goals for threat reduction and delisting criteria, existing data must be supplemented with additional sampling and analysis. Attempts to establish a current habitat status baseline will identify significant data gaps for specific areas and conditions that will require inferences from other sites or related information. An accurate baseline will require a sample set representative of the larger population at both the reach and watershed scale within each physiographic strata of the region. Targeted sampling will be required.

Activities

a. Develop appropriate funding sources and implementation partners.

b. Develop and implement an appropriate plan of work.

c. Design and implement targeted surveys. Select specific measures and protocols consistent with objectives and needs identified in this program. Select sample sites according to sampling plan and data availability

M.M-9. Develop and implement a sampling program to address long-term watershed, stream, and water quality monitoring needs not currently being addressed by other parties.

Priority: High

Lead: LCFRB with support from USFS, WDFW, conservation districts and counties

Rationale: No systematic stream habitat monitoring program currently exists for the Washington lower Columbia salmon Recovery Region. Habitat monitoring is currently conducted by a variety of parties for a variety of purposes, but activities and results are not coordinated or captured for application to salmon recovery monitoring and evaluation purposes. A dedicated sampling program is necessary to meet salmon recovery needs. This monitoring needs to incorporate a mixture of existing programs, new programs implemented by parties to address various needs, and new sampling of representative long term index sites.

Activities

a. Develop appropriate funding sources and implementation partners.
b. Develop and implement an appropriate plan of work.
c. Design and implement a systematic annual stream habitat survey program as per the objectives, strategies and benchmarks detailed in this program.

4.2 Landscape – Watersheds, Uplands/Hill slopes, Wetlands

4.2.1 Objectives

Habitat status monitoring at the landscape scale is primarily intended to characterize watershed upland/hill slope and wetland conditions that affect stream habitat for salmon relative to a baseline at listing and improvements consistent with recovery. The objective at this scale is to detect broad changes in watershed conditions and processes that affect stream habitat forming processes. Stream conditions reflect the direct effects of actions at the stream habitat scale as well as watershed-scale actions and conditions that influence stream habitat forming processes. Monitoring of watershed conditions will identify long-term trends and cumulative effects of recovery measures and other human activities (Box 3).

Landscape-scale habitat information has a variety of applications critical to salmon recovery. A primary application will be to evaluate the status of habitat-related statutory listing factors identified by the NMFS listing status decision framework (NOAA 2007). Comparisons of observed and benchmark watershed and floodplain conditions with salmon habitat distribution also help to identify problem areas and focus actions for maximum effect and efficiency. Landscape scale information is also used to evaluate the effectiveness of actions at that scale. Finally, comparisons of landscape, stream, water, and biological information are the basis for uncertainty and validation research designed to identify key functional relationships and to reduce fundamental uncertainties which might constrain effective recovery plan implementation.

Box 3. Questions and hypotheses addressed by salmon-related landscape monitoring.

Question #1. Are landscape conditions stable or changing as a result of fish protection and restoration actions, and other factors?

Null hypothesis: Watershed, upland/hill slope and wetland conditions are unchanged since listing.

Alternative: Watershed, upland/hill slope and wetland conditions have changed since listing.

Question #2. Which landscape-level areas and factors are most important to stream habitat conditions in key fish production areas?

Null hypothesis: All watershed, upland/hill slope and wetland areas and factors are of equal importance to fish.

Alternative: Some watersheds, upland/hill slope and wetland areas and factors are more important than others.

Question #3. Have specific landscape-level actions achieved the desired physical effects? (see action effectiveness monitoring section)

Null hypothesis: Actions resulted in no change in watershed, upland/hill slope and wetland conditions.

Alternative: Changes in watershed, upland/hill slope and wetland conditions are a result of the action.

Question #4. How are stream conditions affected by landscape/watershed factors? (see uncertainty and validation research section

Null hypothesis: Stream conditions are unaffected landscape factors or stream flow patterns.

Alternative: Stream conditions are affected by landscape factors or stream flow patterns.

4.2.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For landscape-scale monitoring, these include:

1. ***Complete comprehensive assessments of water quality and quantity status and trends at 12 year intervals as prescribed by the Recovery Plan.***

A 12 year assessment interval is identified by the recovery plan for the assessment of stream habitat status relative to baseline conditions and benchmarks. Landscape-scale information will be compiled uniformly across the entire study area at 12-year intervals corresponding with habitat assessment checkpoints identified in the recovery plan.

2. ***Derive landscape-scale data for status and trends monitoring primarily from existing datasets or other regional activities.***

This monitoring program does not anticipate intensive development or derivation of landscape-scale information across the region for the dedicated salmon recovery applications other than for watershed action effectiveness monitoring or research on watershed-stream habitat linkages. Rather, this monitoring program focuses on stream habitat conditions which are the more proximate driving factor in fish status and trends.

4.2.3 Indicators

4.2.3.1 Attributes & Metrics

Landscape scale conditions are characterized through a set of indicators including attributes, metrics, and statistics that reflect the suite of conditions that are relevant to salmonid protection and recovery (Table 29). The program recognizes the subjectivity of defining a boundary between watershed, floodplain, riparian zone and stream attributes due to the complexity of connectivity and functional relationships. Watershed indicators include geomorphology, land use, vegetation cover, road density, and landslides. Floodplain indicators include channel migration zones, connectivity, and wetlands. Indicators are consistent with those identified in NOAA's listing status decision framework for the habitat category and with other diagnostic methods implemented in the region including the Integrated Watershed Assessment (IWA) (LCFRB 2004).

Table 29 Attributes, metrics, and example statistics for use as indicators of watershed and floodplain status.

Attribute	Metric	Example statistics	Relevance to Fish
Watershed conditions & hillslope processes	-Road Density & stream crossing frequency -Mass Wasting -Impervious Surfaces -Land Use / Land Cover	Density and type of road & stream crossing Number and size/scale of events Percent impervious surfaces Area of land use and cover class	Habitat access Supply of spawning substrate Fine sediment supply Landslides and debris flows Flood magnitude and timing Summer low flow availability Pollutant runoff
Floodplain and wetland function; channel migration processes	-Channel migration zone encroachment -Wetland availability -Floodplain connectivity	Width of channel migration zone Acres of wetlands Extent of connected floodplains	In-channel habitat formation and maintenance Off-channel habitat creation Nutrient exchange Flood abatement Flood refuge Temperature moderation

4.2.3.2 Benchmarks

Assessments of habitat suitability for fish and the effects of habitat changes will rely on quantitative and qualitative interpretations of landscape indicators. Interpretations will be based on changes in indicators over time as well as comparisons with benchmark values (Table 30). Benchmarks do not represent goals but are goal-related reference points or standards against which to compare performance achievements.

Given the inherent variability and complexity of natural systems, it is impractical to establish broadly applicable goals for habitat conditions, particularly at the watershed level. A more effective approach for habitat characteristics is to develop relative measures of trends over time. Many different combinations of attribute conditions might satisfy recovery goals. Benchmarks provide useful reference points for the evaluation of attribute conditions in the absence of ESU or population-specific goals at the attribute level. The recovery plan identifies habitat benchmarks based on Properly Functioning Conditions (PFCs) identified by NOAA to reflect freshwater habitat conditions generally favorable for salmonids spawning and rearing (NMFS 1996b). NMFS defines PFCs as "the sustained presence of natural habitat-forming processes in a watershed (*e.g.*, riparian community succession, bedload transport, precipitation runoff pattern, channel migration) that are necessary for the long-term survival of the species through the full range of environmental variation." PFC, then, constitutes the habitat component of a species' biological requirements. The indicators of PFC vary between different landscapes based on unique physiographic and geologic features. For example, aquatic habitats on timberlands in glacial mountain valleys are controlled by natural processes operating at different scales and rates than are habitats on low-elevation coastal rivers. PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes.

Table 30 Salmonid watershed benchmarks based on "Properly Functioning Conditions" Matrix of Pathways and Indicators (NMFS 1996b) and Northwest Forest Plan (1994).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Watershed Conditions:	Road Density & Location	<2 mi/mi² [11], no valley bottom roads	2-3 mi/mi², some valley bottom roads	>3 mi/mi² many valley bottom roads
	Disturbance History	NMFS <15% ECA (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area;	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area;	>15% ECA (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area;
		NWFP-area (except adaptive Management Areas (AMA)), ≥15% retention of Late Successional/Old Growth (LSOG) in watershed[10]	NWFP area (except AMAs), ≥15% retention of LSOG in watershed[10]	does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition >50%[12]	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (≈70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better[12]	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition <25%[12]

[10] Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional Species and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management.

[11] USDA Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.

[12] Winward, A.H., 1989. Ecological Status of Vegetation as a Base for Multiple Product Management. Abstracts 42nd Annual Meeting, Society for Range Management, Billings MT, Denver, CO: Society for Range Management: p. 277

4.2.3.3 Example Information

Example reporting templates for landscape scale data are depicted below. This data may be represented in terms of area-specific physical conditions or can be represented relative to benchmark values. Spatial landscape data is well suited to presentation in a map format and this application is facilitated by use of Geographical Information Systems. Examples were included to illustrate how data might begin to be organized and used. The data included in examples also represents baseline conditions for comparison with results of future monitoring. Many alternative depictions might ultimately be developed.

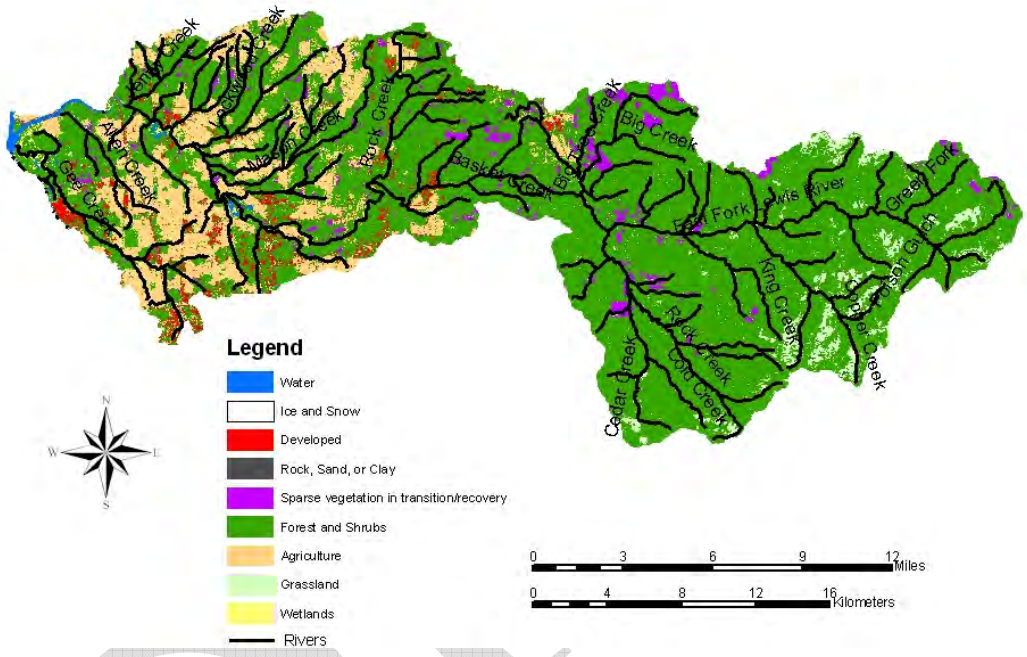

Figure 18. Map example depicting landscape-level data.

Figure 19. Examples of subwatershed categories based on significance to important salmon habitats.

4.2.4 Sampling & Analytical Design

Landscape-scale analyses will rely on region-wide land use and land cover metrics, as well as impairment ratings related to hydrology, fine sediment supply, and riparian function. Watershed-scale attributes are typically broad-scale and slow to change and monitoring is therefore relatively infrequent and covers a wide spatial-scale. An exception might be rapidly developing areas where land cover may change dramatically within a period of years; these areas can warrant a more intensive monitoring focus. More intensive studies in developing areas will be identified but will also rely on existing GIS data sources compiled by cooperating agencies. Intensive watershed-scale studies will be driven by land use trends and data availability.

4.2.5 Current Monitoring Activities

Current monitoring activities at the watershed scale are primarily focused on regulatory, action effectiveness, or research applications. The depth and breadth of this activity varies considerably from place to place. Land management agencies such as the U.S. Forest Service that maintain detailed current information on activities and conditions on Federal forest lands. Ongoing USFS activities include the Aquatic Resource Effectiveness Monitoring Program (AREMP) and the Pacific Intermountain Biological Opinion (PIBO) sampling programs, both of which are using satellite imagery to characterize changes in forest seral stages and roads. Various Washington State agencies monitor and maintain landscape level information related to their responsibilities and authorities. For instance, landscape scale information is collected and maintained by the Department of Natural Resources for land use and conditions on state lands, the Department of Transportation on roads, and so on. Other local agencies and entities collect and maintain specific information within areas of their jurisdiction or interest (e.g. Counties, Utility Districts, etc.). At a more global landscape scale, detailed aerial and satellite imagery is widely available.

Baseline watershed conditions within the Lower Columbia Region have been characterized using a GIS-based approach referred to as the Integrated Watershed Assessment. The IWA explicitly considered three processes known to affect the quantity and quality of fish habitat: hydrology, sediment delivery, and large woody debris recruitment potential. IWA was used characterize existing and probable future conditions in 545 subwatersheds throughout the Washington lower Columbia region. IWA results provide a “top down” view of factors affecting instream habitat conditions.

4.2.6 Information Gaps

The primary gap identified in this monitoring program for landscape scale information is for a systematic regional effort to assemble, synthesize, and evaluate existing information at periodic intervals. The Recovery Plan identifies a 12-year interval for habitat status checkpoints. This is primarily a data mining exercise. Landscape-level analyses of watershed and floodplain conditions in the Integrated Watershed Analysis completed as part of the Recovery Plan captured the current landscape information readily available for the region and will serve as an effective baseline for future analyses.

No significant new data collection efforts at the landscape scale are identified in this monitoring program at this time independent of other watershed and floodplain information needs for regulatory, action effectiveness, or research applications. These needs are detailed in a subsequent section. Note that some landscape-level analysis of remote sensing information is identified as a need in support of stream habitat evaluations in specific reaches – that need is addressed in the stream habitat status and trends monitoring section.

4.2.7 Implementation Actions

M.M-10. Maintain current landscape scale habitat monitoring efforts for application as available in periodic status and trend assessments.

Priority: High

Lead: USFS, WDFW, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Current habitat monitoring programs are implemented and funded by a variety of parties and provide the basis for current status assessments and recovery plans. Habitat status and trend evaluations identified in this program are focused on monitoring at the stream habitat rather than landscape scale but landscape information for other sources will be incorporated into evaluations. Because dedicated landscape scale data collection efforts are not a focus of this monitoring program, future assessments will rely on other sources for information needed to provide a context for evaluation of habitat patterns at the stream scale.

6 Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules
d. Identify constraints and uncertainties
e. Identify coordination considerations.

M.M-11. Seek and utilize opportunities to supplement existing landscape scale information collection, synthesis, and reporting activities appropriate.

Priority: Moderate

Lead: USFS, WDFW, WDNR, WDOE, local conservation districts (Clark, Wahkiakum and Cowlitz), and counties (Clark, Skamania and Cowlitz)

Rationale: Ongoing activities are expected to provide most of the landscape-level information needed to provide a watershed and floodplain context for stream habitat condition status and trends that are the focus of habitat monitoring in this plan. Opportunities may occasionally arise to augment existing efforts by other parties to increase depth and breadth of coverage of various landscape attributes. In this case, existing efforts might be substantially leveraged with very cost effective contributions.

Activities

a. Identify opportunities as available.
b. Identify appropriate funding sources and implementation partners.
c. Develop and implement appropriate plans of work.

4.3 Water – Quantity & Quality

4.3.1 Objectives

Water quantity and quality are key components of this salmon recovery monitoring program. Water quantity and quality either reflect or affect virtually every other habitat characteristic in the watershed and stream habitat feature. These factors can have broad ranging effects on fish populations (e.g. temperature changes alter species distribution and persistence) as well as discrete point source impacts (e.g. chemical discharge at lethal toxicity levels). As with other habitat monitoring, the primary focus is to characterize conditions for salmon relative to a baseline at listing and improvements in statutory listing factors consistent with recovery. This information will also meet other objectives as identified in Box 2, including identification of limiting factors to focus actions, determination of habitat suitability and potential to guide prioritization of areas for preservation and restoration, fish status inferences where biological data is incomplete, action effectiveness evaluations, and research on fundamental linkages among fish, watersheds, and streams.

This program describes monitoring needs specific to salmon recovery. Comprehensive watershed plans completed for Washington lower Columbia subbasins in 2006 (LCFRB 2006b, 2006c). It also considers stream flow and water quality monitoring needs for a full spectrum of human and fish concerns (Box 4). The salmon habitat monitoring program described herein incorporates elements of watershed plan monitoring pertinent to fish. The watershed plan is designed to address the salmon-related monitoring needs for water quantity or quality data. Water quantity and quality monitoring is also conducted in association with hydropower operations – these elements are addressed in the Action Effectiveness section later in this document.

Box 4. Water quantity and quality monitoring needs identified in Washington lower Columbia Watershed Plans (LCFRB 2006b, 2006c).

Flow

- Provide basic data needed to assess current status and long-term trends in stream flow.
- Provide basic data to determine how various components of the watershed contribute to flow.
- Assess how short-term or long-term changes in watershed conditions affect flows.
- Evaluate the effectiveness of specific management actions designed to improve the flow regime.

Water quality

- Determine the effects on human health for drinking water systems relying on surface water.
- Determine the effects on human health through contact recreation.
- Determine the effects on fish species listed under the Endangered Species Act and other aquatic life.

4.3.2 Strategy

The strategy includes a series of overarching guidelines consistent with the monitoring objectives. For water quality and quantity monitoring, these include:

1. ***Complete comprehensive assessments of water quality and quantity status and trends at 12 year intervals as prescribed by the Recovery Plan.***

A 12 year assessment interval is identified by the recovery plan for the assessment of stream habitat status relative to baseline conditions and benchmarks.

2. ***Monitor water quality and quantity as prescribed in Washington's Watershed Management Plans.***

Watershed Management Plans identified a water flow and quality monitoring strategy program designed to address the multiple objectives of this information (LCFRB 2006b, 2006c). Strategies and priorities identified in this comprehensive salmon monitoring program were adopted directly from the Watershed Management Plans.

4.3.3 Indicators

4.3.3.1 Attributes & Metrics

Water quantity and quality are characterized through a set of indicators including attributes, metrics, and statistics relevant to salmonid protection and recovery (Table 31). Instream flow measurements of water quantity are calculated in cubic feet per second and expressed in terms of average low flows during summer or early flow, or in terms of peak flows. Low-flow levels during late summer and early fall can be defined at the 90th percentile, 50th percentile (median), and 10th percentile (flows expected, on average, in 1, 5, or 9 years out of ten, respectively). Peak flows are similarly expressed based on frequency of occurrence. For instance a 2-year flood has a 50% chance of occurring in any single year while a 10-year flood has a 10% chance of occurring in any single year. Frequency statistics generally require historical flow records at stream-gaging sites. Water quality indicators of particular interest to fish include temperature and dissolved oxygen. Other water quality parameters addressed by watershed plans include pH, conductivity, turbidity, nutrients, and indicator bacteria.

4.3.3.2 Benchmarks

Assessments status and trends in water quantity and quality relative to habitat suitability for fish will be evaluated based on changes in indicators over time as well as comparisons with benchmark values. Benchmarks for water quantity are based on broad guidance identified in Properly Functioning Conditions (PFCs) for salmon and on target flows identified in the watershed plans. Benchmarks for water quality were based on PFCs and state water quality criteria.

PFCs were identified by NOAA to reflect freshwater habitat conditions generally favorable for salmonids spawning and rearing (NMFS 1996b). PFCs are not goals or requirements for reaching salmon recovery. They are, however, useful reference points for comparative purposes. PFCs for water quality and quantity are broadly described in terms of functions rather than specific parameter values. The exception is water temperature where specific ranges were identified for salmonids by life stage.

Target flows are intended to reflect a realistic flow regime that could be achieved in most years by following sound management techniques over a long period of time (LCFRB 2006b, 2006c). Targets include both low flows and high flows and their frequency of occurrence over a period of years. These statistics are developed from historical flow conditions, current and projected water uses, and fish habitat needs. Target flows have not been developed all streams in the region at this time, but could be developed in the future in additional areas where significant flow data has been collected over a long period of time (or where acceptable simulated flow data has been generated). Target flows should not be confused with "minimum instream flows" which are stream-specific seasonal or annual low flow rates specifically defined in state law for allocation limitations on the issuance of new water rights.

State surface water quality standards are criteria to ensure that water may be beneficially used for multiple purposes such as fishing, swimming, drinking, and fish habitat (WDOE 2006). Specific standards have been designated for aquatic life based on the presence of, or intent to provide protection for uses identified by species and life stage. Applications of specific criteria also include considerations of naturally-occurring conditions. As an example, failure to meet criteria with no expectation of improvement within 4 years results in an "impaired" designation under section 303(d) of the federal Clean Water Act. The primary vehicle for achieving compliance with state criteria for surface water quality is Ecology's program for Total Maximum Daily Loads (TMDLs), also known as Water Cleanup Plans (LCFRB 2006b, 2006c).

Table 31 Attributes, metrics, and example statistics for use as indicators of stream habitat status.

Attribute	Metric	Example statistics	Relevance to Fish
Instream flows	Normal hydrograph	Seasonal pattern	Summer flow availability for juvenile rearing
	Low flow	Annual average & minimum	Juvenile/adult migration timing & access
	Peak flow	Flood size and frequency (2-year, 10-year, 100-year)	Spawning /rearing habitat availability & quality
		Exceedence levels for low flow target regime	
Water quality	Temperature	Seasonal average & range (º C)	Cool, clean water for adult, egg and juvenile survival
	Dissolved Oxygen	mg/L	Access to suitable habitat
	Turbidity & Suspended Sediments	NTUs	
	pH	Unit measure	
	Conductivity	µS/cm	
	Nutrients	Nitrogen, Phosphorus	
	Contaminants - metals & pollutants	Concentration and extent relative to threshold	

Table 32 Salmonid freshwater habitat benchmarks for water quantity and quality based on "Properly Functioning Conditions" Matrix of Pathways and Indicators (NMFS 1996b).

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Flow/Hydrology:	Change in Peak/ Base Flows	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	zero or minimum increases in drainage network density due to roads[8,9]	moderate increases in drainage network density due to roads (e.g. ≈5%)[8,9]	increases in drainage network density due to roads (e.g. ≈20-25%)[8,9]
Water Quality:	Temperature	50-57° F[1]	57-60° (spawning), 57-64° (migration & rearing)[2]	> 60° (spawning), > 64° (migration & rearing)[2]
	Turbidity	turbidity low	turbidity moderate	turbidity high
	Chemical Contamination & Nutrients	low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches[5]	moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one CWA 303d designated reach[5]	high levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one CWA 303d designated reach[5]

[1] Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.
[2] Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.
[5] A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.
Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.
[8] Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.
[9] e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.

Table 33. Examples of Washington State water quality standards for surface waters related to aquatic life uses of listed lower Columbia River salmonids (WDOE 2006).

	Temperature[1]	Dissolved oxygen[2]	Turbidity[3]	Dissolved gas[4]	pH[5]
Char spawning	9°C (48.2°F)	--	--	≤110%	--
Char spawning and rearing	12°C (53.6°F)	9.5 mg/l	5 NTU or 10% increase	--	6.5-8.5 (0.2 units)
Salmon and trout spawning	13°C (55.4°F)	8.0 mg/l	--	--	--
Core summer salmonid habitat (June 15-September 15)	16°C (60.8°F)	9.5 mg/l	5 NTU or 10% increase	≤110%	6.5-8.5 (0.2 units)
Salmonid spawning, rearing & migration (September 16 – June 14)	17.5°C (63.5°F)	8.0 mg/l	5 NTU or 10% increase	≤110%	6.5-8.5 (0.5 units)
Salmonid rearing and migration only	17.5°C (63.5°F)	6.5 mg/l	20 NTU or 20% increase	≤110%	6.5-8.5 (0.5 units)

[1]Highest 7-day average of the daily maximum temperatures. Criteria also include 1 day maxima.
[2] Lowest 1-day minimum
[3] Based on background below or above 50 NTU.
[4] Percent saturation.
[5] Range and allowable human-caused variation.

4.3.4 Sampling and Analytical Design

Water quantity monitoring requires continuous, long term data on flows. The monitoring design recognizes that installation and operation of gages requires funding, and it may be impossible to fund gages in every location desired. Therefore the Watershed Management Plans identified the following criteria for focusing funding resources on selected subbasins:

- Presence of existing gages that should be maintained permanently;
- Past record of discontinued stream gages, which provide data that can be leveraged if new gages are installed;
- Degree to which flow is impaired now, with potential harm to aquatic habitat;
- Size of subbasin and associated extent of habitat for aquatic life
- Priority of streams in LCFRB Recovery Plan;
- Expected future changes in land use or water withdrawals, that will cause impairment of flow;
- Extent of existing urbanization, and associated feasibility of protecting or enhancing flow (e.g. consider highly urbanized subbasins less feasible)
- Consideration should also be given to whether existing weather stations for measuring precipitation and other weather variables are adequate to meet stream management needs.

Based on these criteria, subbasins were prioritized within the watershed Management Plans for installation and maintenance of permanent, continuously-recording stream gages. Six pilot subbasins in WRIAs 25-28 for more intensive flow monitoring to explore the applicability of stream flow management approaches. More intensive flow monitoring in pilot subbasins can involve lower mainstem and upper basin gages, for instance, to monitor flows from forested headwaters, measure changes due to forest practices, and predict peak flows at downstream locations.

The water quality monitoring strategy incorporated two elements. First, data are needed to characterize water quality conditions in surface waters. Second, it is valuable to gather information on point and non-point sources of water quality impairment to provide a basis for actions to improve water quality. Full documentation of this strategy is presented in a Technical Memorandum (Barber 2004a, 2004b). The Watershed Management Plans designed monitoring to address human health concerns and fish and other aquatic life issues. Collecting information for improved fisheries management (particularly those listed under ESA) was an essential driver. Many of the proposed sites pose little to no threat to drinking water supplies even under projected population growth estimates. Many of the monitoring sites and parameters would be unnecessary and the frequency of sampling would be different if only human health problems were considered.

Note that this strategy does not entail intensive monitoring of flows and water quality in every subbasin. In order to provide representative data on all subbasins and salmon populations throughout the region, this program also incorporates sampling of specific water quantity and quality samples into normal stream habitat assessment protocols described previously.

4.3.5 Current Monitoring Activities

Long term flow data are available from a number of stream gages operated by the US Geological Survey (USGS) throughout the region (Table 34). Gages are funded by the U.S. Geological Survey and other Federal, State, Tribal, and local agencies, and some industries and utilities. Numerous historical stream gages have been discontinued or converted to stage-only stations, primarily due to lack of funding. At this time there are several stream gages on the Cowlitz River, its tributaries in the upper part of the Cowlitz Basin, and on the Toutle River. The only long-term, continuously-recording flow gages in WRIAs 27 and 28 are in the Lewis River Basin. More recent gages have by installed by CPU and Clark County on Vancouver area streams. Little or no current flow data are available in most Coast or Gorge subbasins.

Table 34. Significant stream gage locations and record summary (LCFRB 2006b, 2006c). Sites in current operation are in bold type. (Some sites with limited time series data are not included.)

Subbasin	USGS Station No.	Name/Location	Drainage Area (mi^2)	Period of Record	Current operation
Grays	14249000	Above S. Fork	40	1956-1976	No
"	14250500	West Fork		1949-1969	No
Elochoman	14247500	Elochoman R. near Cathlamet	66	1940-1971	No
Skamokawa					
Mill, Abernathy,	14246500	Mill Cr. near Cathlamet		1949-1956	No
Germany	14246000	Abernathy Cr. near Longview	20	1949-1958	No
Lower Cowlitz	14243000	Castle Rock	2,238	1926-present	Yes
"	14238000	Below Mayfield Dam	1,400	1934-present	Yes
"	14231000	Randle	541	1910-1911, 1993-present	Yes
"	14239000	Salmon Cr. near Toledo			No
Upper Cowlitz	14226500	Packwood	287	1911-present	Yes
Tilton	14236200	Above Bear Cr. Canyon Cr.	141	1956-present	Yes
Cispus	14231900	Above Yellow Jacket Cr.	250	1996-present	Yes
"	14232500	Randle	321	1910-1996	No
Toutle	14242580	Tower Rd.	496	1981-present	Yes
"	14241500	South Fork	120	1939-1957, 1996-present	Yes
Coweeman	14245000	Kelso (RM 7.0)	119	1951-1982	No
Kalama	14223500	Below Italian Cr. near Kalama	198	1947-1975	No
Lewis NF	14220500	Ariel	731	1922-Present	Yes
	14219800	Speelyai Creek near Cougar		1959-2006	Yes
	14216500	Muddy R. near Cougar		1928-2006	Yes
"	14218000	Near Cougar	481	1924-1958	No
"	14216000	Above Muddy River near Cougar	227	1927-1935, 1955-1970, 2006-Present	Yes
"	14213200	Near Trout Lake	127	1959-1972	No
Lewis EF	14222500	Near Heisson	125	1930-Present	Yes
Salmon	14212000	Near Battle Ground	18.3	1944-1975, 1988-1990, 1992-Present	Yes
"	14211895	Burnt Bridge Cr. at 112th Ave	8	1999-Present	Yes
"	14211898	Burnt Bridge Cr. at 19th St	18	1999-Present	Yes
Washougal	14143500	Washougal	108	1945-1981	No
"	14144000	Little Washougal R. near Washougal	23	1951-1956	No
Bonneville tribs	--	--	--	--	--
Gorge tribs	14123500	White Salmon	386	1912--present	Yes
"	14125000	Little White Salmon near Cook		1957-1978	No
"	14125000	Little White Salmon above Lapham Cr.		1949-1964	No
Wind	14128500	Near Carson		1935-1981	No

A variety of water quality monitoring occurs throughout the basin under the auspices of various local, State, and federal programs and regulations. Washington's Watershed Management Plans (LCFRB 2006b, 2006c) describe local, State, and federal monitoring programs in the study area in detail. Significant water quality monitoring activities currently include:

- U.S. Forest Service, under the Northwest Forest Plan, is monitoring water temperature at 23 stations in the headwaters of the North Fork Lewis and East Fork Lewis Rivers every 30 minutes from June through September.
- U.S. Geological Survey collects some information on water quality (e.g. sediment discharge) at selected stream gage sites.
- Washington Department of Ecology, through their Statewide and regional water quality assessment program, is monitoring five stations in the study area on a monthly basis.
- Clark County is monitoring water quality at ten long-term index stations on tributaries to Lake River, Salmon Creek, Cedar Creek, Lacamas, Little Washougal, and East Fork Lewis River.
- Clark County is also monitoring water quality in the Salmon Creek subbasin, a program that was started in 1995 by Clark Public Utilities.
- PacifiCorp is monitoring water quality at each of its project tailraces on the Lewis River.

Water quality monitoring frequencies, protocols and parameters sampled vary among programs, locations, or even within subbasins due to factors such as the perception of ambient water quality conditions, permit requirements for wastewater discharges, limitation of resources, technical capabilities, and sampling location accessibility monitoring (LCFRB 2006b, 2006c). Waterbody segments or subbasins that are thought to be impaired are typically monitored more intensively than those thought to be unimpaired by pollution. However, the list of 303(d) impaired waterbody segments is also driven by the availability of quality-assured water quality monitoring programs and the ambient water quality data they generate. Thus, the 303(d) list of impaired waterbody segments may not represent a complete inventory of water quality impaired segments or conditions where standards are in violation of water quality criteria.

4.3.6 Information Gaps

Existing water quantity and quality information is not adequate to address the objectives and strategies identified in the watershed management or for salmon recovery plans. Priorities for installation and maintenance of permanent, continuously-recording stream gages for water quantity monitoring were identified by the watershed plans and are summarized in Table 35. Pilot subbasins identified for more intensive stream flow monitoring included the Grays River, Elochoman River, Coweeman River, Lower Cowlitz River tributaries, East Fork Lewis River, and Washougal River. Former and new monitoring sites were identified with priority to former sites to take advantage of previous data collected. As temperature is also a concern for anadromous fish, all monitoring sites would be equipped with temperature gages.

Table 35. Subbasin priorities for stream gage installation and maintenance identified in Watershed Management Plans (LCFRB 2006b, 2006c).

	Name/Location	Status	High	Medium	Lower
Grays	Above S. Fork	Former	X		
	West Fork	Former		X	
	Middle mainstem, South Fork	New		X	
Elochoman	Elochoman R. near Cathlamet	Former	X		
	Elochoman R. upper mainstem	New		X	
Skamokawa	Lower mainstem	New		X	
Mill, Abernathy, Germany	Lower mainstem	New		X	
Lower Cowlitz	Below Mayfield Dam	Current	X		
	Olequa Creek	New	X		
	Salmon Cr. near Toledo	New	X		
	Other tributaries (Lacamas, Leckler, Mill, Delameter, Arkansas Creeks)	New	X		
	Coal Creek/Longview Slough	New			X
Upper Cowlitz	At Packwood	Current	X		
Tilton	Above Bear Creek Canyon Cr.	Current	X		
Cispus	Near Randle	Current	X		
Toutle	At Tower Rd.	Current	X		
Coweeman	Near Kelso	Former	X		
	Upper mainstem	New		X	
Kalama	Below Italian Creek near Kalama	Current		X	
Lewis NF	Ariel	Current	X		
	Speelyai Creek near Cougar	Current	X		
	Muddy R. near Cougar	Current	X		
	Lewis R. Above Muddy R.	New			
Lewis EF	Near Heisson	Current	X		
Salmon	Near Battle Ground	Current		X	
	Burnt Bridge Creek at 112th Ave	Current			X
	Burnt Bridge Creek at 19th St	Current			X
Washougal	Near Washougal	Former	X		
	Little Washougal River near Washougal	Former	X		
Bonneville tribs	Hamilton, Hardy, Duncan	Former			X
Gorge tribs	Little White Salmon R.	Former	--	--	--
	White Salmon R.	Current	--	--	--
Wind	Near Carson	Former	--	--	--

As part of its assessment of water quality information, the Watershed Management Planning Unit reviewed existing water quality monitoring activities being conducted by local, State, and federal agencies. From this review, it was apparent that water quality monitoring activities currently in place are designed to meet specific needs of various programs but are not comprehensive in terms of either the network of streams or the types of parameters monitored. In the absence of a comprehensive monitoring framework at the regional scale, it is difficult to identify impaired water bodies, characterize status and trends in surface water quality, or develop effective approaches to improving water quality.

Watershed Management Plans proposed a Water Quality Analysis Plan (WQAP) for monitoring core water quality information related to flow, temperature, nutrients, and several other parameters at as many as 28 different stream segments (not all parameters measured at each segment). The monitoring plan for field sampled parameters of particular concern to fish is shown in Table 36 and Table 37. Details of core laboratory parameters identified in the WQAP may be found in LCFRB (2006b, 2006c) and Barber (2004a, 2004b).

The WQAP is particularly focused on monitoring for 1) identifying specific existing or emerging water quality problems and 2) characterizing waters and identifying changes or trends in water quality over time. The types of monitoring objectives that the WQAP would address are those concerned with baseline information and background information for identifying long-term trends. A range of options was discussed with the Planning Unit members in order to determine the practical scope of the monitoring plan in terms of what could be expected given funding limitations. It became apparent that given the size of the watersheds in WRIAs 27 and 28, sampling each waterbody for parameters such as macroinvertebrates, pesticides, and heavy metals would be too expensive.

Table 36 Summary of Core Water Quality Parameters in WRIA 25/26 (Table 5.3 in LCFRB 2006b).

Waterbody Segment	Field Sites (locations-frequency)				
	Flow[1]	Dissolved Oxygen	pH	Specific Conductance	Temperature[2]
Abernathy/Germany Creek Subbasin					
Abernathy Creek	1-Q	1-M	1-M	1-M	1-M
Germany Creek	1-Q	1-M	1-M	1-M	1-M
Coal Creek Subbasin					
Coal Creek	1-Q	1-M	1-M	1-M	1-M
Coweeman River Subbasin					
Coweeman River		1-M	1-M	1-M	1-M
Goble Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Mulholland Creek		1-Q	1-Q	1-Q	1-Q
Cowlitz River Subbasin					
Lower					
Cowlitz River		2-M	2-M	2-M	2-M
Olequa Creek		1-M	1-M	1-M	1-M
Ostrander Creek	1-Q	1-M	1-M	1-M	1-M
Upper Cowlitz River		1-M	1-M	1-M	1-M
Elochoman River Subbasin					
Elochoman River	1-Q	2-M	2-M	2-M	2-M
West Fork		1-T	1-T	1-T	1-T
Grays River Subbasins					
Grays River	1-Q	1-M	1-M	1-M	1-M
Hull Creek		1-M	1-M	1-M	1-M
South Fork Grays River	1-Q	1-T	1-T	1-T	1-T
West Fork Grays River	1-Q	1-M	1-M	1-M	1-M
Toutle River Subbasin					
Green River		1-M	1-M	1-M	1-M
North Fork Toutle River	1-Q	2-M	2-M	2-M	2-M
South Fork Toutle River	1-Q	2-M	2-M	2-M	2-M
Toutle River	1-Q	1-M	1-M	1-M	1-M

A – annually, C – continuously, M – monthly, T – two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled
[1] Download of continuous stage recorder and rating curve development
[2] Verification of continuous temperature loggers

Table 37 Summary of Core Water Quality Parameters (WRIA 27/28)

Waterbody Segment	Field Sites (locations-frequency)				
	Flow[1]	Dissolved Oxygen	pH	Specific Conductance	Temperature[2]
Burnt Bridge Creek Subbasin					
Burnt Bridge Creek	3-Q	3-M	3-M	3-M	3-M
Columbia River Tributaries					
Gibbons Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Greenleaf Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Kalama Subbasin					
Kalama River	1-Q	1-T	1-T	1-T	1-T
Little Kalama River	1-Q	1-T	1-T	1-T	1-T
Lacamas Creek Subbasin					
China Ditch		1-T	1-T	1-T	1-T
China Lateral		1-T	1-T	1-T	1-T
Fifth Plain Creek	1-Q	1-M	1-M	1-M	1-M
Lacamas Creek	2-Q	2-M	2-M	2-M	2-M
Mill Ditch	1-Q	1-M	1-M	1-M	1-M
Shanghai Creek		1-M	1-M	1-M	1-M
Lake River Subbasin					
Lake River		2-M	2-M	2-M	2-M
Lewis River Subbasin					
Lewis River		2-T	2-T	2-T	2-T
Burris Creek		1-Q	1-Q	1-Q	1-Q
Salmon Creek Subbasin					
Mill Creek	1-Q	1-M	1-M	1-M	1-M
Morgan Creek	2-Q	1-T	1-T	1-T	1-T
Salmon Creek	1-Q	2-M	2-M	2-M	2-M
Weaver Creek		1-M	1-M	1-M	1-M
Washougal Subbasin					
Washougal River Site 1	1-Q	1-T	1-T	1-T	1-T
Washougal River Site 2		1-T	1-T	1-T	1-T
Little Washougal River	1-Q	1-T	1-T	1-T	1-T
West Fork Washougal		1-T	1-T	1-T	1-T

A – annually, C – continuously, M – monthly, T – two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled
[1] Download of continuous stage recorder and rating curve development
[2] Verification of continuous temperature loggers
Note: Monitoring shown here is in addition to active, ongoing monitoring activities (see Appendix K)

4.3.7 Implementation Actions

M.M-12. Maintain existing stream flow gages over the long term and install additional permanent gages as per recommendations and priorities identified in Watershed Management Plans.

Priority: Very High

Lead: USGS

Rationale: For purposes of improving stream flow management in the region, it is important that existing stream gages be maintained over the long term and that additional, permanent stream gages are installed. Recommendations for stream gaging at specific sites are provided in The Watershed Management Plans (LCFRB 2006b, 2006c).

6 Year Implementation Work Schedule Activities**:**

f. Inventory current funding levels and sources.

g. Solidify long-term commitments to maintain adequate funding.

M.M-13. Implement a systematic water quality monitoring program based on existing and enhanced activities as per recommendations and priorities identified in Watershed Management Plans.

Priority: Very High

Lead: WDOE

Rationale: Water quality monitoring activities currently in place are designed to meet specific needs of various programs but are not comprehensive in terms of either the network of streams or the types of parameters monitored (LCFRB 2006b, 2006c). In the absence of a comprehensive monitoring framework at the regional scale, it is difficult to identify impaired water bodies, characterize status and trends in surface water quality, or develop effective approaches to improving water quality.

6 Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.

b. Solidify long-term commitments to maintain adequate funding.

c. Identify data reporting schedules

d. Identify constraints and uncertainties

e. Identify coordination considerations.

M.M-14. Incorporate selected water quantity and quality metrics into systematic stream habitat survey protocols identified in section 1.2.6 of this program in order to provide broad regional coverage of key limiting factors.

Priority: Very High

Lead: WDFW

Rationale: Monitoring activities identified in the Watershed Management Plans provide detailed information on selected sites and are also concentrated in subbasins where water management issues are intensive. Additional information is needed in other areas in order

to provide broad regional representation of parameters that limit fish (temperature, dissolved oxygen) or are related to limiting factors (conductivity). These parameters can be easily and inexpensively incorporated into standard stream habitat sampling protocols.

6 Year Implementation Work Schedule Activities**:**

a. Inventory current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify data reporting schedules
d. Identify constraints and uncertainties
e. Identify coordination considerations.

5.0 Implementation/Compliance Monitoring

Implementation and compliance monitoring determines whether actions were implemented as planned or meet established laws, rules, and benchmarks. Salmon Recovery and Watershed Plans for the lower Columbia Region identify over 650 specific actions for implementation by 82 partners. Partners include a broad spectrum Federal, State, and local governmental agencies, as well as a variety of nongovernmental organizations (Table 38). Neither of these plans has the authority to mandate implementation of these actions. Objective success will thus depend on voluntary implementation of actions. Implementation & compliance monitoring is one of the simplest and most direct measures of whether the plan is being followed as designed.

Successful implementation of all actions may or may not affect salmon owing to uncertainty in the significance of many limiting factors and in net effectiveness of many actions. NOAA (2007) notes that this type of monitoring cannot direct link restoration actions to response as physical, chemical or biological parameters are not measured. However, failure to implement significant actions identified in the plan is likely to result in failure to achieve the desired biological outcomes.

5.1 Objectives

1. Determine whether actions identified in the Salmon Recovery Plan were implemented as planned.
2. Determine whether actions meet established laws, rules, and benchmarks specific to each action

5.2 Strategy

1. Complete comprehensive assessments of action implementation and compliance at e-year intervals for the purpose of evaluating Recovery Plan progress.

A 2-year assessment interval is identified by the recovery plan for implementation & compliance monitoring. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 2-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

2. Rely on implementing agencies to identify, evaluate and report on progress in the implementation and compliance of specific actions identified by the plan.

Implementing partners are identified in the plan for every action. Partners are expected to implement these actions by maintaining current programs where adequate, revising existing programs where necessary, and developing new programs where missing. Tracking and reporting progress for actions under their responsibility is part and parcel to their accountability for plan implementation.

3. Develop and maintain a centralized clearinghouse and database to track and summarize action implementation.

Periodic evaluations of plan progress and appropriate course corrections will be based on a summary and review of action implementation and compliance. This evaluation will be facilitated through use of a centralized clearing house and database.

Table 38. Numbers of implementation actions identified in Washington Lower Columbia River Salmon Recovery Plan by implementation partner.

Partner	Threat/ Type									
	Habitat	Hydropower	Mainstem/ Estuary	Harvest	Hatchery	Ecological	Implementation	Monitoring	All	No. of Actions
Battleground	6									9
BPA	2	1							1	6
BPA/NPCC	1								1	6
Camas	7									13
Castle Rock	5									5
Cathlamet	6									6
Chinook	4									4
Clark CD	6								1	7
Clark Co	8								1	9
Clark PU	1									1
Conservation Commission	1									1
County Noxious Weed Control Boards	1									1
Cowlitz Co	9		3							12
Cowlitz PUD									1	1
Cowlitz Tribe	3									3
Cowlitz/Wahkiakum CD	5		1						1	7
CREST			1							1
EPA			1							1
FERC	3	1								4
Implementing Partners								34		34
Kalama	7									7
Kelso	8									8
LCFEG	7								1	8
LCFRB	3						1			4
LCFRB/RPOC							22			22
LCREP			1						1	2
Lewis CD	5								1	6
Lewis Co	7									7
Lewis Health Districts	1									1
Longview	7									7
Morton	4									4
Mossyrock	3									3
NOAA	1	3	2	21	9	2	3		1	42
Non Governmental Orgs.	5		2		1					8
NPCC/BPA		3	3			2				8
NRCS	2		1							3
Pacific CD	4		1						1	6
Pacific Co	6		3							9
Pacific Co Health Districts	1									1
PacifiCorp	3	2			3				1	9
Port of Camas/Washougal	1									1
Port of Kalama	2									2
Port of Longview	1									1
Port of Vancouver	3									3
PSMFC	1					1				2
Skamania Co	7									7

Partner	Threat/ Type									
	Habitat	Hydropower	Mainstem/ Estuary	Harvest	Hatchery	Ecological	Implementation	Monitoring	All	No. of Actions
Skamania Health Districts	1									1
SRFB	1									1
State Noxious Weed Control Board	1									1
State Parks	1									1
Tacoma Power	3	2			3				1	9
Tribes				5						5
Underwood CD	5								1	6
USACE	3	3	3						1	10
USFS	2									2
USFWS	4		1	5	34	5			1	50
USGS									1	1
Vancouver	8									8
WADA	2									2
Wahkiakum Co	6		3							9
Wahkiakum Health Districts	1									1
Washougal	7									7
WDFW	12	1	2	34	45	9			1	104
WDNR	5								1	6
WDOE	5		1						1	7
Winlock	6									6
Woodland	8									8
WRIA 25/26 Planning Unit	1									1
WRIA 27/28 Planning Unit	1									1
WSDOT	2									2
Yakama Nation	2									2

5.3 Indicators

Action implementation and compliance is evaluated based on identification and completion of tasks specific to each action. Tasks are simply subactions identified by the implementing agent. Evaluations are based on partner and action assessments. Partner assessments describe progress in the implementation of all actions and tasks under the responsibility of each implementing partner (Table 39). Action assessments describe progress in the implementation of all actions and tasks across partner (Table 40).

Table 39. Example data for action implementation/compliance monitoring at the partner assessment level.

		No. of	No. of tasks			
Partner	Type/Threat	actions	Identified	Completed	Pending	Overdue
WDFW	Habitat					
	Mainstem/Estuary					
	Hydropower					
	Harvest					
	Hatchery					
	Ecological					
	Implementation					
	Monitoring					

Table 40. Example data for action implementation/compliance monitoring at the action assessment level.

		No. of	No. of tasks			
Type/Threat	Action	partners	Identified	Completed	Pending	Overdue
Habitat	101 Floodplain protection					
	102 Native plant restoration					
Mainstem/Estuary						
Hydropower						
Harvest						
Hatchery						
Ecological						
Implementation						
Monitoring						

5.4 SalmonPORT

SalmonPORT (Salmon Partners Ongoing Recovery Tracking) is a web-tool designed to track actions and activities identified in the Plan in an efficient and effective manner. Salmon PORT is an interactive system that allows users to add, review, and edit IWS elements. Salmon PORT is designed to answer basic questions regarding how and when recovery actions are completed, and at what cost. This system will help to establish benchmarks and milestones, and identify impediments to implementation such as budgetary and logistical constraints. It will also allow users, agencies and the public to access information and view a variety of reports related to implementation of salmon recovery efforts.

Figure 20. Salmon PORT interface page at http://www.lowercolumbiasalmonrecovery.org/.

S-PORT provides partnering agencies, local governments, organizations, and the public in the lower Columbia with the ability to track their activities and progress in managing their watersheds. Users of S-PORT and involved entities can enter and maintain information on salmon recovery and watershed management actions for their program or for the specific unit within an agency or organization. This interactive website is intended for use in updating and changing information as needed, coordinating efforts among the partners, and monitoring progress and deadlines. Users and the interested public can query information and create reports through this database to obtain information about progress and agencies or organizations that are responsible. A multitude of queries can be applied; including searches by action, subbasin, partners, and others. Salmon PORT also provides added levels of functionality to participating entities/users pertaining to its own progress and tasks.

Table 41. Salmon PORT worksheet for database entry of implementation partner works schedules.

LOWER COLUMBIA SALMON RECOVERY
PARTNER'S IMPLEMENTATION WORK SCHEDULE
SALMON PORT WORKSHEET

ACTIVITY SECTION Purpose: Implementation partners are encouraged to draft work schedules using Salmon PORT. The following form is provided to assist you with developing or revising programs that affect salmon recovery. Completing this form for each activity will provide the basis for entering and monitoring information in Salmon PORT. Additional information is available by contacting the Lower Columbia Fish Recovery Board at 360 425-1555.	
Activity Name	*Name of project or program addressing an action or set of actions*
Partner	*Name of implementing organization*
Objective	*Describe the goals and objectives of the activity as they relate to the action(s).* *[200 character limit including spaces]*
Explanation	*Briefly describe the plan for implementing the activity identified for a specific program or organizational unit. Provide a clear and concise summary of the goals, objectives and expected outcomes related to implementation of the recovery actions for the six-year period (2006-2011). Goals should be a general statement of what you hope to achieve. For example, the goal of a county's land use program might be to protect habitat from further decline.* *[1500 character limit including spaces]*
Is this a New, Existing or Revised activity?	*Many of the actions included in the recovery plan are already mandated by existing laws, administrative rules, regulations or policies and would be implemented regardless of whether or not a salmon recovery program is implemented. In some cases, development of new activities, or revisions to existing ones, will be needed to complete recovery plan actions.*
	☐ New ☐ Existing ☐ Revised
Total Activity Cost for all tasks in all years	*Many of the actions included in the recovery plan are already mandated and will be completed regardless of whether or not a salmon and steelhead recovery program is implemented. The purpose of this section is to develop cost estimates for implementation of recovery actions that either exceed existing requirements or are not currently required under existing laws, rules or policies. For example:* *i. Costs associated with implementing programs or actions required under existing laws, rules, and regulations would not be included. This includes the costs associated with ESA Section 7 consultations.* *ii. The incremental costs associated with enhancing or expanding existing programs to implement recovery actions beyond what is required by existing laws, rules, and regulations would be included.* *iii. The cost of developing and implementing new programs to implement recovery actions not required by existing laws, rules, and regulations would be included.*
	Salmon PORT automatically calculates and enters the total cost identified in the following tasks
Annual Key Cost Drivers	*Describe the key costs and whether the costs will change during the course of the activity.* *[200 character limit including spaces]*
Has this activity been fully funded?	*Where an activity is proposed for implementing a recovery action(s), identify whether the activity is fully funded. If not, what steps will be taken to fully fund and implement the program?* *Where new or modified activities are proposed, describe what steps will be taken to fully fund and implement the program.*
	☐ Yes ☐ No

What has not been funded and to what extent?	*Describe what tasks have not been funded and how you expect to address this limitation.* *[1000 character limit including spaces]*
What action(s) are addressed by this activity?	*Identify the specific actions that will be addressed by the proposed activity [Salmon PORT automatically filters for the partner's actions]*
	Action # _____ Action # _____ Action # _____ Action # _____ Action # _____ Action # _____ Action # _____ Action # _____
Is the action(s) fully addressed by this activity?	*This question focuses on the partner's contribution to the action(s), recognizing that multiple partners may be involved. The partner may consider the action fully addressed if there is only 1 activity and 1 partner associated with the action(s). If more than 1 activity is needed to accomplish the action, then identify the action as not being fully addressed.* *Actions requiring coordination between partners or that are dependent upon another partners activity(s) should also be identified as not being fully addressed.*
	☐ Yes ☐ No

TASK SECTION

Purpose: In the following section, describe the specific tasks needed to complete the activity identified above. Tasks are defined by the partner and may be related to another work plan already in place, or to a discrete set of steps necessary to achieve the goals of the activity. Specific milestones or timelines related to each task should be provided where possible. Tasks should provide sufficient detail to ensure the activity is successfully implemented. There is no limitation to the number of tasks. The form should be duplicated to provide space for additional tasks as needed.

Task Name	*Name the specific task*
Expected outcome or milestone	*Briefly describe the objective and outcomes related to this task.* *[200 character limit including spaces]*
Schedule	
Start Date	*Month, day and year are required fields. If you chose to use month and year only please select the first or last day of the month as a default day.*
	MM/DD/YYYY
Planned Completion	*Month, day and year are required fields. If you chose to use month and year only please select the first or last day of the month as a default day.*
	MM/DD/YYYY
Actual Completion	*If the task is completed both the planned and actual completion dates should be the same entry.*
	MM/DD/YYYY

Cost

Cost for each year should include the incremental cost for the task. The total is automatically calculated.

Period Beginning	Amount
MM/2006	$
MM /2007	$
MM/2008	$
MM/2009	$
MM/2010	$
Total	*Automatic calculation*

Challenges

Constraints Or Uncertainties	*Identify policy, legal, budget, social, or cultural constraints or uncertainties that could affect implementation of the activity. Identify and briefly describe them.* *[200 character limit including spaces]*
Response	*For each constraint or uncertainty, briefly describe how it will be addressed to achieve the expected outcomes.* *[200 character limit including spaces]*

Coordination

	For each partner you identify, please provide a summary of the dependent relationship(s) this task has with the partner or the coordination necessary to complete this task. *[200 character limit per partner; additional spaces may be added for more partnering entities]*

Name Partnering entity:	
☐ Dependent ☐ Coordination	Activity description:
Name Partnering entity:	

Subbasins

Select the subbasins this task will address [subbasins may vary from task to task]

☐ Estuary Tributaries	☐ Lower NF Lewis
☐ Estuary Mainstem Columbia	☐ Upper NF Lewis
☐ Grays	☐ EF Lewis
☐ Elochoman/Skamokawa	☐ Salmon
☐ Mill/Abernathy/Germany	☐ Washougal
☐ Lower Cowlitz	☐ Bonneville Tributaries (Hamilton, Hardy, Duncan)
☐ Upper Cowlitz (and Tilton and Cispus)	☐ Wind
☐ Toutle	☐ Upper Gorge Tributaries
☐ Coweeman	☐ Little White Salmon
☐ Kalama	

Species

Select the species this task will address [species may vary from task to task]

☐ Fall Chinook Tules	☐ Summer Steelhead
☐ Fall Chinook Brights	☐ Chum
☐ Spring Chinook	☐ Coho
☐ Winter Steelhead	☐ Bull Trout

5.5 Implementation Actions

2. Maintain a coordinated database of federal, tribal, state, local, and on-governmental programs and projects implemented throughout the recovery region.

Lead: LCFRB

Funding source: To be determined

Rationale: The LCFRB has been specifically charged with development and oversight of recovery plan implementation throughout the Washington lower Columbia River region. In order to determine if recovery actions are being conducted and objectives met, implementation and compliance monitoring will be spearheaded by the newly developed SalmonPORT (S-Port) database.

2-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

3. Periodically summarize and report action implementation progress at the task level using the LCFRB Salmon PORT database system.

Lead: All implementing partners

Funding source: To be determined

Rationale: Reporting will occur at biennial intervals.

2-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

4. Prepare biennial reports of progress in implementation and compliance of recovery actions.

Lead: LCFRB

Funding source: To be determined

Rationale: The LCFRB has been specifically charged with development and oversight of recovery plan implementation throughout the Washington lower Columbia River region.

2-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

6.0 Action Effectiveness Monitoring

Action effectiveness monitoring is defined in this program to evaluate the significance and status of threats to listed salmon and steelhead status, and changes in threat levels associated specific types of recovery actions. This monitoring is specifically intended to evaluate the status and trends in statutory listing factors identified by NOAA (NOAA 2007).

In this focused monitoring effort, functional effectiveness has been purposefully distinguished from biological effectiveness. Although biological effectiveness is the ultimate goal in recovery planning, population trends take many years to appear and are frequently confounded by the effects of environmental variability and uncertainty. As such, functional effectiveness serves as a more proximate and tractable measure of progress. Where species and habitat status and trend monitoring weighs the aggregate effect of a full complement of protection and restoration actions, action effectiveness monitoring considers the incremental effects of specific actions or suites of actions that affect habitat, hydropower, hatchery, fishery, and ecological interaction threats. Action effectiveness monitoring ultimately helps determine which actions work the best and what level of contribution toward recovery is contributed by an action or suite of actions.

Effects of actions may be estimated directly based on estimates of desired fish population attributes (e.g., abundance, productivity, spatial structure, diversity) or indirectly based on effects on limiting factors or causative mechanisms. Formal experiments and rigorous statistical analysis may be required, for instance involving test and control populations. Action effectiveness monitoring complements and utilizes the same information needed for status and trend monitoring of fish and habitat status.

Monitoring and evaluation plans in other regions have sometimes adopted a more narrow definition of action effectiveness monitoring specifically focused on research on cause and effect relationships.

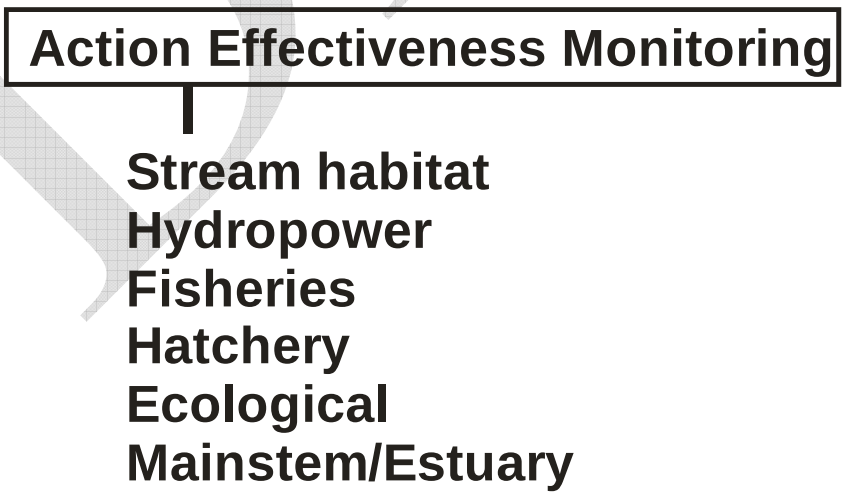

Figure 21. Categories of action effectiveness monitoring addressed by this plan.

6.1 Habitat

6.1.1 Objectives

Habitat action effectiveness monitoring is intended to determine if specific protection and restoration projects function as planned. Where the baseline habitat status and trend monitoring generally provides a more global picture of the net effects of all activities on conditions for fish, habitat action effectiveness monitoring is focused on the specific proximate effect of a particular action. Where habitat action implementation/compliance monitoring evaluates whether actions were implemented as planned, action effectiveness monitoring evaluates whether they function as intended.

Stream habitat action effectiveness monitoring has many elements in common with habitat status and trend monitoring but generally addresses a much narrower set of objectives. For instance, where habitat status and trend monitoring might quantify the number of stream miles accessible to anadromous salmonids, action effectiveness monitoring might evaluate whether culvert replacement has effectively increased access to a given amount of suitable habitat. Habitat action effectiveness monitoring addresses stream habitat, water quality and flow, and watershed actions.

Box 5. Questions addressed by habitat action effectiveness monitoring.

1. **Have passage improvement actions increased access to significant amounts of suitable habitat for salmonids?**
2. **Have channel structure and bank stability improvement actions increased habitat quantity and quality for salmonids?**
3. **Have off-channel and side-channel improvement actions increased habitat quantity and quality for salmonids?**
4. **Have floodplain restoration actions increased habitat quantity and quality for salmonids?**
5. **Have water quality improvement actions increased habitat quantity and quality for salmonids?**
6. **Have water flow-related actions increased habitat quantity and quality for salmonids?**
7. **Have watershed actions increased watershed functions deemed beneficial to stream salmonid habitats?**

6.1.2 Strategy

1. Complete comprehensive assessments of habitat action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.

A 6-year assessment interval is identified by the recovery plan for the effectiveness of actions relative to baseline conditions and benchmarks. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

2. ***Monitor the effectiveness of habitat-related actions affection the stream, water quantity and quality, and watershed conditions.***

The recovery plan identifies actions specific to each of these factors. Stream habitat related actions that address access to habitat blocked by artificial barriers, stream channel habitat structure and bank stability, off-channel and side-channel habitat, floodplain function and channel migration processes, and riparian conditions and functions. Water quantity and quality measures address limiting factors such as temperature, the adequacy of instream flows during critical periods, and the effects of regulated stream flows on critical habitat functions. Watershed measures address watershed conditions and hillslope processes (e.g. runoff and sediments) that affect stream habitats.

3. ***Develop and maintain a comprehensive up-to-date inventory of habitat-related actions across the region.***

A comprehensive project inventory is a basic first step in accurately evaluating the significance of habitat actions intended to improve fish status and ameliorate habitat-related threats. Projects are being implemented by a tremendous variety of parties which makes it difficult to characterize the nature and extent of these activities. An inventory is one simple measure of the significance of the effort expended.

4. ***Intensively monitor the effectiveness of a subset of representative habitat actions using a formal statistical research design.***

It is neither necessary nor feasible to conduct intensive scientific evaluations of the effectiveness of every habitat action. Resources are limited and benefits of monitoring to assure that actions are beneficial must be balanced with the costs of monitoring. Intensive effectiveness monitoring activities should be focused on a representative subset of actions. Effects of other similar actions may then be judged based on inference.

5. ***Estimate and report the physical and biological effects and functional lifespan of every habitat-related project or program implemented in the region based on site-specific evaluations or by inference from similar project types elsewhere.***

While every habitat project need not be evaluated with a formal statistically-designed research project, every project should describe or estimate expected benefits as required step in the proposal, design or implementation stage. This information will formalize considerations of assumed or expected benefits, highlight situations where basic effectiveness monitoring information is lacking and provide basic data to the regional habitat action inventory. This will force implementers to ask and answer what they intend to accomplish with any given project.

6. ***Conduct habitat action effectiveness monitoring in close and complementary association with habitat status and trend monitoring.***

Habitat status and trend monitoring has many common elements with habitat action effectiveness monitoring. Wherever possible action effectiveness monitoring should capitalize on information that is useful for multiple applications. Action effectiveness monitoring should also adopt comparable metrics and protocols where appropriate. It is not likely, however, that habitat status and trend monitoring will provide the fine scale habitat data needed to evaluate site-specific changes. Nor is it likely that action effectiveness habitat monitoring will always provide habitat data suitable that is representative of a broader region.

6.1.3 Indicators

Habitat action effectiveness indicators are identified for stream, water, and watershed characteristics in Table 42. Statistics describe the action, response, and functional lifespan of each project. Action descriptions that may be qualitative or quantitative. Response descriptions may include physical or biological parameters. Lifespan of effect is of particular importance in evaluating short term vs. long term benefits. Response indicators for habitat action effectiveness monitoring have been categorized into three levels by the WSMOC (2003). Level 1 involves continued physical function as designed (e.g. did it survive high water?). Level 2 involves a physical response (e.g. did it provide the desired fish habitat condition?). Level 3 involves a biological response (e.g. were fish use and density affected as expected?)

6.1.4 Sampling and Analytical Design

This plan generally adopts habitat action effectiveness monitoring designs and protocols developed by the Washington Salmon Recovery Board. An overarching approach to habitat action effectiveness monitoring was described in Washington's comprehensive monitoring strategy and action plan for watershed health and salmon recovery (WSMOC 2002). Results of reach scale effectiveness monitoring activities are reported annually by the Salmon Recovery Funding Board (WSSRFB 2007). Protocols for intensive habitat action effectiveness monitoring study designs have been developed by the WSSRFB for a variety of project types (Table 42).

This plan identifies two levels of habitat action effectiveness evaluation design.

Intensive

Intensive habitat action effectiveness monitoring involves a carefully designed and controlled scientific research design to describe physical and/or biological changes associated with a given project. It often employs a robust Before-and-After-Control-Impact (BACI) design. A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred (WSSRFB 2004). This design tests for changes at the area of impact relative to changes observed in a comparable control site where no impact occurs. This type of design is required when effects of external factors can confound before and after comparisons at the project site. An intensive sampling design for habitat action effectiveness typically involves repeated sampling over a period of years following project implementation. An intensive sampling regimen may also involve evaluations of project function as design (a level I response), physical effects of the project (a level II response), and biological effects (a level III response). Drawbacks of this design are the costs and years of data required. As a result, it is not feasible or desirable to implement an intensive action effectiveness monitoring effort for every project.

Extensive

This plan defines extensive habitat action effectiveness monitoring based simply on level I indicators that describe whether a project continues to function as designed for a specified period. Continued function along with assumed physical and biological benefits provide a sound basis for assuming project effectiveness where more intensive monitoring has demonstrated effectiveness of comparable projects. Extensive monitoring can provide basic data on a large number of projects in a cost effective manner.

Table 42. Example statistics describing habitat actions for use in effectiveness monitoring.

				Response Indicators			
Feature	Factor	Example Project types	Descriptive statistics	Level I	Level II	Level III	Protocol[1]
Stream	Access	Culverts, bridges, fishways, logjams, dam removal, debris removal	Number & type of improvements Affected stream length	Continued function as designed or placed	--	Species affected Fish use/density	MC-1
	Instream structure	Reconfiguration, deflectors, log & rock control structures, roughened channels, spawning gravel	Number & type of improvements Miles treated	Continued function as designed or placed	Pool frequency, stream width, substrate	Species affected Fish use/density	MC-2, MC-7
	Off-channel & side channel	Channel connectivity, channel or alcove construction	Number & type of improvements Effective area	Continued function as designed	Physical stream measurements	Species affected Fish use/density	MC-5
	Floodplain	Dike removal/setback, riprap removal, road removal/setback, landfill removal, wetland restoration	Number & type of improvements Effective area	Continued function as designed	Channel profile & capacity Pool frequency & depth	Species affected	MC-6
	Riparian	Planting, invasive plant removal or control, livestock exclusion	Number & type of improvements Stream length, width of zone Acres affected	Plant survival, plant reinvasion, fencing intact	Bank shading or erosion Canopy complexity	Species affected	MC-3, MC-4
Water	Quality	Point & non-point sources	Number & type of improvements	Continued function as designed	Temperature Contaminants	Species affected Fish use/density	
	Nutrients	Stream fertilization, carcasses or analogs	Area treated Volume of treatment	Continued function as designed		Species affected Fish use/density	
	Flow	Water lease or purchase, irrigation practice	Number & type of improvements Amount of flow (cfs) by time of year, water volume (acre ft.)	Continued function as designed	Stream flow	Species affected	
	Flow Regulation	Irrigation diversion dams, water treatment plants, pipes, ditches, head gates	Number & type of improvements	Continued function as designed	Stream flow	--	MC-8
Watershed	Condition	Sediment reduction, upland agriculture, upland vegetation,	Number & type of improvements Miles of affected road Acres affected	Continued function as designed	Stream, riparian, upland characteristics	Species affected Fish use/density	MC-10
	Protection		Affected area	Continued function as designed	Stream, riparian, upland characteristics	Fish & macro invertebrates	MC-10

1 Report number reference for Washington Salmon Recovery Funding Board action effectiveness monitoring protocols (http://www.rco.wa.gov/srfb/docs.htm#strategy).

6.1.5 Current Monitoring Activities

A comprehensive list of all current habitat action-related monitoring activities may be found in the appendix.

6.1.6 Information Gaps

A comprehensive assessment of information gaps will require analysis of specific datasets relative to the information needs identified above. This work is identified in implementation actions.

6.1.7 Implementation Actions

1. ***Maintain current habitat effectiveness monitoring activities of all significant habitat protection and restoration programs.***

   Lead: All habitat agencies

   Funding source: Various

   Rationale: Current action effectiveness monitoring programs provide critical information regarding adequacy to address statutory listing factors.

   6-year Implementation Work Schedule Activities**:**

   a. Identify current funding levels and sources.
   a. Solidify long-term commitments to maintain adequate funding.
   b. Identify constraints and uncertainties.
   c. Identify coordination considerations.

2. ***Develop and maintain a comprehensive up-to-date database inventory of habitat-related actions across the region.***

   Lead: LCFRB

   Funding source: To be determined

   Rationale: Actions are distributed among a wide spectrum of parties. Data is needed to provide basic information on the scale of habitat-related recovery action. The LCFRB is uniquely situated to implement this action.

   Activities**:**

   a. Identify appropriate opportunities and funding sources.
   b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
   c. Identify constraints and uncertainties
   d. Identify coordination considerations

3. ***Formalize effectiveness monitoring activities for habitat-related actions by every implementing party by identifying expected benefits, describing criteria by which effectiveness will be monitored, and referencing the basis for estimated benefits.***

   Lead: All habitat agencies

   Funding source: Various

   Rationale: Some consideration of action effectiveness needs to be incorporated into every habitat protection and restoration action although every action does not require an intensive controlled pre and post project evaluation. Tasks and activities that address

effectiveness monitoring should be a design element of every habitat-related project or program.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

4. Implement focused investigations of critical assumptions and uncertainties related to the effectiveness of representative types of habitat protection and restoration actions.

Lead: All habitat agencies

Funding source: To be determined.

Rationale: Current assessments rely on a series of critical assumptions which affect the accuracy of those estimates. Intensive evaluations of representative actions will provide a basis for inference of similar actions throughout the basin.

Activities**:**

a. Identify appropriate funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

6.2 Hydropower

6.2.1 Objectives

Hydropower action effectiveness monitoring is intended to determine if related fish protection, restoration, and mitigation actions reduce or limit effects on wild fish to levels consistent with the conservation and recovery of listed fish species while also achieving desired fish production benefits. Construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control have fundamentally altered habitat conditions for fish and particularly anadromous fish throughout the Columbia River basin by the. Lower Columbia salmon, steelhead and trout are threatened by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage; and ecological changes in impoundments. Dams in the Lewis, Cowlitz, and White Salmon subbasins have blocked access by anadromous fishes to large areas of productive habitat.

Box 6. Questions and hypotheses addressed by hydropower action effectiveness monitoring.

Question #1. Are juvenile and adult passage and survival though hydropower facilities effectively limited to target levels for each program consistent with recovery?

Null hypothesis: Juvenile and adult passage and survival through hydropower facilities are not effectively limited to target levels for each program consistent with recovery.

Alternative: Juvenile and adult passage and survival through hydropower facilities are effectively limited to target levels for each program consistent with recovery.

Question #2. Are upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities effectively limited to target levels for each program consistent with recovery?

Null hypothesis: Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are not effectively limited to target levels for each program consistent with recovery.

Alternative: Upstream and downstream habitat, water quantity, and water quality effects of hydropower facilities are effectively limited to target levels for each program consistent with recovery.

Question #3. Are fish reintroduction efforts into previously-blocked tributaries meeting population viability objectives identified in the recovery plan?

Null hypothesis: Fish reintroduction efforts in tributaries are not meeting population viability objectives identified in the recovery plan.

Alternative: Fish reintroduction efforts in tributaries are meeting population viability objectives identified in the recovery plan.

Question #4. Are hydropower mitigation benefits for fish adequately meeting prescribed program objectives?

Null hypothesis: Mitigation benefits are not meeting program objectives.

Alternative: Mitigation benefits are meeting program objectives.

6.2.2 Strategy

1. ***Complete comprehensive assessments of hydropower action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.***

A 6-year assessment interval is identified by the recovery plan for the effectiveness of hydropower actions relative to baseline conditions and benchmarks. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

2. ***Evaluate hydropower action effectiveness for passage, habitat protection and restoration, reintroduction and mitigation-related impacts on salmon and steelhead at all significant mainstem and tributary facilities that currently limit the viability of listed lower Columbia River populations.***

Hydropower facilities that affect Washington populations of lower Columbia River salmon include Bonneville Dam on the mainstem Columbia River, multi-dam complexes blocking the upper portions of the Cowlitz and Lewis systems to anadromous fish, and Condit Dam on The White Salmon River which also blocks anadromous passage. The recovery plan identifies significant actions for the benefit of listed populations involving each of these facilities.

3. ***Monitor facility operations that potentially affect fish or fish habitat.***

This includes normal operations data on inflow, outflow, spill, turbine operations, bypass and fishway operations, etc.

4. ***Conduct intensive annual monitoring and evaluation of juvenile and adult passage.***

Annual monitoring of fish passage is necessary to evaluate the effectiveness of current facilities. Both adult and juvenile passage need to be monitored.

5. ***Monitor and evaluate effectiveness of hydro-related habitat measures based on downstream effects on stream habitat characteristics, water quantity, and water quality.***

Downstream habitat effects of hydro operations can significantly affect fish migration, spawning and rearing conditions either directly or indirectly via influences on habitat forming processes.

6. ***Monitor effectiveness of adaptively-implemented reintroduction efforts above tributary facilities in the Cowlitz, Lewis, and White Salmon rivers based on net productivity.***

Recovery of several lower Columbia River species to meet criteria identified by the Technical Recovery Team cannot be achieved without restoring viable populations in several areas currently blocked to anadromous fish by hydropower facilities. The success of these reintroduction efforts will depend on achieving a net productivity measured in terms of net replacement rates.

7. ***Monitor effectiveness of additional actions designed to mitigate hydropower impacts, where appropriate.***

In some cases, hydro actions involve mitigation for impacts through the implementation of other beneficial measures rather than direct remedies for the effects of facilities. The monitoring and evaluation program needs to include considerations of mitigation action effectiveness.

8. Implement hydropower monitoring programs consistent with requirements of Federal Energy Commission Licenses, Biological Opinions, and other plans and agreements.

Monitoring and evaluation activities related to hydropower facilities are described, directed and governed by a variety of existing licenses, opinions, and agreements. The monitoring and evaluation strategy for hydropower action effectiveness relative to salmon recovery must be implemented in the context of the existing programs. It is expected that existing programs have fully address needs identified in the recovery plan or are in the process of revision to ensure the adequacy of existing programs relative to recovery needs.

6.2.3 Indicators

6.2.3.1 Attributes & Metrics

Hydropower indicators are identified for operations, passage, habitat, and reintroduction metrics. Operations are simply project activities with the potential to affect fish. Passage includes both juveniles and adults and a variety of related metrics and terms are in current usage depending on the nature of the dam and passage facilities. Habitat effects related to hydropower include water flow patterns, water quality, physical habitat features affected by flow and material recruitment processes. Reintroduction involves the rebuilding of viable populations in areas currently blocked from anadromous production. Mitigation refers to other activities designed to improve fish status affected by hydropower facilities.

Table 43. Attributes, metrics, and example statistics for potential use as indicators of hydropower effects.

Attribute	Related Metrics	Example
Operations	--	Facility activities that potentially affect fish
	Project-specific	Discharge, spill, turbine operations, gate/weir openings, bypass and operations, fishway operations
Passage	--	Effective movement through hydropower facilities
	Collection efficiency	Proportion of t juvenile population that passes a facility.
	Fish guidance efficiency	Proportion of juveniles entering turbine intakes that are guided into a bypass
	Fish passage efficiency	Proportion of juvenile migrants that pass a dam via non-turbine routs
	Passage survival	Proportion of the adult or juvenile population that survives passage of passage (may be net or route-related)
	Conversion rate	Proportion of adult population that passes a facility and associated reservoir
	Fallback rate	Proportion of adults that pass a dam but subsequently fall back downstream typically over the spillway
	Delay/travel time	Additional time required to negotiate artificial passage structures and other habitat impact. For juveniles can include reservoir passage due to discharge regulation
Habitat	--	Physical and environmental factors that limit fish
	Structure	Stream channel morphology, substrate, large woody debris
	Water quantity	Seasonal & annual discharge patterns & flood flows, seasonal minimum flows
	Water quality	Temperature, dissolved gas levels (seasonal averages, exceedence frequency)
Reintroduction	--	Restoration of viable populations upstream from facilities that currently block passage
	Productivity	Net production or replacement rate on a per adult basis (in part a function of passage)
	Viability	Abundance, productivity, spatial structure, diversity (see biological monitoring)
Mitigation	--	Beneficial actions implemented to indirectly address project effects
	Various	Project-specific including habitat protection & restoration, hatchery production, predator management, monitoring and research, information & education, etc.

6.2.3.2 Benchmarks

Hydro related monitoring benchmarks are detailed for each facility in operating documents including Federal Energy Commission Licenses and Biological Opinions. The reader is referred to these documents for more details on project-specific benchmarks pertinent to salmon recovery.

6.2.3.3 Example Data Types

Example reporting templates for hydropower effectiveness monitoring data are included below to illustrate how this information might begin to be organized. Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 44. Example data for dam passage and passage-related operations of potential use in action effectiveness monitoring (river run facility such as Bonneville Dam).

				Recent years					Recent
Species	Metric	Goal	Base	2000	2001	2002	2003	2005	avg.
Operations	Downstream flows minimum[1]								
	Annual maximums								
	Spill days & volumes								
Passage	Guidance efficiency (juv.)								
(by species)	Passage efficiency (juv.)								
	Passage survival (juv.)								
	Conversion rate (ad.)								
	Fallback rate (ad.)								
	Passage delay (ad.)								
Habitat	Tailrace dissolved gas levels[2]								

[1] Seasonal frequency of falling below target levels during winter for instance.

[2] Days exceeding standards during juvenile migration periods for instance.

Table 45. Example data for dam passage and passage-related operations of potential use in action effectiveness monitoring (terminal facilities subject to upstream reintroduction efforts as in the Cowlitz and Lewis rivers).

				Recent years					Recent
Species	Metric	Goal	Base	2000	2001	2002	2003	2005	avg.
Operations	Downstream flows minimum								
	Annual maximums								
Passage	Collection efficiency (juv.)								
(by species)	Passage survival (juv.)								
	Collection efficiency (ad.)								
	Passage survival (ad.)								
Reintroduction	Adult returns								
	Juvenile abundance								
	Productivity/replacement rate								
Habitat	Downstream temperature[1]								
	Habitat complexity[1]								
Mitigation	Hatchery production & return[2]								
	Habitat								

[1]See habitat monitoring.

[2]See hatchery action effectiveness monitoring.

6.2.4 Sampling and Analytical Design

6.2.4.1 Framework

The hydropower sampling design incorporates the following sampling and analytical design elements:

1. Routine monitoring and description of project operations on an hourly or daily basis as per current practice.
2. Systematic annual monitoring of juvenile and adult passage success based on mark-recapture and/or telemetry studies.
3. Systematic annual sampling of the abundance, productivity, distribution, and diversity of experimental reintroduced populations. (see biological status and trend monitoring)
4. Focused empirical analyses of the efficacy of habitat (see habitat action effectiveness monitoring)
5. Hatchery and habitat monitoring programs consistent with mitigation objectives for each facility (see hatchery and habitat action effectiveness monitoring).
6. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.2.4.2 Methods

Many hydropower action effectiveness monitoring and evaluation methods are similar to those described for other factors. However, passage efficiency and survival evaluations are of particular importance to hydro evaluations and are discussed briefly below.

Passage efficiency

Passage or collection efficiencies are typically estimated based on the proportion of a known population sampled in a specific collection point. Known populations are typically estimated based on recaptures of marked fish in a single release design. For instance, passage efficiency of juveniles in a collection facility often involves release of a known number of marked fish immediately upstream of the facility. Adult collection efficiencies are typically estimated based on detections of radio, acoustic, or PIT tagged fish released downstream of a facility. Estimates can be complicated where multiple routes of passage are possible

Survival

Survival studies to estimate passage success typically involve mark-recapture studies of paired releases of tagged groups of fish. Differences in recapture rates of fish released above and below a facility describe mortality associated with the facility. Extensive PIT tag studies involving system-wide tagging of juvenile hatchery and wild fish are being used to estimate project and reach survival rates throughout the mainstem Columbia River. Juvenile and adult PIT tag detectors have been placed in many mainstem dam bypass systems in the basin including Bonneville Dam. A towed detection system is also being used in the estuary to collect recapture information on PIT tagged fish.

6.2.4.3 Program Targets

Hydro-related monitoring levels are detailed for each facility in operating documents including Federal Energy Commission Licenses and Biological Opinions. The reader is referred to these documents for more details on project-specific targets pertinent to salmon recovery.

6.2.5 Current Monitoring Activities

Current hydro monitoring programs and monitoring responsibilities are summarized in the following table.

Table 46. Significant hydro facilities in the Washington lower Columbia River recovery area and project monitoring responsibilities.

Location	Facility	Responsibilities
Cowlitz River	Mayfield & Mossyrock dams	Tacoma Power
Cowlitz River	Cowlitz Falls Dam	Lewis County Public Utility District
Toutle River	Sediment Control Structure	U.S. Army Corps of Engineers
Lewis River	Merwin, Yale & Swift dams	PacifiCorp
Columbia River	Bonneville Dam	U.S. Army Corps of Engineers, Bonneville Power Administration
White Salmon River	Condit Dam	PacifiCorp

6.2.6 Information Gaps

- Reintroduction monitoring and evaluation in the Lewis River contingent on direction and agreements in the renewed license.
- Systematic monitoring and evaluation of downstream habitat and water quality effects of the sediment retention structure in the Toutle River.

Implementation Actions

1. ***Maintain current monitoring and evaluation of adult and juvenile collection, passage, and survival rates at Bonneville Dam.***

   Lead: USACE, BPA, Fish Passage Center

   Funding source: BPA

   Rationale: Extensive monitoring programs are currently being implemented for Federal Columbia River Power System Facilities including Bonneville Dam. These programs are critical to limiting and improving passage success that limits the viability of upstream populations.

   6-year Implementation Work Schedule Activities**:**

   a. Identify current funding levels and sources.
   b. Solidify long-term commitments to maintain adequate funding.
   c. Identify constraints and uncertainties.
   d. Identify coordination considerations.

2. ***Maintain current monitoring and evaluation of the relative abundance, distribution and dewatering of chum and fall Chinook redds in the Bonneville Dam tailrace.***

   Lead: USACE, BPA, USFWS, WDFW

   Funding source: BPA

   Rationale: Bonneville Dam operations significantly affect habitat suitability downstream for populations of chum and fall Chinook of significant importance to salmon recovery. The importance of the chum population in particular is elevated by the limited scope for improvement of the chum population affected by Bonneville

   6-year Implementation Work Schedule Activities**:**

   a. Identify current funding levels and sources.

b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination consider

3. Continue to implement intensive monitoring and evaluation of reintroduction efforts for coho, spring Chinook and steelhead in the upper Cowlitz and Cispus rivers.

Lead: Tacoma Power, Lewis County PUD, WDFW

Funding source: Tacoma Power, Lewis County PUD

Rationale: These significant populations for recovery and effective reintroduction will depend on continuing facility refinements guided by monitoring and evaluation result.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

4. Implement intensive monitoring and evaluation of reintroduction efforts for coho, spring Chinook and steelhead in the upper Lewis River as per license direction and agreements.

Lead: PacifiCorp, WDFW

Funding source: PacifiCorp

Rationale: These significant populations for recovery and effective reintroduction will depend on continuing facility refinements guided by monitoring and evaluation result.

Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

5. Monitor the downstream channels of Mayfield (Cowlitz), the Sediment Retention Structure (Toutle), and Merwin (Lewis) dams for changes in flow, substrate, stream morphology, and water quality.

Lead: Tacoma Power, Lewis County PUD, PacifiCorp, U.S. Army Corps of Engineers

Funding source: Tacoma Power, Lewis County PUD, PacifiCorp, U.S. Army Corps of Engineers

Rationale: Downstream habitat impacts of impoundment and operation can have significant long term effects on habitat suitability for salmonids due to changes in sediment and flow conditions.

Activities**:**

a. Complete inventory of specific limitations of existing approach.

b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6. Implement focused investigations of critical assumptions and uncertainties in current hydro-related monitoring and evaluation efforts.

Lead: WDFW, USFWS, NOAA

Funding source: To be determined.

Rationale: Current assessments rely on a series of critical assumptions which affect the accuracy of those estimates.

Activities**:**

a. Identify appropriate funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

6.3 Fisheries

6.3.1 Objectives

Harvest action effectiveness monitoring is intended to determine if fishery management regulatory processes and actions reduce or limit fishery-related mortality to levels consistent with the conservation and recovery of listed fish species while also providing significant and sustainable fishery opportunity and harvest.

Fisheries that affect lower Columbia River salmon and steelhead are managed to optimize current and future fishing opportunity and harvest within the limitations and constraints of impact limits specified to protect weak, listed stock components. Fisheries do not target listed species but listed fish are incidentally caught in fisheries for hatchery and strong wild stocks. Incidental take of lower Columbia salmon and steelhead occurs in commercial, recreational, and tribal fisheries in the ocean from Alaska to northern California and in the mainstem Columbia and tributaries.

Fishery action effectiveness evaluations are complicated because harvest is identified as both a threat and a goal in the Washington lower Columbia Recovery Plan. Harvest acts as a threat through direct mortality of adult fish which decreases abundance and productivity, and can increase risks of extinction when the fishery impact is excessive. However, restoration of wild salmonids to sustainable, harvestable levels is also a recovery goal. Healthy, viable salmonid populations produce regular harvestable surpluses in excess of escapement needs for population sustainability. This program therefore includes monitoring and evaluation of both fishery impacts and benefits.

Box 7. Questions and hypotheses addressed by fishery action effectiveness monitoring.

Question #1.	**Are fishery impacts on sensitive stocks effectively limited to prescribed levels?**
Null hypothesis:	Fishery management systems and actions do not limit impact rates to prescribed levels.
Alternative:	Fishery management systems and actions limit impact rates to prescribed levels.
Question #2.	**Are prescribed fishing levels consistent with long term viability of listed stocks?**
Null hypothesis:	Prescribed fishery impact rates do not pose significant jeopardy to the long term viability of listed species.
Alternative:	Prescribed fishery impact rates pose significant jeopardy to the long term viability of listed species.
Question #3.	**Are significant fishery opportunity and harvest being sustained by existing populations and management?**
Null hypothesis:	Fishery opportunity and harvest is not being sustained at levels adequate to meet broad sense goals.
Alternative:	Fishery opportunity and harvest is being sustained at levels adequate to meet broad sense goals.

6.3.2 Strategy

1. ***Complete comprehensive assessments of fishery action effectiveness at 6 year intervals as prescribed by the Recovery Plan.***

A 6 year assessment interval is identified by the recovery plan for evaluating the effectiveness of fishery actions relative to baseline conditions and benchmarks.

2. ***Monitor annual impacts relative to prescribed limits for significant ocean and Columbia River sport and commercial fisheries on representative index groups for all species based on in-season data on fish numbers and fishery mortality collected using systematic statistical surveys of catch, catch composition, and harvest.***

Annual in-season monitoring is necessary to regulate direct and incidental fishing impacts within prescribed limits for each fishery while also optimizing fishery benefits in any given year. Fishery opportunity and effort is adjusted based on real time data on fish run strength, stock composition, and fishery success. Fisheries are managed based on index stocks representing sensitive species, life stage, and population groups.

3. ***Periodically re-evaluate effects of prescribed fishery impact levels and strategies on long term viability of listed stocks based on risk assessments that consider recent stock abundance and productivity.***

Prescribed fishery impact limits are based on prior assessments of the effects of fishery-related mortality on spawning escapements of weak stock groups. Limits are ideally based on risk assessments that calculate the marginal change in low run size probability due to fishing. Risks are sensitive to fishing rates, variance in fishing rates, relationships between fishing rate and abundance, and stock abundance and productivity patterns. Periodic reassessments are needed to consider whether prescribed fishery limits remain consistent with long term viability based on current abundance and productivity information.

4. ***Monitor annual fishery opportunity based on effort, harvest, and value in significant ocean, Columbia River, and tributary sport and commercial fisheries for all species.***

Monitoring of fishery statistics provides a basis for meeting sustainable use and value goals as well as the variety of escapement and allocation objectives consistent with optimum management of the fishable stocks and the fishery. These evaluations must consider the interaction in effects of protection measures for Columbia River stocks on fisheries directed on mixed stocks including fish originating in the upper Columbia and Snake rivers as well as Washington, Oregon, and Canadian systems outside the basin.

5. ***Conduct annual evaluations of fishery assessment and management processes and tools based on post-season run reconstruction and analysis of forecast, in-season and actual information on fishery impacts and opportunities in order to optimize efficacy.***

Fishery assessment and management processes and tools are continually evolving based on recent experience and new data. Annual reporting of numbers is a long-standing practice although the depth and breadth of corresponding evaluations varies among fisheries. This strategy highlights the need conduct systematic formal post season evaluations on an annual basis. These evaluations also provide the basis for adaptive preseason planning of the next year's fisheries.

6. Systematically implement improvements in assessment methods, processes, and tools based on annual efficacy evaluations and directed investigations of critical uncertainties in current assessments and systems.

This strategy includes focused effort on significant uncertainties in current assessment methods, processes, and tools. Specific examples are detailed under information gaps.

6.3.3 Indicators

6.3.3.1 Attributes & Metrics

Fishery indicators are identified for impact, effect, and benefit metrics. Impact is defined fishery-related mortality rate and is calculated as total harvest plus total indirect mortality divided by number of fish available. Indirect mortality includes catch-release mortality of fish that die following release due to the effects of handling in the fishery. In some fisheries, indirect mortality can also include drop-off mortality of fish that succumb prior to landing due to encounter with the fishing gear. Catch-release mortality is typically estimated as a fraction of the released component of the catch where the fraction has been based on directed studies. Catch composition apportions the catch in any mixed stock fishery among stocks of origin typically based on visual differences, recaptures of tagged fish or genetic information.

We define fishery effect in terms of the significance of fishing level to long term viability of the stock of interest. Significance to listed stocks is evaluated based on effects of fishing on extinction risk. This risk considers abundance and productivity of the limiting stocks as well as normal stock variation (process "error") and variance in fishery impacts due to fishing strategy and fishery implementation uncertainty (measurement "error").

We define fishery benefit based on effort, harvest, and value. Recreational fishery opportunities are typically assessed based on angler participation and success rates. Commercial opportunities are typically assessed based on harvested numbers or weight of fish and the economic value of that harvest.

6.3.3.2 Benchmarks

Benchmarks for fishery action effectiveness monitoring are identified in this program based on historical fishery impacts and current impact limits. Historical rates about the time of listing are a useful reference point for measuring decreases in impacts implemented to reduce near term extinction risks of listed stocks until sustainability is restored by a comprehensive suite of recovery actions. Current ESA impact limits have been adopted by Federal, State, and Tribal fishery managers to protect long term viability of listed stocks in the interim. Aggregate fishery impact rate allowances for wild salmon populations currently vary from 5% for lower Columbia River chum to 49% for lower Columbia River tule fall Chinook based on species-specific differences in productivity (Table 48).

Table 47. Attributes, metrics, and example statistics for use as indicators of fishery effects.

Attribute	Related Metrics	Example
Impact	--	Proportion of available population that is subject to fishery-related mortality. Typically includes harvest and release mortality.
	Catch	Number of fish landed including those reduced to possession or released
	Harvest	Number of fish harvested (a portion of the total catch)
	Releases	Number of fish caught or encountered but not harvested. Can include releases of non-target species or stocks as well as fish that are encountered but not landed where the encounter is deemed significant (e.g. drop-off mortality).
	Catch composition	Species and stock of origin of fish caught, harvested, released, or encountered.
	Run size	Number of fish available to fishery. Typically defined in terms of ocean recruits or Columbia River return.
	Encounter rate	Proportion of available fish that are caught (includes harvested and released fish)
	Harvest mortality rate	Proportion of available fish that are harvested directly.
	Non-harvest mortality rate	Proportion of available fish taken by catch and release or other encounter mortality.
Effect	--	Significance of fishing level to long term viability of listed stocks
	Implementation uncertainty	Direction and variance in differences between planned and actual fishery impact rates due to forecast and in-season assess uncertainties (affects risk).
	Risk	Marginal reduction in extinction risk due to fishery impacts on current and future spawner numbers (as propagated through the life cycle).
Benefit	--	Significance of fishery opportunity and harvest
	Effort	Measure of angler participation typically in terms of angler trips (recreational fishery) or fishery days, net days, number of participants (commercial).
	Harvest	Fish numbers or weight
	Value	Catch-per-unit-effort, ex-vessel value

Table 48. Significant benchmarks for fishery impact rates and the current distribution of harvest among fisheries for lower Columbia River salmon and steelhead.

	Fishery wild impact rates				Harvest distribution (total to 100%)[1]			
	Historic highs[1]	Pre-listing[1]	ESA limit	Recent avg.[1]	AK/BC ocean	OR/WA ocean	Col. R.	Trib
Coho	85%	51%	25%[2]	18%	<1%	50%	44%	6%
Spring Chinook	65%	53%	25%[3]	22%	59%	23%	9%	9%
Fall Chinook (tule)	80%	65%	49%[4]	45%	33%	33%	22%	11%
Fall Chinook (bright)	65%	50%	49%	40%	48%	8%	20%	25%
Chum	60%	5%	5%	2.5%	0%	0%	60%	40%
Steelhead	75%	10%	10%[5]	8.5%	0%	<1%	41%	59%

[1] Reported by LCFRB 2004 (Table 6 on Pg. 3-67). Averages reflect 2001-2003 fishing period.

[2] Future ESA rate to be determined. Rates of 15% and 20% were established for 2006 and 2007 fisheries.

[3] Freshwater fishery limit for Willamette spring Chinook is 15%. Ocean fisheries typically take an additional 10%.

[4] NMFS has recommended consideration of lowering of this limit from 49% to 42% (NMFS 2007).

[5] Limitation for summer steelhead populations above Bonneville is 17%.

6.3.3.3 Example Data Types

Example reporting templates for fishery effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation of the impacts on listed stocks (Table 49) and fishery opportunity and value (Table 50). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 49. Net annual fishery impacts on listed wild lower Columbia River salmon and steelhead.

Species	Return Year	Fishery	Run size	Harvest rate	Indirect rate	Net Impact	Vs. Limit
Spring Chinook	2005	AK/BC ocean OR/WA ocean Col. R mainstem Tributary Total					
…	…	…					

Table 50. Fishery effort, harvest, catch rate, and value statistics including the relative significance of wild lower Columbia River stocks in the catch.

Species	Fishery	Year	Effort	Total harvest	Catch per effort	Value	% LCR wild in catch
Coho	AK ocean (all)	2005 2006 2007 2008 2009 2010					
	BC ocean (all) OR/WA ocean sport OR/WA ocean comm. Col. R. sport Col. R. commercial Tributary	…					
Spring Chinook . . .							

Note: units vary with type of fishery (sport vs. commercial)

6.3.4 Sampling and Analytical Design

6.3.4.1 Framework

This design framework addresses freshwater and marine salmon fisheries in Oregon and Washington to which lower Columbia River salmon and steelhead are subject. These fisheries are already subject to a comprehensive monitoring framework designed and implemented by State, Federal, and Tribal fishery management partners operating under a series of interconnected jurisdictional and programmatic structures including the Pacific Fishery Management Council; State Fish and Wildlife Commissions in Washington, Oregon, and Idaho; the Columbia River Compact between Oregon and Washington; U.S. v. Oregon jurisdictions, and Treaty Tribal Councils and Fishery Commission. Canadian and Alaska fishery impacts on Columbia River stocks are regulated and monitored under the auspices of the U.S.-Canada Treaty and the Pacific Salmon Commission. Most of these processes also include annual reporting elements.

Key sampling and analytical design elements of existing programs include:

1. Comprehensive accounting of effort, harvest, and impacts on listed stocks in all fisheries.
2. Stratified statistical random sampling of major ocean and Columbia River sport, commercial, and Tribal ceremonial, subsistence, and commercial fisheries.
3. Intensive effort, catch, and biological subsampling programs of significant commercial, sport and fisheries.
4. Intensive in-season monitoring to estimate and regulate fisheries within prescribed limits.
5. Comprehensive annual pre- and post-season analysis and reporting of monitoring information.
6. Regular validation research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools.

6.3.4.2 Methods

Fishery monitoring activities include a number of common elements as described below.

Effort Surveys (Recreational Anglers)

Fishing effort by recreational anglers is typically based on roving counts of boats, boat trailers, or anglers made either by airplane, boat, or vehicle (e.g. Columbia River mainstem fisheries). Effort may also be estimated based on access point surveys are useful where access is limited (e.g. ocean salmon fisheries). Effort can be highly variable by time and area. Counts generally involve a systematic stratified sampling scheme at prescribed days, times and areas. Counts provide index numbers for effort that are then expanded to provide total effort based on documented relationships between index and total numbers. Relationships between index and total numbers require very intensive surveys which are periodically recalibrated. Effort data is typically combined with angler survey data to estimate total harvest.

Angler surveys (Recreational Anglers)

Recreational angler or creel surveys typically involve interviews of anglers to determine number and composition of the catch and provide estimates of catch per effort. The catch of interviewed anglers is typically sampled or subsampled for collection of biological measurements including any tagged or marked fish. Statistical surveys involve a random stratified sampling scheme either in a roving or access point survey. Non statistical surveys are also sometimes conducted to obtain descriptive fishery data or biological samples. Catch per effort data is typically combined with

effort survey data to estimate total harvest. Effort surveys are an intensive and costly sampling method and typically utilized for large and significant fisheries.

Catch Record Cards (Recreational)

Recreational anglers in Washington and Oregon are required to immediately record each salmon and steelhead harvested on catch record cards provided along with the fishing licenses. This is primarily an enforcement measure for ensuring that daily or annual bag limits are not exceeded. Catch record cards are also required to be returned to the respective state fish and wildlife departments each year. Numbers are periodically tabulated and provide an estimate of salmon harvest by species, date, and area. Estimates typically involve expansions for unreported tags (only a portion of catch record cards are returned as required) and corrections for a non-reporting bias (anglers that catch fish are typically more likely to return tags than anglers that don't catch fish). Catch record cards provide a general indication of the scale and timing of fisheries but this data tends to be much less certain than survey data.

Fish Receiving Tickets (commercial)

All commercial fish buyers in Oregon and Washington are required to complete and submit fish receiving tickets upon purchase of any fish. Catch is reported by species and weight. Only licensed fishers are allowed by law to sell fish and only licensed buyers are allowed to make large scale fish purchases. Some provisions are made for direct fisherman to consumer fish sales. These require a separate license and also have stringent reporting requirements. Columbia River Treaty Indian fisheries upstream from Bonneville Dam also sell fish direct to consumers ("over-the-bank sales") and these numbers are estimated independently by tribal and intertribal fishery managers. Fish tickets are generally reported to the state fishery management agencies in real time and provide very accurate estimates of total harvest in commercial fisheries. These numbers are the basis for intensive in-season fishery management decisions.

Catch Sampling (Commercial)

The commercial fishery is typically subsampled at representative commercial fish buying sites for collection of biological measurements including any tagged or marked fish. This information is used to identify stock composition and collect age, sex, and size information including average weight. Catch sampling can sometimes involve on-board observers where additional information is desired on things like number of fish released in selective fisheries or marine mammal encounters. In addition, test fisheries are sometimes implemented by fishery management agencies working with commercial fishers to collect information on fish relative abundance or stock composition.

Index Stock Marks and Tags

Stock identification in mixed-stock commercial and sport fisheries in the ocean and Columbia River mainstem is a critical component of current fishery monitoring efforts. Fisheries are generally regulated based on limits prescribed for index stocks selected for representation of different populations or groups of populations. A subsample of each index stocks is typically batch marked with coded wire tags placed in the snout of juveniles. CWT tagged fish in the sport or commercial harvest are identified by magnetic detectors. Snouts of these fish are removed to state laboratories and CWTs are recovered and read to identify the source stock and apportion the harvest. Adipose fin clips are also currently in use to distinguish hatchery and wild fish. All lower Columbia River hatchery coho, spring Chinook, fall Chinook and steelhead are currently being ad-marked. Some unmarked hatchery fish are still being released in streams upstream from Bonneville Dam.

Escapement Monitoring

Estimates of fishery exploitation, harvest, or impact rates require estimates of both harvest and escapement. Thus, accurate fishery action effectiveness monitoring also requires much of the same abundance data discussed in detail in the biological status monitoring section of this report.

Run Reconstructions

Run reconstructions are detailed analyses of fish numbers by stock or population based on estimates of harvest and escapement. They involve summary and synthesis of all of the information described above. This information is used for a wide variety of fishery management, hatchery management and stock assessment purposes.

6.3.4.3 Program Targets

This plan identifies the following representative sampling program targets as a starting point for further consideration and discussion by the fishery management programs.

- Annual estimates of net fishery impacts on indicator stocks representative of limiting population in each listed lower Columbia River ESU.
- Minimum of 20% mark sample rate of the harvest in significant fisheries to estimate stock composition (this is the current target rate).
- Documentation of estimation precision for effort and harvest by stock in significant fisheries.
- Estimation precision of net fishery impacts for each ESU of not less than the greater of: a) 10% of the target impact rate with 80% confidence or b) an absolute impact of ± 2% with 80% confidence.
- Identification and assessment of the magnitude of critical uncertainties in key assumptions of fishery estimates.

6.3.5 Current Monitoring Activities

Current fishery monitoring activities are summarized in the following table.

Table 51. Summary of current fishery monitoring activities and management process or authority.

4Fishery	Effort surveys	Angler surveys	Catch Records	Fish Receiving Tickets	Catch Sampling	Reporting[1]
AK ocean	--	--	X	X	X	ADFG/PSC
BC ocean				X	X	BCDFO/PSC
WA ocean sport	X	X	X	--	X	WDFW/PFMC
WA ocean commercial	--	--	X	X	X	WDFW/PFMC
OR ocean sport	X	X	X	--	X	ODFW/PFMC
OR ocean commercial	--	--	X	X	X	ODFW/PFMC
Lower Col. R. Sport	X	X	X	--	X	WDFW/ODFW
Lower Col. R. Comm.	--	--	X	X	X	WDFW/ODFW
Tributary sport	limited	limited	X	--	limited	WDFW/ODFW
Col. R. Treaty Tribes	--	X	--	X	X	Tribes/CRITFC

[1] ADFG = Alaska Department of Fish and Game, PSC = Pacific Salmon Commission, BCDFO = British Columbia Department of Fisheries and Oceans, WDFW = Washington Department of Fish and Wildlife, ODFW = Oregon Department of Fish and Wildlife, PFMC = Pacific Fishery Management Council, Tribes = Warm Springs, Yakama, Umatilla, Nez Perce. CRITFC = Columbia River Intertribal Fish Commission.

6.3.6 Information Gaps

The following information gaps were identified in fishery monitoring based on a review of the available information including annual fishery reports, biological assessments, and research, monitoring and guidance documents. Many of these gaps involve critical assumptions or unknowns relative to the effects of fishing.

1. Improved accuracy in wild escapement estimates of coho, Chinook, and steelhead upon which fishery impacts estimates are based (as identified in the biological monitoring section of this plan).
2. Stock identification methods (tags or other markers) adequate to accurately estimate current freshwater fishery impact rates on early and late wild coho from the available harvest data.
3. Evaluations of the suitability of current index stocks for accurate evaluation of impacts of fisheries on wild Chinook.
4. Empirical estimates of indirect or incidental mortality in mark-selective fisheries and gear, time, and area selective fishing alternatives in the Columbia River.
5. Assessments of the accuracy and precision of all fishery impact estimates based on current information.
6. Assessments of the effects of current fishing rates, limits and strategies on risk/viability of listed ESUs (e.g. are prescribed levels consistent with recovery?).

6.3.7 Implementation Actions

1. ***Maintain current monitoring programs of annual harvest and harvest rates of representative index stocks in ocean, Columbia River mainstem, and tributary fisheries.***

   Lead: WDFW, ODFW, NOAA, Tribes

   Funding source: Various

   Rationale: Current fishery monitoring programs provide accurate and timely estimates of fishery effort, harvest, and impacts on listed stocks. This information is used to regulate fisheries within prescribed limits that optimize opportunity and value while also seeking to ensure escapements adequate to protect long term sustainability of the fishery and viability of affected stocks. This information also provides a sound basis for continuing evaluations of the effectiveness of fishery actions for regulating harvest at appropriate levels.

   6-year Implementation Work Schedule Activities**:**

   e. Identify current funding levels and sources.
   d. Solidify long-term commitments to maintain adequate funding.
   e. Identify constraints and uncertainties.
   f. Identify coordination considerations.

2. ***Implement additional intensive biological monitoring of wild adult escapements of all species in order to improve the accuracy of fishery impact assessments.***

   Lead: WDFW

   Funding source: Various

Rationale: The accuracy of current fishery impact assessments is constrained by the quality of the available wild escapement data. This is particularly true for wild lower Columbia River coho.

Activities**:**

f. Identify appropriate opportunities and funding sources.
g. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
h. Identify constraints and uncertainties
i. Identify coordination considerations

3. Evaluate and expand where appropriate current Chinook and coho wild index stock marking efforts to provide an adequate basis for stock identification and fishery impact estimation.

Lead: WDFW, ODFW

Funding source: To be determined.

Rationale: Current wild index stock identification methods are not adequate for accurate estimation of fishery impacts on wild salmon in Columbia River fisheries.

Activities**:**

j. Identify appropriate funding sources.
k. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
l. Identify constraints and uncertainties.
m. Identify coordination considerations.

4. Implement focused investigations of critical assumptions and uncertainties in current fishery monitoring and evaluation efforts (to include efficacy of selective fisheries).

Lead: WDFW, ODFW, NOAA, Tribes

Funding source: To be determined.

Rationale: Current fishery assessments rely on a series of critical assumptions which affect the accuracy of those estimates. With the widespread advent of mark-selective fisheries, assumptions regarding indirect mortality are among the more proximate concerns.

Activities**:**

n. Identify appropriate funding sources.
o. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
p. Identify constraints and uncertainties.
q. Identify coordination considerations.

5. Develop and implement a comprehensive annual assessment and report of fishery impact, effect, and opportunity information for each listed ESU (to include assessments of the accuracy of impact estimates and effects on ESU viability).

Lead: NOAA

Funding source: To be determined.

Rationale: Current fishery information is reported piecemeal for fisheries spread over a wide area of overlapping jurisdictions. Fishery effects on listed stocks are identified in semi-annual biological assessments of each fishery but comprehensive assessments of net fishery effects on listed fish and the full complement of fishery opportunities affected by listed species protection.

Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6.4 Hatchery

6.4.1 Objectives

Hatchery action effectiveness monitoring is intended to determine if hatchery management actions reduce or limit effects on wild fish to levels consistent with the conservation and recovery of listed fish species while also achieving desired fish production benefits. Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat resulting from the Columbia River hydrosystem and widespread habitat development. Hatcheries provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates.

Box 8. Questions and hypotheses addressed by hatchery action effectiveness monitoring.

Question #1.	**Are hatchery impacts on sensitive stocks effectively limited to prescribed levels?**
Null hypothesis:	Hatchery actions do not limit impact rates to prescribed levels.
Alternative:	Hatchery actions limit impact rates to prescribed levels.
Question #2.	**Is hatchery performance consistent with objective benefits and risks identified for each program?**
Null hypothesis:	Performance is not consistent with objective benefits and risks prescribed for each program.
Alternative:	Performance is consistent with objective benefits and risks prescribed for each program.
Question #3.	**Are hatchery practices consistent with objectives identified for each program?**
Null hypothesis:	Practices are not consistent with program objectives.
Alternative:	Practices are consistent with program objectives.

6.4.2 Strategy

1. Complete comprehensive assessments of fishery action effectiveness at 6 year intervals as prescribed by the Recovery Plan.

A 6-year assessment interval is identified by the recovery plan for the effectiveness of hatchery actions relative to baseline conditions and benchmarks.

2. Intensively monitor potential hatchery threats to wild population status for every salmon and steelhead hatchery program.

Hatchery influences are pervasive on many lower Columbia River salmon and steelhead populations. Hatchery effects have been identified as a significant threat to the status of these listed species.

3. Monitor the potential impacts of hatcheries on the status of wild populations based on the annual incidence of natural spawning by hatchery fish and the contribution of natural origin fish to the hatchery brood stock.

Annual monitoring is necessary to regulate hatchery impacts within prescribed limits for each natural population. While the net effect hatchery-origin fish spawning in the wild on wild fish is unknown, it is clearly related to the relative frequency of naturally-spawning hatchery fish and natural-origin fish in the hatchery broodstock.

4. Monitor hatchery performance and practices in order to evaluate program benefits relative to associated risks and activities related to both risks and benefits.

Detailed hatchery production and return statistics provide a systematic quantitative basis for the evaluation of benefits associated with risks and corresponding hatchery actions. Production and return data are routinely collected by all hatcheries for use in program planning and evaluation relative to various production and mitigation goals. This same information will be useful in evaluations of conservation objectives or limitations associated with hatchery programs.

6.4.3 Indicators

6.4.3.1 Attributes & Metrics

Hatchery indicators are identified for impact, performance, and practice metrics. Impact is defined in terms of hatchery contributions to naturally-spawning populations. Performance refers to hatchery production levels that are related to both hatchery benefits and risks. Practice refers to hatchery activities that affect impact and performance.

Table 52. Attributes, metrics, and example statistics for use as indicators of hatchery effects.

Attribute	Related Metrics	Example
Impact	--	Significance of hatchery interaction with natural populations
	Hatchery-origin spawners (pHOS)	Proportion hatchery-origin spawners in local natural population
	Out-of-basin strays	Proportion of total return that is observed in natural spawning areas outside the basin of origin
	Proportion natural influence (PNI)	Index of local hatchery effect (product of proportion of hatchery origin spawners and proportion of natural origin brood stock
Performance	--	Description of hatchery effectiveness
	Smolt-adult survival	Proportion of release surviving to return
	Fishery contribution	Number of hatchery-origin fish harvested in fisheries (by fishery)
	Hatchery return	Number of adults returning to hatchery collection facilities
	Age composition (adults)	Proportion by age of hatchery return
	Size at age (adults)	Average & range of length at age
	Migration & Spawn Timing	Temporal distribution of hatchery return relative to natural population
Practice	--	Description of hatchery activities related to hatchery effectiveness & effect on natural populations
	Brood stock no.	Number of broodstock spawned
	Brood stock origin (pNOB)	Proportion natural-origin fish incorporated into brood stock
	Egg take	Total number of eggs collected
	Release number	Total number of fish released
	Release size	Size at release (typically #/lb)
	Release practice	Acclimation type, release site, etc.
	Mark rate	Proportion of release marked by fin clip and coded wire tag

6.4.3.2 Benchmarks

Hatchery action effectiveness benchmarks are program specific and based on changes relative to historical base periods as well as specific objectives identified in Hatchery Genetic Management Plans (HGMPs) adopted for each program. Thus, generic benchmarks for evaluating hatchery performance are not included herein. HGMPs are developed and revised based on ESA consultations for the operation of specific programs. Reference values for evaluation of reductions in hatchery impacts to each wild population are also identified by the Recovery Plan consistent with the recovery priority of each population.

6.4.3.3 Example Hatchery Data Types

Example reporting templates for hatchery effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation of the impacts on listed stocks (Table 49) and performance and practice (Table 50). Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 53. Net annual hatchery impacts on listed wild lower Columbia River salmon and steelhead.

		Hatchery fraction (average)			Proportion Natural Influence		
Species	Population	Goal[1]	Base[2]	Recent[3]	Goal[1]	Base[2]	Recent[3]
Chinook							
Spring	Kalama						
	Cowlitz						
	Lewis						
Fall	…						
…	…						

[1] Base period refers to historical average at the time of initial widespread listings prior to year 2000.
[2]Goals to be determined in hatchery implementation plans based on population recovery priorities.
[3] Recent refers to recent annual average for prescribed evaluation period.

Table 54. Summary of recent lower Columbia River hatchery release and return numbers in Washington subbasin hatchery programs.

		Releases			Returns (to hatchery)		
Species		Base	Goal	Recent	Base	Goal	Recent
Chinook							
Spring	Deep						
	L. Cowlitz						
	U. Cowlitz						
	Kalama						
	NF Lewis						
	Wind						
	L. White Salmon						
	Totals						
…	…						

Table 55. Program summary for __(each)___ Washington Lower Columbia River Program.

Species	Metric	Goal	Base	Recent years					Recent avg.
				2000	2001	2002	2003	2005	
...	Brood stock no.								
	Brood stock origin (pNOB)								
	Egg take								
	Release number								
	Release size								
	Release practice								
	Mark rate								
	Smolt-adult survival								
	Fishery contribution								
	Hatchery return								
	Age composition (adults)								
	Size at age (adults)								
	Migration & Spawn Timing								
...	...								

6.4.4 Sampling and Analytical Design

6.4.4.1 Framework

The hatchery effectiveness sampling design incorporates the following sampling and analytical design elements:

1. Systematic annual sampling of hatchery contributions to natural populations of every significant salmon and steelhead population targeted for protection or improvement to moderate or higher levels of viability (see biological status monitoring).
2. Systematic annual sampling of broodstock and production information in every hatchery program.
3. Fishery sampling programs adequate to estimate the contribution each hatchery program to the harvest (see fishery action effectiveness monitoring).
4. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.4.4.2 Methods

Hatchery monitoring activities include a number of common elements as described below.

Escapement Monitoring

Escapement monitoring is discussed in detail in the Biological Status Monitoring section. Estimates of the proportion of hatchery fish in natural spawning populations are a critical piece of hatchery action effectiveness monitoring. This information is obtained from stratified random samples of spawning escapements for marks or tags.

Broodstock Sampling

Current hatchery practices collect detailed count data on fish returning to hatchery collection facilities and also typically involve regular and systematic subsampling of the hatchery return for biological data. In many cases, current activities will provide most of the information identified as pertinent to monitoring for action effectiveness applications. In some cases, procedures might warrant more formal implementation to ensure that related needs are met.

Production Inventory

Current hatchery practices collect detailed count data on numbers, sizes and marks of fish released and as well as a variety of other production statistics (egg take). In many cases, current activities will provide most of the information identified as pertinent to monitoring for action effectiveness applications. In some cases, procedures might warrant more formal implementation to ensure that related needs are met.

Fishery Sampling

Fishery sampling provides information of hatchery contributions which is a critical component of evaluations of the hatchery benefits associated with risks to listed wild populations.

Index Stock Marks and Tags

Marks and tags of hatchery fish are used to distinguish naturally-spawning hatchery-origin fish and to identify stock composition in mixed-stock commercial and sport fisheries in the ocean and Columbia River mainstem. Lower Columbia River hatchery-origin spawners are (coho, steelhead and Spring Chinook) or will soon be (Fall Chinook) marked with ad-clips. A subsample of most significant hatchery production groups is tagged with coded wire tags which identify the hatchery of origin. Hatchery groups often serve as index stocks for estimating and regulating fishing rates.

Run Reconstructions

Run reconstructions are detailed analyses of fish numbers by stock or population based on estimates of harvest and escapement. They involve summary and synthesis of all of the information described above. This information is used for a wide variety of hatchery evaluation, fishery management, and biological status assessment purposes.

6.4.4.3 Program Targets

This plan identifies the following representative sampling program targets as a starting point for further consideration and discussion by the fishery management programs.

- Estimation precision of hatchery origin spawners for each primary and contributing population of not less than an absolute impact of ± 5% with 80% confidence.
- Estimation precision for hatchery production numbers of ± 10% with 80% confidence
- Minimum of 20% mark sample rate of the harvest in significant fisheries to estimate stock composition (this is the current target rate).

6.4.5 Current Monitoring Activities

Current hatchery programs and hatchery performance and practice monitoring responsibilities are summarized in the following table.

Table 56. Washington lower Columbia River fish hatcheries currently in operation and species produced (LCFRB 2004).

			Chinook				Steelhead	
Hatchery	Location	Operator[1]	Spring	Fall	Chum	Coho	Winter	Summer
Sea Resources	Chinook	Sea Resources	--	X	--	X	--	--
Grays	Grays	WDFW			X	X	--	--
Elokomin	Elochoman	WDFW	--	X	--	X	X	--
Abernathy	Abernathy	WDFW	--	X	--	--	--	--
Cowlitz Trout	Cowlitz	WDFW	X	--	--	--	X	X
Cowlitz Salmon	Cowlitz	WDFW	X	X	--	X	--	--
Mossyrock	Cowlitz	WDFW	--	--	--	--	--	--
North Toutle	Toutle	WDFW	--	X	--	X	--	--
Fallert Creek	Kalama	WDFW	X	--	--	X	--	--
Kalama Falls	Kalama	WDFW	X	X	--	X	X	X
Lewis River	Lewis	WDFW	X	--	--	X	--	--
Merwin	Lewis	WDFW	--	--	--	--	X	X
Speelyai	Lewis	WDFW	X	--	--	--	--	--
Skamania	Washougal	WDFW	--	--	--	--	X	X
Washougal	Washougal	WDFW	--	X	X	X	--	--
Carson	Wind	USFWS	X	--	--	--	--	--
Willard	L. White Salmon	USFWS	--	--	--	--	--	--
Little White Salmon	L. White Salmon	USFWS	X	X	--	--	--	--
Spring Creek	Columbia	USFWS	--	X	--	--	--	--

[1] WDFW = Washington Department of Fish and Wildlife, USFWS = Oregon Department of Fish and Wildlife.

6.4.6 Information Gaps

The following information gaps were identified in hatchery monitoring based on a review of the available information including annual biological assessments, hatchery plans, and research, monitoring and guidance documents.

1. Improved accuracy in estimates of the hatchery origin spawners in wild coho, Chinook, and steelhead populations.
2. Empirical information on hatchery-wild interactions including the relative success of hatchery and wild spawners, effects of broodstock integration, the value of supplementation for recovery purposes, and other ecological effects of hatchery fish (see Research).

6.4.7 Implementation Actions

1. Maintain current monitoring programs for performance and practice of every hatchery.

Lead: WDFW, ODFW, USFWS, NOAA, Tribes

Funding source: Various

Rationale: Current hatchery monitoring programs collect extensive information on production and returns. This information is used to guide and optimize hatchery operations. This information also provides a sound basis for continuing evaluations of the effectiveness of hatchery actions relative to objective benefits of each program.

6-year Implementation Work Schedule Activities**:**

a. Identify current funding levels and sources.
b. Solidify long-term commitments to maintain adequate funding.
c. Identify constraints and uncertainties.
d. Identify coordination considerations.

2. Implement additional biological monitoring of adult escapements of all species in order to accurately assess levels of hatchery contribution to natural production.

Lead: WDFW, USFWS, ODFW

Funding source: Various

Rationale: Information on hatchery fractions in natural populations is widely collected but is incomplete, particularly for natural populations of coho. The accuracy of current hatchery impact assessments is constrained by the quality of the available escapement data. In part this is related to historic difficulties in distinguishing hatchery and wild fish. The advent of 100% adipose marking of hatchery fish is expected to greatly facilitate assessment of the proportion of hatchery origin spawners.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

3. Develop and implement a comprehensive regular assessment and report of hatchery impact, performance, and practice for all lower Columbia hatchery programs for use in periodic recovery action effectiveness assessments.

Lead: NOAA

Funding source: To be determined.

Rationale: Current hatchery information is collected by all programs and maintained by the respective operating agency (WDFW, ODFW, USFWS, Tribes). Various reporting protocols are followed by the various parties but regular comprehensive summaries that address the evaluation needs relative to ESA and recovery plan implementation are not available. NOAA currently completes periodic status assessment reviews that would include assessments of both biological status and threat factors including hatcheries.

Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

4. Implement collaborative research to resolve critical uncertainties regarding hatchery-wild interactions to guide assessments of hatchery effects. (See Research)

Lead: WDFW, ODFW, USFWS, Tribes, NOAA

Funding source: To be determined.

Rationale: Hatchery risks and benefits remain a source of continuing controversy with significant uncertainty in whether significant production hatchery influences are consistent with salmon recovery and if conservation hatchery programs may be an effective tool for recovery in some circumstances. Further research is needed to clarify the nature and magnitude of effects and to guide development of appropriate remedies.

Activities**:**

a. Complete inventory of specific limitations of existing approach.
b. Identify appropriate funding sources.
c. Develop, submit, and support a detailed sampling proposal, work plan and data reporting schedules.
d. Identify constraints and uncertainties.
e. Identify coordination considerations.

6.5 Ecological Interactions

6.5.1 Objectives

Ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Limiting factors include interactions with non-native species, effects of salmon on system productivity (e.g. nutrient cycling), and native predators of salmon. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alteration. Ecological action effectiveness monitoring is intended to determine if current management activities are adequate to address current or developing threats involving new species invasions and potentially manageable predation. Several significant ecological elements are subject to detailed monitoring programs already in place and this chapter briefly summarizes those efforts and refers to the detailed plans for further information.

6.5.2 Strategy

1. ***Complete comprehensive assessments of ecological interaction action effectiveness at 6-year intervals for the purpose of evaluating Recovery Plan progress.***

A 6-year assessment interval is identified by the recovery plan for the effectiveness of hydropower actions relative to baseline conditions and benchmarks. The assessment may involve annual collection and compilation of data and ongoing adaptive management based on results. The 6-year assessment is simply a formal checkpoint for evaluating progress and net effects in all areas.

2. ***Evaluate effectiveness of actions to address ecological interactions involving non-native species introductions and predation effects that currently limit or could grow to limit the viability of listed lower Columbia River populations.***

The recovery plan identifies significant actions for the benefit of listed populations involving these categories.

3. ***Implement a periodic systematic monitoring program for aquatic nonindigenous species of plants, invertebrates, and fishes in the Columbia River mainstem and estuary.***

Recovery plan measures include regulatory, control and education measures for the prevention of exotic species invasions. Effective treatment of this threat will involve early detection of invasion. Without a systematic sampling program involving both periodic surveys in at risk areas and adaptive sampling to response to newly-identified problems, emerging problems may not be recognized in time to be effectively addressed. This plan does not envision a large scale intensive statistical sampling program for all elements of the ecosystem owing to the expense and limited direct benefit of such an effort to salmon recovery. Rather, it envisions a surgical and focused systematic effort aimed at identifying emerging threats. Significant problems may then be candidates for more focused monitoring or research efforts specific to the nature of the particular problem.

4. ***Monitor the status of existing introduced species including shad based on current information and appropriate refinements identified critical uncertainty research regarding the potential significance of this threat.***

Current fish sampling programs provide periodic information assumed to suffice for identifying significant changes that could alter the significance of existing threats. For instance, ladder counts of American shad at Columbia River mainstem dams provide extensive annual data on numbers and distribution throughout the system. Similarly, systematic angler surveys provide

information on the occurrence of introduced sport fish species in the catch. The significance of a number of these potential threats is unclear has been identified as a critical uncertainty that warrants future research. Additional monitoring needs in this area may be identified as a result of additional research.

5. ***Conduct intensive annual monitoring and evaluation of the effectiveness of measures to manage predation in the Columbia River mainstem and estuary by northern pikeminnow, marine mammals and piscivorous birds.***

This includes the effectiveness of measures to discourage concentrated predation by pinnipeds in areas of salmon vulnerability downstream from Bonneville Dam, reduce predation by northern pikeminnow by exploitation in the sport reward fishery, and to redistribute Caspian Terns and other bird species from concentrated nesting areas of the estuary where predation on juvenile salmonids is significant. Note that assessments of the significance and trends of these factors are addressed by dedicated research projects identified in that section of this plan.

6.5.3 Indicators

6.5.3.1 Attributes & Metrics

Ecological indicators are identified for monitoring of non-native species and predation. The examples below include metrics currently in use by existing monitoring and evaluation programs for aquatic nonindigenous species (Sytsma et al. 2004), avian predators (Collis et al. 2006), pikeminnow predators (Porter 2006), and pinnipeds (Stansell 2004; Wright et al. 2007).

Table 57. Attributes, metrics, and example statistics for use as indicators of hatchery effects.

Category	Focus	Attribute	Example
Non-native species	Invasive exotics	Occurrence	Presence/absence, density or distribution by species
	Shad	Numbers	Daily ladder counts in Columbia mainstem dams
Predators	Avian (Terns & cormorants)	Abundance	Numbers or index counts of nests & nesting adults
		Productivity	Nesting success/fledge rates, rate of population change
		Distribution	Nesting distribution
		Diet composition	% salmonids
		Predation rates	Minimum estimates based on PIT tag recoveries
	Fish (pikeminnow)	Angler participation	Numbers of sport reward participants
		Harvest	Number of pikeminnow harvested by sport reward anglers
		Exploitation rate	Proportion of population harvested annual by anglers
		Size & age structure	% of pikeminnow tagged and harvested by size over time
	Pinnipeds (seals & sea lions)	Abundance	Index numbers / observation frequency
		Distribution	Relative abundance near Bonneville & downstream
		Diet	Species composition by time and area
		Predation rate	Number of salmonids eaten near Bonneville Dam relative to dam count

6.5.3.2 Benchmarks

Monitoring benchmarks are program specific and based on changes relative to historical base periods as well as specific objectives identified in related action plans.

6.5.3.3 Example Data Types

Example reporting templates for ecological effectiveness monitoring data are included below to illustrate how this information might begin to be organized for evaluation. Annual data would be summarized for six year intervals consistent with the reporting interval identified by the Recovery Plan for action effectiveness and threat reduction evaluation.

Table 58. Example monitoring data summary for avian predation in the Lower Columbia River.

Metric	Baseline or target	Long-term avg.	Recent years 2002	2003	2004	2005	2006	2007	Recent avg
Caspian terns									
Abundance									
E Sand Island %									
Juveniles/pair									
Diet % salmonids									
Salmonids eaten									
Cormorants									
Abundance									
E Sand Island %									
Juveniles/pair									
Diet % salmonids									
Salmonids eaten									

Table 59. Example monitoring data summary for the Northern Pikeminnow management program in the Lower Columbia River.

Metric	Baseline or target	Long-term avg.	Recent years 2000	2001	2002	2003	2004	2005	Recent avg
Anglers	--								
Catch/angler	--								
Harvest	--								
Average fish size	??								
Exploitation rate	10-20%								

Table 60. Example monitoring data summary for pinniped predation in the Bonneville Dam tailrace.

Metric	2002	2003	2004	2005	2006	2007	Avg
No of individuals							
Ca. sea lions							
Steller sea lions							
Harbor seals							
Max daily no.							
Days any present							
Predation loss (total)							
Deterrent engagements							
Number removed							

6.5.4 Sampling and Analytical Design

6.5.4.1 Framework

The ecological effectiveness sampling design incorporates the following sampling and analytical design elements:

1. A combination of systematic periodic and opportunistic sampling for invasive plants, invertebrates, and fishes at index sites in the estuary and mainstem.
2. Intensive systematic annual sampling of avian predators and predation in the estuary.
3. Intensive systematic annual sampling of the northern pikeminnow population and sport reward fishery for pikeminnow in the lower Columbia mainstem and estuary.
4. Systematic annual sampling of pinniped numbers and predation.
5. Applied research and analysis to evaluate critical assumptions, improve estimate precision, and refine assessment method and tools (see uncertainty and validation research).

6.5.4.2 Methods

Methods employed for current action effectiveness monitoring programs related to ecological factors are summarized below.

Aquatic Nonindigenous Species

A comprehensive literature review and field survey of exotic species in the lower Columbia River was completed in 2001-2004 (Sytsma et al. 2004). This survey describes baseline conditions and establishes effective protocols for any future monitoring efforts. A variety of sampling projects have been conducted prior to 2004 but a systematic periodic sampling program has not been established.

Avian predators

Avian predation is currently being monitored in the Columbia River estuary to: 1) evaluate the effectiveness of efforts to reduce impacts on juvenile salmonid by relocating nesting colonies of Caspian tern, 2) assess potential management options to reduce predation by double-rested cormorant, and 3) monitor colonies of other piscivorous waterbirds (Collis et al. 2007). Avian predation in the Columbia River estuary has been systematically monitored since 1997. Terns and cormorants have been identified as a significant mortality factor on juvenile salmonid migrants. Efforts are underway to reduce tern predation by relocating nesting colonies to estuary islands closer to the ocean where alternative food sources result in less salmonid mortality. The effectiveness of this action is being evaluated by monitoring the abundance, distribution, productivity and diet of nesting colonies. A Caspian Tern Management Plan for the Columbia River Estuary will guide further management of Caspian terns. Similar actions are being contemplated for cormorants based on results from the ongoing research and monitoring program.

Pikeminnow predation

A northern pikeminnow management program has been underway in the Columbia River mainstem since 1990 (Porter 2006). This program provides monetary rewards to anglers for the harvest of pikeminnow and also includes contract anglers fishing in restricted areas of the dams where predators congregate. Previous research has concluded that nominal exploitation of this fish will significantly reduce predation on juvenile salmonids by reducing survival to large sizes

of pikeminnow that account for the majority of the predation losses. The effectiveness of this program is based on trends in angler participation, catch rate, harvest, annual exploitation rates, and size structure of the predator population. Angler effort, harvest and biological information is collected at participant registration stations. A sample of pikeminnow are caught, marked, and released prior to each fishing season in order to estimate exploitation rates from tag recoveries by anglers. Biological data includes size and age (estimated from bony structures).

Marine mammals

Marine mammal monitoring efforts in the lower Columbia mainstem and estuary have been implemented and expanded in recent years in response to growing numbers of California sea lions, Steller sea lions, and harbor seals throughout the lower river and increasing seasonal concentrations of sea lions and observations of predation in the tailrace of Bonneville Dam (NOAA 2007). Monitoring efforts include systematic observations of pinniped numbers and salmonids eaten by pinnipeds in the Bonneville Dam tailrace. Beginning in 2005, a hazing program was implemented to deter predation on vulnerable salmon and steelhead in the dam tailrace (Wright et al. 2007).

6.5.4.3 Program Targets

To be determined

6.5.5 Current Monitoring Activities

Current ecological action effectiveness monitoring programs in the lower Columbia River.

Table 61. Washington lower Columbia River fish hatcheries currently in operation and species produced (LCFRB 2004).

Focus	Years	Implementors[1]
Invasive species	Periodic (none ongoing)	Various (see Sytsma et al. 2004)
Shad	1938 – present (dam counts)	USACE
Avian (Terns & cormorants)	1997-present	USGS, BPA
Fish (pikeminnow)	1990 – present	PSMFC, ODFW, WDFW, BPA
Pinnipeds	1999-present (Bonneville tailrace)	USACE, NOAA, WDFW, ODFW, CRITFC, PSMFC

[1] CRITFC = Columbia River Inter-Tribal Fish Commission, BPA = Bonneville Power Administration, ODFW = Oregon Department of Fish and Wildlife, PSMFC = Pacific States Marine Fisheries Commission, USACE = U.S. Army Corps of Engineers, USGS = U. S. Geological Survey, NMFS = National Marine Fisheries Service, WDFW = Washington Department of Fish and Wildlife.

6.5.6 Information Gaps

The following information gaps in ecological monitoring were identified based on a review of the available information including annual biological assessments, and research, monitoring and guidance documents.

1. Systematic monitoring for the occurrence and spread of new species invasive plants, invertebrates, and fishes in the Columbia River mainstem and estuary.
2. Marine mammal population levels and predation rates on adult salmonid in the lower Columbia River mainstem and estuary downstream from the immediate vicinity of the dam where current monitoring is concentrated.

6.5.7 Implementation Actions

M.M-1. Monitor occurrences of new exotic aquatic fishes, invertebrates or plants based on a dedicated sampling program in indicator sites and incidental observations during other biological status monitoring, anecdotal reports, and follow-up sampling where appropriate.

Lead: TBD

Funding source: TBD

Rationale: The objective of this activity is to proactively identify emerging threats while there is still a possibility of containment. This will involve development of a program that does not currently exist.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M-2. Continue to monitor abundance of American shad based on Bonneville Dam counts.

Lead: USACE

Funding source: BPA

Rationale: Dam counts continue to provide an inventory of status and trends in shad abundance and will identify any significant changes in numbers or population dynamics. They will provide a direct indicator of the response to any shad management actions that might be contemplated based on results of research on the significance of any interaction with salmonids.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M-3. Monitor annual angler participation, harvest, and exploitation rate in northern pikeminnow management program in Columbia River mainstem.

Lead: PSMFC, ODFW, WDFW

Funding source: BPA

Rationale: Continued monitoring is needed to determine whether program is achieving desired 10-20% annual exploitation rates intended to reduce pikeminnow predation on juvenile salmonids by 50%. In involves monitoring of anglers registered, numbers and sizes of fish caught, and the annual percentage of tagged fish caught.

Activities**:**

a. Identify appropriate opportunities and funding sources.

b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M-4. Conduct periodic censuses of the abundance, distribution, and diet of avian predator including Caspian terns and Cormorants.

Lead: USGS

Funding source: BPA

Rationale: This monitoring is needed to determine if management measures limit avian predator numbers and distribution achieve the desired effects.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

M.M-5. Conduct periodic censuses of the abundance, distribution, and diet of marine mammals throughout the lower Columbia River mainstem and near Bonneville Dam and evaluate response to hazing, exclusion, and other management measures as implement.

Lead: NOAA

Funding source: BPA

Rationale: Monitoring of marine mammal status and behavior will determine the trend in this increasing mortality factor as well as the effectiveness of management measures.

Activities**:**

a. Identify appropriate opportunities and funding sources.
b. Develop, submit, and support a detailed sampling proposal, work plan, and data reporting schedules
c. Identify constraints and uncertainties
d. Identify coordination considerations

6.6 Mainstem/Estuary

Mainstem/Estuary action effectiveness monitoring is intended to identify trends and effects of protection, restoration, and management actions affecting habitat conditions critical to salmon migration and rearing. Estuary and lower Columbia mainstem habitats play an important but poorly understood role in the anadromous fish life cycle. Large scale changes in river flow, water circulation, sediment transport, and floodplain and wetland destruction or isolation have altered habitat conditions and processes important to migratory and resident fish and wildlife. Hydro flow regulation, channel alternations, and floodplain development and diking have all contributed to these habitat changes. Estuary conditions and actions affect all salmon ESUs in the Columbia River basin and are treated in a comprehensive estuary recovery plan module (NOAA 2006) and a dedicated research, monitoring, and evaluation program (Johnson et al. 2006). The Estuary RM&E program identified by Johnson et al. (2006) meets the status monitoring, action effectiveness monitoring, and uncertainties research needs of the Washington Lower Columbia Recovery plan. Key elements are summarized below and the reader is referred to the regional plan for further detail.

6.6.1 Objectives

1. Measure the effects of individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives (termed effectiveness monitoring in the estuary plan).
2. Estimate the collective effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitat and performance (termed validation monitoring in the estuary plan).

6.6.2 Indicators

The framework organizing action effectiveness research is built on an estuary conceptual that relates stressors, controlling factors, ecosystem structures, ecosystem processes and ecosystem functions. Monitoring indicators corresponding to these factors are identified in the following table.

Table 62. Indicators identified for application to estuary action effectiveness monitoring.

Category	Monitored indicators
Flow regulation	Water discharge
Passage/Flow Barriers	Passage Barriers
Invasive Species	Species composition, abundance, spatial distribution
Watershed conditions	Discharge, water velocity/temp., sediment budget, large woody debris
Geology sediments	Accretion rates, contaminants, Redox potential, soil composition
Hydrodynamics	Ground water level, Surface water elevation, water velocity
Bathymetry/Topography	Bathymetry, Floodplain topography
Water quality	Dissolved oxygen, nutrients, pH, Salinity
Temperature	Temperature
Landscape features	Ecosystem structures map, area restored, large woody debris
Tidal Channel Morphology	Edge/Density/Sinuosity
Vegetation cover	Percent cover by species
Food web	Foraging success, predation index, prey availability
Salmonid preference	Abundance, age/size structure, distribution, growth rate, migration pathways, residence time, species composition

6.6.3 Implementation Actions

The estuary research, monitoring, and evaluation program identifies two actions specific to action effectiveness research/monitoring in addition to a suite of actions for estuary status and trend monitoring, estuary uncertainties research, and estuary implementation compliance monitoring.

Action effectiveness actions are:

- New and ongoing projects should consider applying monitoring protocols in the plan.
- Develop an analytical model to quantify and evaluate the cumulative effects of multiple hydrologic reconnection restoration projects.

7.0 Uncertainty and Validation Research

Uncertainty and validation research targets specific issues that constrain effective recovery plan implementation. Research includes evaluations of cause and effect relationships between fish and limiting factors, and actions that address specific threats related to limiting factors. Incomplete understanding of biological systems and of the human impact upon those systems, results in uncertainty about the outcomes of the actions identified in the Recovery Plan. The plan supports the careful consideration of uncertainty by explicitly identifying assumptions and working hypotheses, incorporating safety factors into recovery scenarios, conducting validation research to explore uncertainty and adjusting recovery actions when appropriate. Research provides focused information on a variety of questions and often involves some type of adult or juvenile sampling program. Research can be costly, often evolves as a series questions are answered, and ends when its purposes it met. Research can provide very specific and detailed information on key monitoring subjects and results are often incorporated into long term monitoring programs in the form of sampling protocols, expansion factors or bias corrections, or estimates of precision and accuracy.

7.1 Objectives

The objective of uncertainty and validation research is to characterize unknown ecological relationships and critically examine cause and effect relationships between fish, limiting factors/threats, and actions that address specific factors/threats. These critical uncertainties constrain our ability to identify or evaluate the effects of specific actions.

7.2 Current Research Activities

Table 63 documents the long-term research studies including habitat or biological attributes, the entity, location, and variable or measurement being sampled. Also included are frequency of sampling, period, protocol and point of contact. By conducting long term monitoring efforts on a multitude of physical and biological factors, these programs will identify functional relationships relevant to recovery planning and thereby reduce uncertainty in planning efforts.

Although the research is varied in scope and scale, the following attributes are being investigated:

- Habitat complexity and cover
- Riparian vegetation, cover and structure
- Channel morphology
- Water quality
- Biological attributes
- Instream Flows

Key entities involved in research at the subbasin level include:

- U.S. Forest Service
- U.S. Geological Survey
- Washington Department of Fish and Wildlife
- Washington Department of Ecology
- Lower Columbia Fish Recovery Board (LCFRB)
- Clark County Conservation District
- Columbia River Research Laboratory (CRRL)

- Underwood Conservation District
- Salmon Recovery Funding Board/Intensively Monitored Watersheds

Several subbasins have been designated as the focus of intensive research and monitoring programs designed to provide detailed information on the status and interactions of fish, stream habitat conditions, and watershed conditions as well as the effects of a variety of protection and restoration actions involving habitat and hatcheries. These Intensively Monitored Watersheds include East Fork Lewis, Mill/Germany/Abernethy complex and Wind River (Figure 22).

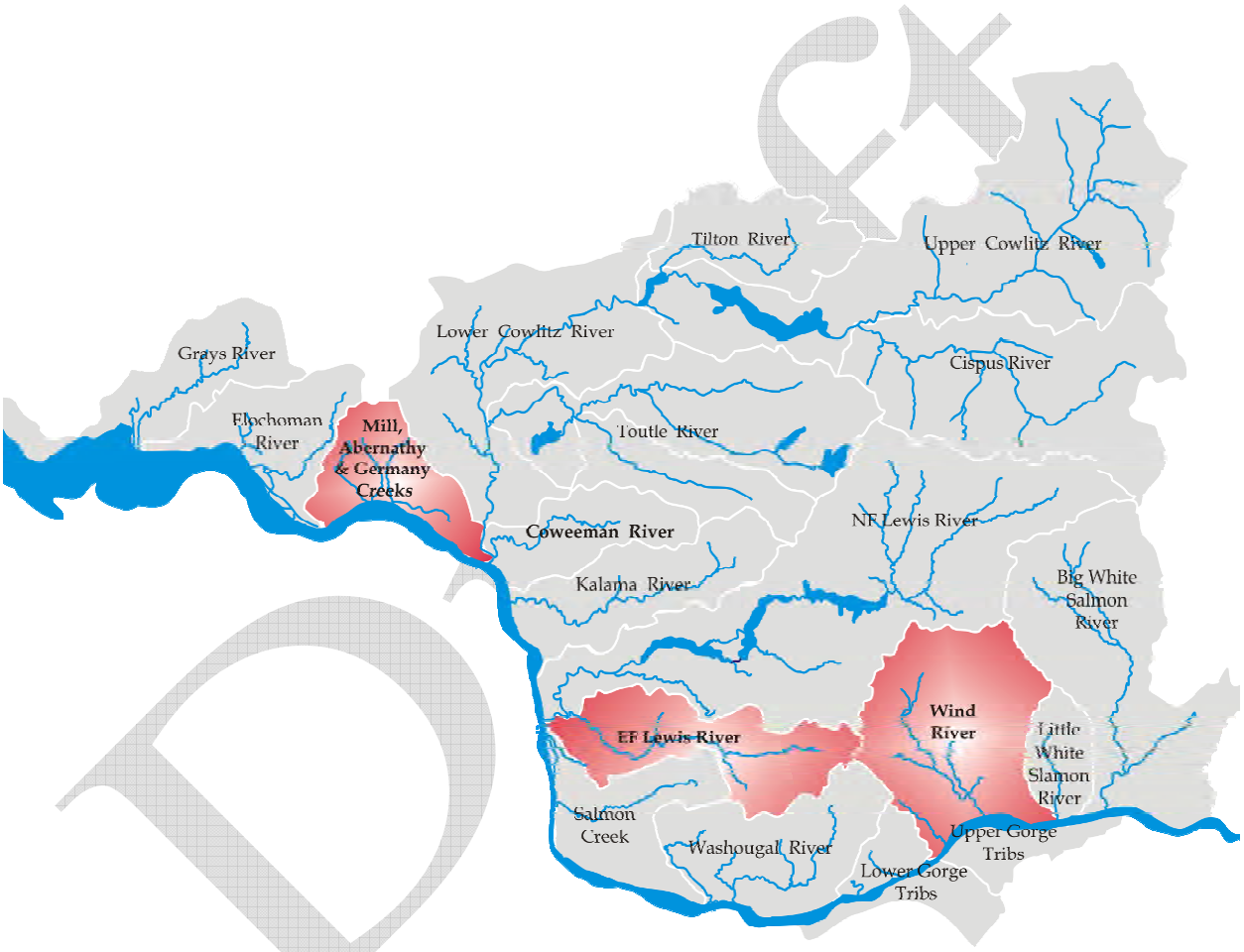

Figure 22. Map highlighting primary basins for study.

Table 63. Summary of significant critical uncertainty research activities at the subbasin scale.

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Habitat Complexity & Cover	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Riparian Vegetation Cover & Structure	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Channel Morphology	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	AREMP	1987-Present	NA	Steve Lanigan 503-808-2261 slanigan@fs.fed.us
Water Quality	USFS	EF Lewis Basin	Temperature	annual	WDEQ Protocol	1996-Present	NA	Dianna Perez 360-891-5108 dperez@fs.fed.us
Water Quality	USGS	EF Lewis Basin	Temperature, nutrients, contaminants	Intermittent	WDEQ Protocol	1976-80, 1980	NA	http://wa.water.usgs.gov/data/
Habitat Complexity & Cover	WDFW	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	Salmon and Steelhead Habitat Inventory and Assessment Program - Level II	1991-Present (2004?)	NA	Dianna Perez 360-891-5108 dperez@fs.fed.us
Water Quality	WDOE	EF Lewis Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present	NA	Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Habitat Complexity & Cover	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Steve Manlow 360-425-1552 www.LCFRB.org
Riparian Vegetation Cover & Structure	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Steve Manlow 360-425-1552 www.LCFRB.org
Channel Morphology	LCFRB	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA	Steve Manlow 360-425-1552 www.LCFRB.org
Habitat Complexity & Cover	Clark County CD	EF Lewis River	Habitat Restoration Monitoring, Stream Surveys	Intermittent	?	?	64a	Denise Smee, 360-883-1987 http://www.clarkcd.org

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Water Quality	Clark County CD	EF Lewis River	Water Quality	annual	WDEQ Protocol	1994-Present	NA	Denise Smee, 360-883-1987 http://www.clarkcd.org
Water Quality	SRFB / IMW	Mill/Germany	Aluminum concentrations & fish abundance	ongoing	WDEQ Protocol	2004 - present	NA	http://www.iac.wa.gov
Biological Attributes	SRFB / IMW	Mill/Germany/Abernathy	Juvenile Abundance Estimate (smolt trapping)	ongoing	mark recapture	2001-present	NA	http://www.iac.wa.gov
Biological Attributes	SRFB / IMW	Mill/Germany/Abernathy	Spawning Surveys (coho, steelhead, Chinook, chum)	ongoing	TFW - spawning module	?	NA	http://www.iac.wa.gov
Channel Morphology	SRFB / IMW	Mill/Germany/Abernathy	Sediment Surveys: sediment budgets	ongoing	Washington Watershed Assessment Module	2004 - present	NA	http://www.iac.wa.gov
Channel Morphology	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2005	NA	http://www.iac.wa.gov
Habitat Complexity & Cover	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2004 - present	NA	http://www.iac.wa.gov
Instream Flows	SRFB / IMW	Mill/Germany/Abernathy	Flow Gages to assess altered flow regimes	ongoing	WDEQ Protocol	2004 - present	NA	http://www.iac.wa.gov
Riparian Vegetation Cover & Structure	SRFB / IMW	Mill/Germany/Abernathy	Stream Surveys in streams with coho present	ongoing	Hankin & Reeves	2004	NA	http://www.iac.wa.gov
Water Quality	SRFB / IMW	Mill/Germany/Abernathy	Temperature	ongoing	WDEQ Protocol	2004 - present	NA	http://www.iac.wa.gov

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Water Quality	Under-wood CD	Wind Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992	NA	Jim White 503-493-1936 ucd@gorge.net
Habitat Complexity & Cover	USFS	Wind Basin	Stream/Riparian Surveys	Intermittent	AREMP	1991-Present	NA	Dianna Perez 360-891-5108 dperez@fs.fed.us
Biological Attributes	USFS-CGSA	Wind Basin	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead	1994-Present	NA	Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us
Water Quality	USGS	Wind Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1980	NA	http://wa.water.usgs.gov/data/
Biological Attributes	USGS – CRRL	Wind Basin	Chinook Spawning Surveys	NI	?	1998-present	NA	Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov
Water Quality	USGS	Wind Basin	Salmon Carcass analog study	annual	Nutrients Water Quality and Chemistry monitoring. Macroinvertebrate response, juvenile salmonid response	2003-2006	NA	Matt Messa 503-538-2299 ext 246 matt_mesa@usgs.gov
Habitat Complexity & Cover	USGS – CRRL	Wind Basin	Stream Habitat Surveys,	annual	Gradient, Riparian Condition, LWD, Pool Frequency		NA	Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov
Water Quality	USGS – CRRL	Wind Basin	Temperature Monitoring	annual	USGS	2001-present	NA	Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov
Instream Flows	USGS – CRRL	Wind Basin	Stream Gage	annual	WDEQ Protocol	1998-Present	NA	Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov
Biological Attributes	USGS – CRRL	Wind Basin	Snorkel Surveys, Electrofishing	annual	Population abundance	1998-Present	NA	Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov

Attribute	Entity	Location	Variable or Measurement	Frequency	Protocol	Period	Action	Contact Information
Habitat Complexity & Cover	WDFW	Wind Basin	Stream/Riparian Surveys	Intermittent	Salmon and Steelhead Habitat Inventory and Assessment Program - Level II	1988-Present	NA	Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov
Water Quality	WDOE	Wind Basin	Temperature, nutrients, contaminants	annual	TMDL	1973 1976-83, 1995	NA	Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main
Instream Flows	WDOE	Wind Basin	Stream Gage	annual	WDEQ Protocol	1934-Present	NA	Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main.
Biological Attributes	WDFW	Wind Basin	Juvenile Steelhead Densities & Biomass	?	?	?	NA	Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov
Riparian Conditions & Function	Skamania County	Wind Basin	Riparian setback monitoring	ongoing	?	?	56o	Karen Witherspoon skamaniacounty.org
Biological Attributes	WDFW	Wind Basin	smolt trapping	?	mark recapture weir	?	NA	Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov
Biological Attributes	WDFW	Wind Basin	spawning surveys	?	TFW - Spawning module	?	NA	Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov

Sources:

1. Salmon Recovery Funding Board (2004): http://www.iac.wa.gov/Documents/SRFB/Monitoring/IMW_progress_rpt.pdf

2. Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan Volume II, Draft. Prepared By: Lower Columbia Fish Recovery Board for the Northwest Power & Conservation Council (http://www.nwppc.org/fw/subbasinplanning/lowerColumbia/plan/).

3. Personal Communication with entities listed above (May 2006)

7.3 Research Needs

Research needs were identified by a review of the literature and plans related to salmon status and recovery. Sources are referenced where a research need was specifically identified in a particular plan or report. Needs are listed by category.

7.3.1 Salmonid Status and Population Viability

1. Validate recovery goals and preliminary estimates of persistence probabilities based on life cycle analyses and long term data sets.
2. Empirically evaluate assumptions regarding the significance of Allee effects and depensation at small population sizes associated with quasi-extinction risk estimates.
3. Identify relationships and co-variation between marine and freshwater survival and productivity patterns for salmon.
4. Identify long term trends in global factors affecting salmon production including climate and ocean conditions.
5. Adapt and apply new genetic stock identification methods to population status assessments.
6. Climate change: How will different scenarios of climate change affect ecosystem dynamics, habitat characteristics, and ultimately population condition across all life stages? (NOAA 2007)
7. Natural cycles: How can the effects of poor ocean conditions related to the Pacific Decadal Oscillation (PDO) or El Niño Southern Oscillation (ENSO) be quantified and managed for in the future? (NOAA 2007)

7.3.2 Stream Habitat

1. Apply monitoring feedback loops to inform EDT analysis and improve estimates of fish productivity and capacity based on habitat and fish productivity data.
2. Determine relative short term and long term tradeoffs in the benefits of site-specific and process based actions.
3. What are the quantitative relationships between tributary in-stream flow and juvenile rearing and out-migrant survival? (NOAA 2007)
4. What is the uncertainty associated with various models (EDT, Shiraz) used for evaluating limiting factors? (NOAA 2007)
5. What is the relationship of habitat type and quality to a quantitative fish productivity level? (NOAA 2007)
6. Which habitats are most important in determining juvenile and adult migration patterns and potential for increases in viability? (NOAA 2007)
7. How are genotypic variations related to habitat use? (NOAA 2007)
8. How can the use of ongoing PIT tagging and other tagging and marking studies and data be used to determine origin and estuarine habitat use patterns of different stocks? (NOAA 2007)
9. How can action effectiveness be linked to changes in population and ESU status and viability (multiple scales)? (NOAA 2007)
10. What is the effect of toxic contaminants on salmonid fitness and survival in the Columbia River estuary and ocean? (NOAA 2007)

11. What effect do invasive species have on salmon, and how can those effects be controlled? (NOAA 2007)
12. What are the relationships between micro- and macro-detrital inputs, transport, and end-points? (NOAA 2007)
13. How have historical changes in estuary morphology and hydrology affected habitat availability and ecosystem processes? (NOAA 2007)

7.3.3 Hydropower

1. Determine feasibility of re-establishing self-sustaining anadromous populations upstream of hydropower facilities in the Lewis, Cowlitz and Tilton systems.
2. Determine effects of flow on habitat in the estuary & lower mainstem.
3. What is the feasibility of re-establishing self-sustaining anadromous populations upstream of hydropower? (NOAA 2007)
4. How do uncertainties in estimates of delayed mortality affect conclusions regarding population status and viability? (all ESUs) (NOAA 2007)
5. Pre-spawning mortality (all ESUs)? (NOAA 2007)

7.3.4 Fisheries

1. Evaluate innovative techniques (e.g., terminal fisheries and tangle nets) to improve access to harvestable stocks and reduce undesirable direct and indirect impacts to wild populations.
2. Evaluate appropriateness of stocks used in weak stock management.
3. How do uncertainties in exploitation rate estimates affect evaluations of the effects of harvest on VSP and population status? (NOAA 2007)
4. How does uncertainty surrounding the use of indicator (hatchery) stocks to infer fishery mortality on natural-origin fish affect conclusions regarding population status and viability? (NOAA 2007)
5. Are there gaps in quantitative data available for analyses of fishery impacts at relevant units (e.g., by population, MPG, or ESU) and if so, how does this affect the certainty of concluding the status of the population and ESU? (NOAA 2007)
6. How have distributions (instead of point estimates) of parameter estimates been used to improve our understanding of how harvest effects impact populations, and how our management is working to reduce negative impacts? (NOAA 2007)
7. Is the accuracy of estimates of incidental mortality related to bycatch in non-target fisheries and from specific gear types in catch and release fisheries known, and how does that affect our management? (NOAA 2007)

7.3.5 Hatcheries

1. Develop a strategy for assessing the interactions between hatchery and wild fish
2. Determine relative performance of hatchery and wild fish in wild in relation to broodstock divergence and hatchery practices.
3. Experimentally determine net effects of positive and negative hatchery effects on wild populations.

4. Experimentally evaluate the efficacy of hatchery program integration, segregation, and supplementation.
5. Determine hatchery effects on disease and predation on wild fish.
6. How do uncertainties in estimates of reproductive success of hatchery and natural-origin fish spawning affect evaluations of the effect of hatchery practices on population status and viability? (NOAA 2007)
7. How do surplus hatchery-origin fish on the spawning grounds affect the productivity and genetic integrity of the natural population? (NOAA 2007)
8. What are the short- and long-term effects of hatchery fish intervention on the status of viability attributes of natural-origin populations within the sub-basins as well as within the migratory corridors? (NOAA 2007)
9. Is early spawn time of hatchery steelhead stocks a successful management tool for segregating hatchery and natural fish? (NOAA 2007)
10. How effective are fish culture techniques, such as acclimation, in segregating hatchery fish from natural populations? (NOAA 2007)

7.3.6 Ecological Interactions

1. Experimentally evaluate nutrient enrichment benefits and risks using fish from hatcheries or suitable analogs.
2. Determine the interactions and effects of shad on salmonids.
3. Is predation by marine mammals a significant factor limiting the status of some populations, and if so, how can it be managed? (NOAA 2007)
4. What is the rate of infection of disease in the natural population? (NOAA 2007)
5. How is the rate of transmission of disease affected by anthropogenic impacts on physical and biological processes? (NOAA 2007)

7.3.7 Mainstem/Estuary

A research, monitoring, and evaluation (RME) plan for the Columbia River estuary and plume was recently developed (Johnson et al. 2003) for the purpose of fulfilling certain requirements of Reasonable and Prudent Alternatives of the 2000 Biological Opinion on the Operation of the Federal Columbia River Power System (NMFS 2000). Research needs were identified in that process at a 2003 workshop. The following research needs were identified at that workshop:

1. Move from a collection of available conceptual frameworks to an integrative implementation framework, where we combine what we have learned in the various conceptual frameworks to identify the most important areas for restoration actions, and what are the most likely avenues for success.
2. Implement selected restoration projects as experiments, so that we can learn as we go.
3. Implement pre- and post-restoration project monitoring programs, to increase the learning.
4. "Mining" of existing, underutilized data to minimize the risk of collecting redundant or unnecessary data, and to compare with current and projected conditions.

5. Make more use of ongoing PIT tagging and other tagging and marking studies and data to determine origin and estuarine habitat use patterns of different stocks.
6. Collect additional shallow water bathymetry data for refining the hydrodynamic modeling, and identifying/evaluating potential opportunities for specific restoration projects.
7. Determine operational and hydrologic constraints for the FCRPS, so that we have a better understanding of feasibility and effectiveness of modifying operations.
8. Identify and implement off-site mitigation projects in CRE tributaries.
9. Establish a data and information sharing network so that all researchers have ready and up-to-date access.
10. Increased genetic research to identify genotypic variations in habitat use.
11. Understanding salmonid estuarine ecology, including food web dynamics.
12. Understanding sediment transport and deposition processes in the estuary.
13. Understanding juvenile and adult migration patterns.
14. Identifying restoration approaches for wetlands and developing means for predicting their future state after project implementation.
15. Improve our understanding of the linkages between physical and biological processes to the point that we can predict changes in survival and production in response to selected restoration measures.
16. Improve our understanding of the effect of toxic contaminants on salmonid fitness and survival in the CRE and ocean.
17. Improve our understanding of the effect of invasive species on restoration projects and salmon and of the feasibility to eradicate or control them.
18. Improve our understanding of the role between micro- and macro-detritus al inputs, transport, and end-points.
19. Improve our understanding of the biological meaning and significance of the Estuarine Turbidity Maximum relative to restoration actions.
20. Identify end-points where FCRPS BO RPA action items are individually and collectively considered to be satisfied, so that the regulatory impetus is withdrawn.
21. Increase our understanding of how historical changes in the estuary morphology and hydrology have affected habitat availability and processes.
22. What are the effects of flow on habitat in the estuary and lower mainstem? (NOAA 2007)

8.0 Programmatic Evaluation

The RM&E program directly supports the adaptive framework of the Lower Columbia Basin. As discussed in the programmatic overview, the program explicitly implements the checkpoints, assessments and benchmarks. Recovery plan implementation includes a series of checkpoints, assessments, benchmarks and decisions (Figure 23). Checkpoints are time-based decision points where substantive changes in direction will be considered. Assessments are formal evaluations of progress and results. Benchmarks are standards or criteria that will drive decisions depending on observed progress in implementation effort and effectiveness. Decisions identify refinements in efforts or new directions based on progress relative benchmarks observed at checkpoints.

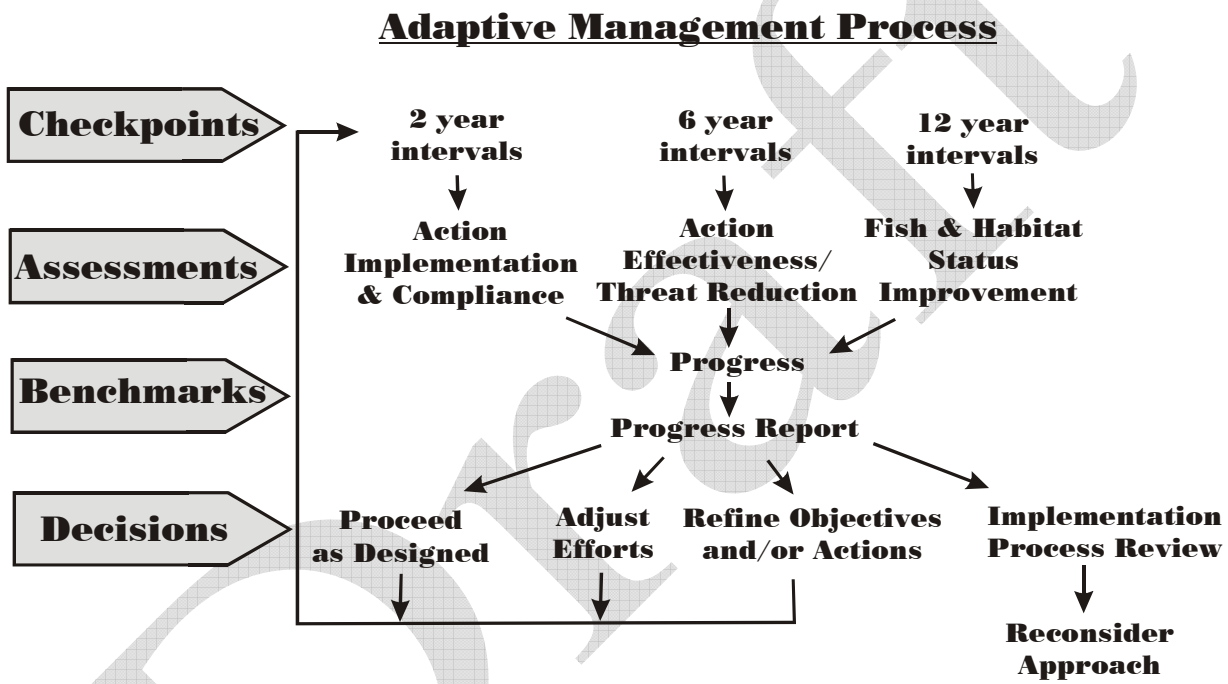

Figure 23. Elements and decision structure for adaptive management process for implementation of Washington Lower Columbia Fish Recovery Plan (LCFRB 2004)

8.1 Reporting Strategy

1. ***Conduct a data management needs assessment and use it to develop a data management plan.***

   Explanation: Additional assessments are needed to coordinate with complementary data management activities throughout the region. For example, the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is developing a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Although it is still under development with uncertain funding for the future, it will likely compliment the needs of the Lower Columbia RM&E program and thus warrant continued attention.

2. ***Maintain consistent regionally-standardized datasets and archive in regional data storage and management facilities (e.g., Pacific State Marine Fisheries Commission StreamNet, Washington Department of Fish and Wildlife SSHIAP, NOAA Fisheries biological datasets).***

   Explanation: Existing infrastructures will be used to archive relevant data and metadata generated through monitoring and research activities. Data will be compiled and subject to rigorous quality assurance/quality control protocols by the collecting agency. Collecting agencies will be responsible for maintaining databases and providing access upon request. Information will be also distributed to multiple archives to maximize accessibility.

3. ***Produce and distribute regular progress and completion reports for monitoring and research activities.***

   Explanation: Regular reporting is essential in making new information available to technical/scientific staff, decision-makers, stakeholders, and the public. It is likely that much of the routine reporting will be conducted electronically.

4. ***Closely coordinate Washington lower Columbia River monitoring, research, and evaluation efforts with similar efforts throughout the basin, including prioritization of activities and standardization of data methods.***

   Explanation: Other RM&E efforts are underway at local and regional scales across the Pacific Northwest. Coordination of Washington lower Columbia River efforts will provide synergistic benefits. For instance, many critical uncertainties are common among different areas and need not be addressed in each area. Standardization of data methods will greatly enhance comparative and interpretative power of monitoring and research activities.

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Appendices

Appendix A. Other Monitoring, Research and Evaluation Programs

Governor's Forum on Monitoring Salmon Recovery and Watershed Health (GFM)

The mission of the GFM is to improve coordination of the state's monitoring efforts associated with salmon recovery and watershed health. GFM provides monitoring recommendations to the Salmon Recovery Funding Board, the Governor's Salmon Recovery Office and appropriate state agencies. Additionally, GFM works with local and regional watershed and salmon recovery groups, tribes, other states, the Northwest Power and Conservation Council, U.S. Environmental Protection Agency, NOAA Fisheries, U.S. Fish and Wildlife Service, and U.S. Forest Service. *www.iac.wa.gov/monitoring*

Salmon Recovery Funding Board (SRFB)

In 1999, the Washington State Legislature created the SRFB to help support salmon recovery by funding habitat protection and restoration projects. It also supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. The SFRB program identified five purposes for monitoring including status and trend (Index) monitoring, implementation monitoring, project effectiveness monitoring, validation monitoring, and compliance monitoring. To date, SRFB has helped finance over 600 projects. *www.iac.wa.gov/srfb/board.htm*

Northwest Power & Conservation Council (NPCC)

The Council develops and maintains a regional power plan and a fish and wildlife program to balance the Northwest's environment and energy needs. They are tasked with developing a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River Basin. In a collaborative effort with the National Marine Fisheries Service (NOAA Fisheries) and the Columbia River Indian Tribes, NPCC contributes to the Independent Scientific Advisory Board (ISAB). In March 2006, the ISAB released a guidance document in which it describes an integrated 3-tier monitoring program for assessing recovery of tributary habitat based on trend or routine monitoring, statistical monitoring, and experimental research monitoring. The Northwest Power Planning Council and the National Marine Fisheries Service have also established an Independent Scientific Review Panel (ISRP) to provide independent scientific advice and recommendations on issues related to regional fish and wildlife recovery programs under the Northwest Power Act and the Endangered Species Act in the Columbia River Basin. *www.nwcouncil.org*

Pacific Coastal Salmon Recovery Fund (PCSRF)

Established in 2000 to provide grants to the states and tribes, and to assist state, tribal and local salmon conservation and recovery efforts. The PCSRF was requested by the governors of the states of Washington, Oregon, California and Alaska in response to Endangered Species Act (ESA) listings of West Coast salmon and steelhead populations. The PCSRF supplements existing state, tribal and federal programs to foster development of federal-state-tribal-local partnerships in salmon recovery and conservation; promotes efficiencies and effectiveness in recovery efforts through enhanced sharing and pooling of capabilities, expertise and information. The goal of the PCSRF is to make significant contributions to the conservation, restoration, and sustainability of Pacific salmon and their habitat.

http://webapps.nwfsc.noaa.gov/servlet/page?_pageid=784&_dad=portal30&_schema=PORTAL30

Upper Columbia Salmon Recovery Board (UCSRB)

Established in 1999, the UCSRB is a standing committee of the North Central Washington Resource Conservation and Development Council which coordinates all activities of sub-basin planning in the Upper Columbia. In 2004, the technical team of the UCSRB released a monitoring strategy report (UCRTT 2004). Addressing statistical and sampling design, spatial scale, indicators, measurement protocols and implementation, UCRTT draws from existing strategies to develop a monitoring approach specific to the upper Columbia Basin.
http://www.governor.wa.gov/gsro/regions/upper.htm

Federal Columbia River Power System (FCRPS)

NOAA working with the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation, developed a detailed and intensive research, monitoring, and evaluation plan for implementing the 2000 Federal Columbia River Power System Biological Opinion (FCRPS). The FCRPS plan included six principle components; population and environmental status monitoring, action effectiveness research, critical uncertainty research, implementation/compliance monitoring, data management and regional coordination.

Collaborative Systemwide Monitoring and Evaluation Project (CSMEP)

CSMEP is a coordinated effort to improve the quality, consistency, and focus of fish population and habitat data to answer key monitoring and evaluation questions relevant to major decisions in the Columbia Basin. The CSMEP project was initiated in 2003 and is administered by the Columbia Basin Fish and Wildlife Authority, with participation from over 30 scientists from federal, state and tribal fish and wildlife agencies, and consulting firms.

Survey of Environmental Monitoring Programs and Associated Databases within Washington State (2003)

A survey by the SRFB of existing environmental monitoring programs and their associated databases in Washington State (as of October 2003). Identifies different monitoring or database programs which directly or indirectly support watershed health or salmon recovery. It describes the type of monitoring, geographic focus, whether data is available on-line, and data overlaps between entities.
www.iac.wa.gov/Documents/SRFB/Monitoring/Environmental_Monitoring_Survey.pdf

Evaluating Watershed Response to Land Management and Restoration Actions: Intensively Monitored Watershed 2005 Progress Report

This document describes a series of intensively monitored watersheds (IMW) established expressly to measure the effect of habitat restoration on salmon and trout productivity. The Germany, Mill, and Abernathy watersheds were selected as IMW sites for the Lower Columbia Basin. Annual data is available regarding water/climate, habitat surveys, and fish populations for those watersheds. *www.iac.wa.gov/Documents/SRFB/Monitoring*

Strategy for Coordinating Monitoring of Aquatic Environments in the Pacific Northwest

The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) provides a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. PNAMP has developed a strategy document for subbasin planners based on a synthesis of

existing strategies and plans. It includes a series of considerations regarding monitoring objectives, monitoring indicators, data reporting, coordination and management. The document identifies the types of monitoring being conducted, which entity is responsible for a particular action, protocols, and data analysis standards and advances a coordinated approach to regional monitoring. *www.pnamp.org*

Quality Assistance Monitoring Plan: Status and Trends Monitoring for Watershed Health and Salmon Recovery

This Quality Assurance monitoring plan guidance document describes a standardized monitoring protocol for assessing the water quality and habitat of our rivers and streams in the State of Washington. The monitoring plan was designed to answer major management questions about the current status and trends of our river and stream aquatic resources. *www.ecy.wa.gov/biblio/0603230*

Environmental Monitoring and Assessment Program (EMAP)

EMAP is a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of current ecological condition and forecasts of future risks to our natural resources. *http://www.epa.gov/emap/index.html*

State of the Salmon (SoS)

State of the Salmon is a nongovernmental consortium dedicated to improving understanding of salmon status and trends across the North Pacific. SoS has information on stock status and trends, international standards for monitoring data collection, and research and monitoring database. www.stateofthesalmon.org

Appendix B. Detailed Inventory of Ongoing Monitoring Activities

Appendix Table 1. Ongoing habitat and biological status monitoring activities (sorted by implementing entity).

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	ongoing	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	annual, since 1992	46a			www.efw.bpa.gov/	
Instream Flows	BLM	Lower Columbia Basin	Maintain and operate effective juvenile and adult passage facilities (including facilities, flow, and spill) at Bonneville Dam	ongoing		annual, since 1992	302c			www.efw.bpa.gov/	
Instream Flows	BPA	Lower Columbia Basin	Maintain adequate water flows in Bonneville Dam tailrace and downstream habitats throughout salmon migration, incubation and rearing periods	ongoing		annual, since 1992	303c			www.efw.bpa.gov/	
Biological Attributes	BPA	Lower Columbia Basin	smolt trapping, spawning surveys, passage counts, P.I.T. data, migration timing	ongoing	unknown	annual, since 1992	302c			www.efw.bpa.gov/	
Channel morphology and complexity	BPA	Lower Columbia Basin	Stream/Riparian Surveys	ongoing		annual, since 1992	46a			www.efw.bpa.gov/	
Water Quality	Clark County	Salmon Basin	Temperature	annual	WDEQ Protocol	1998-Present	NA			?	
Channel morphology and complexity	Clark County CD	EF Lewis River, Salmon Creek, Gee Creek, Gibbons Creek	Habitat Restoration Monitoring	Intermittent			64a			Denise Smee, 360-883-1987 http://www.clarkcd.org	
Water Quality	Clark County CD	EF Lewis River, Salmon Creek, Gee Creek, Gibbons Creek	Water Quality	annual	WDEQ Protocol	1994-Present	NA			Denise Smee, 360-883-1987 http://www.clarkcd.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Stream/Riparian Surveys	ongoing	unknown		32a			clarkpublicutilities.com	
Floodplain and wetland function; channel migration processes	Columbia River Estuary Task Force (CREST)	Lower Columbia Basin, Columbia River Estuary, Grays River Basin, Youngs Bay, Baker Bay	Tidal Wetlands Monitoring, Tide Gate Effectiveness Monitoring	ongoing			205a			Peter Heltzel 503-325-0453 www.oregonvos.net/~crest	
Biological Attributes	Conservation Commission	Lower Columbia Basin	Statewide Salmon Habitat Limiting Factors Analysis	ongoing	ID habitat problems that are preventing natural spawning salmon populations from reaching their full potential.		24b			Ed Manary 360-407-6236 www.scc.wa.gov/districts/list/	
Biological Attributes	Conservation Commission	Germany/ Mill/ Abernathy	Salmon and Steelhead Habitat Limiting Factors: Water Resource Inventory Area 25		WRIA 25 Inventory						
Channel morphology and complexity	Cowlitz CD	Mill Basin	Stream/Riparian Surveys	Intermittent	unknown	1999-2003	NA				
Channel morphology and complexity	Cowlitz CD	Abernathy Basin	Stream/Riparian Surveys	Intermittent	unknown	1997-2003	NA				
Channel morphology and complexity	Cowlitz CD	Germany Basin	Stream/Riparian Surveys	Intermittent	unknown	1997-2003	NA				
Channel morphology and complexity	Cowlitz CD	Lower Cowlitz Basins	Stream/Riparian Surveys	Intermittent	unknown	1996-2001	NA				
Channel morphology and complexity	Cowlitz CD	Lower Cowlitz Basins	Stream/Riparian Surveys	Intermittent	unknown	1996-2001	NA				
Water Quality	Cowlitz CD	Abernathy Basin	Temperature Monitoring	annual	WDEQ Protocol	2002	NA			Kali Robinson 360-425-1880	
Water Quality	Cowlitz CD	Coal Creek	Temperature Monitoring	annual	WDEQ Protocol	2002	NA			Kali Robinson 360-425-1880	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	Cowlitz CD	Abernathy Basin	Temperature Monitoring	annual	WDEQ Protocol	2002	NA			Kali Robinson 360-425-1880	
Water Quality	Cowlitz CD	Arkansas Creek	Temperature Monitoring	annual	WDEQ Protocol	2002	NA			Kali Robinson 360-425-1880	
Watershed Conditions & Hillslope Processes	Cowlitz CD	Arkansas Creek	Arkansas Creek Watershed Plan				NA			Lynn Simpson 360-425-1880 lynnsimpson@wa.nacdnet.org	
Watershed Conditions & Hillslope Processes	Cowlitz CD	Silver Lake	Watershed Plan				NA			Lynn Simpson 360-425-1880 lynnsimpson@wa.nacdnet.org	
	Cowlitz Indian Tribe	Toutle Basin, Cowlitz Basin								Shannon Wills 360-577-8140 www.cowlitz.org	
Channel morphology and complexity	Cowlitz Public Utilities	NF Lewis Basin	Spawning Gravel Study							360-423-2200 www.co.cowlitz.wa.us	
Channel morphology and complexity	Cowlitz Public Utilities	NF Lewis Basin	In-Stream Habitat Monitoring							360-423-2200 www.co.cowlitz.wa.us	
Blocked Habitat	Cowlitz Public Utilities	NF Lewis Basin	Fish Passage Study?							360-423-2200 www.co.cowlitz.wa.us	
Water Quality	Cowlitz Public Utilities	NF Lewis Basin	Temperature Monitoring		WDEQ Protocol					Kali Robinson 360-425-1880	
Instream Flows	Cowlitz Public Utilities	NF Lewis Basin	Velocity Barriers				80c			360-423-2200 www.co.cowlitz.wa.us	
Biological Attributes	Cowlitz Public Utilities	NF Lewis Basin	Predator Study				NA			360-423-2200 www.co.cowlitz.wa.us	
Biological Attributes	FERC	NF Lewis Basin	NF Lewis (Pacific Corp & Cowlitz PUD), Cowlitz River Basin (Cowlitz and Lewis PUD, Tacoma City Light	NA	monitors for compliance with license permit (see specific license)	NA	48c			Patrick Regan 503-522-2741 www.ferc.gov	
Biological Attributes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Channel morphology and complexity	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Blocked Habitat	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Floodplain and wetland function; channel migration processes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Water Quality	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Instream Flows	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	
Watershed Conditions & Hillslope Processes	Governors Salmon Recovery Office (GSRO)	Lower Columbia Basin	Watershed Assessment, Comprehensive Monitoring Strategy & Action Plan, Natural Resource Information Portal	NA	Comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health.	NA	NA			http://www.governor.wa.gov/gsro/monitoring/default.htm	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Watershed Conditions & Hillslope Processes	Lewis County	Salmon Creek Watershed	L Salmon Creek Watershed Study		watershed plan		NA			Craig Swanson 360-747-1440 www.fortress.wa.gov/lewisco/home/	
Blocked Habitat	Lewis County CD	Lower & Upper Cowlitz Basin, Newaukum, Skookumchuck	Culvert inventories & passage Assessment in Lewis County				NA			?	
Water Quality	Lewis County Health Districts	?	Water Quality		sodium, magnesium, and iron		NA			www.doh.wa.gov	
Blocked Habitat	Lewis County PUD	Cowlitz Basin	passage at dams				NA			www.lcpud.org	
Biological Attributes	Lewis County PUD	Cowlitz Basin	fish counts				NA			www.lcpud.org	
Biological Attributes	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	population monitoring		smolt trap (mark/recapture)		NA			Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org	
Channel morphology and complexity	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	Habitat Typing, Restoration Monitoring		TRF Ambient Monitoring Module		39f			Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org	
Water Quality	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	nutrients, temperature, dissolved oxygen		WDEQ Protocol		NA			Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org	
Blocked Habitat	Lower Columbia Fish Enhancement Group (LCFEG)	Lower Columbia Basin, Larson Creek, Wind River, Whittle Creek, Grays River	regional culvert inventory		SSHEAR		33j			Tony Meyer 360-882-6671 www.lcfeg.org tony@lcfeg.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Riparian Conditions & Function	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Channel morphology and complexity	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Blocked Habitat	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Water Quality	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Instream Flows	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Watershed Conditions & Hillslope Processes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	
Biological Attributes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Monitor salmon protection and restoration projects completed in the lower Columbia Region.	ongoing	NA	1998-present	701a			Steve Manlow 360-425-1552 www.LCFRB.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Temperature, Dissolved Oxygen, Turbidity		WDEQ Protocol					Scott McHuen Matt Burlin 503-226-1565	
Channel morphology and complexity	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery		203a			Scott McHuen Matt Burlin 503-226-1565	
Riparian Conditions & Function	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery		203a			Scott McHuen Matt Burlin 503-226-1565	
Floodplain and wetland function; channel migration processes	Lower Columbia River Estuary Partnership (LCREP)	Lower Columbia Basin	Habitat Mapping		satellite and hyperspectral imagery		203a			Scott McHuen Matt Burlin 503-226-1565	
Biological Attributes	NOAA	Lower Columbia Basin	Estuary fish monitoring	NA	NA	NA	204a			www.nwr.noaa.gov	
Biological Attributes	NOAA	Lower Columbia Basin	Estuary - Limiting Factors Research	NA	NA	NA	203b			www.nwr.noaa.gov	
Biological Attributes	NOAA	Lower Columbia Basin	ESA Fishery Management Plans	NA	NA	NA	401a			www.nwr.noaa.gov	
Biological Attributes	NOAA	Lower Columbia Basin	Regulatory enforcement	NA	NA	NA	405a			www.nwr.noaa.gov	
Biological Attributes	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database, fish passage center, fish passage,	NA	The Council works to protect, mitigate and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA	NA			www.nwcouncil.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database	NA	The Council works to protect, mitigate and enhance fish and wildlife of the Columbia River and guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA	NA			www.nwcouncil.org	
Water Quality	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database	NA	Project/Research Database	NA	NA			www.nwcouncil.org	
Watershed Conditions & Hillslope Processes	National Power Planning Council (NPPC)	Lower Columbia Basin	NED database, restoration monitoring protocols (PNAMP)	NA	The Council guides Bonneville Power Administration's funding of projects to implement the fish and wildlife program	NA	NA			www.nwcouncil.org	
Blocked Habitat	National Power Planning Council (NPPC)	Lower Columbia Basin	Effective dam passage facilities	NA	Operate Fish Passage at Bonneville Dam	NA	302b			www.nwcouncil.org	
Water Quality	National Resource Conservation Service (NRCS)	Lower Columbia Basin	National Water & Climate Center Database		WDEQ Protocol		NA			Doug Fenwick www.nrcs.usda.gov	
Habitat Complexity & Cover	PacifiCorp	NF Lewis Basin	Stream/Riparian Surveys		Hankin/Reeves	1999-2003	NA			Frank Shrier 503-813-6622	
Habitat Complexity & Cover	PacifiCorp	Lewis Basin	Stream/Riparian Surveys		Hankin/Reeves	1989-Present (2004?)	NA			Frank Shrier 503-813-6623	
Water Quality	PacifiCorp	NF Lewis Basin	Temperature	annual	WDEQ Protocol	1999-2000		New licenses cont.		Frank Shrier 503-813-6624	
Instream Flows	PacifiCorp	NF Lewis Basin	Stream Gage	annual	WDEQ Protocol	1926-Present		New licenses cont.		Frank Shrier 503-813-6626	
Biological Attributes	PacifiCorp	NF Lewis Basin	Adult and juvenile passage, reintroduction of spring Chinook/coho/steelhead	annual	Lewis River Monitoring Plan	2008-2057		Annual report		Frank Shrier 503-813-6627	
Water Quality	PacifiCorp	NF Lewis Basin	Temperature	annual	WDEQ Protocol	2008-2058		Annual report		Frank Shrier 503-813-6628	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Blocked Habitat	PacifiCorp	NF Lewis Basin	monitor flows in bypass reach	annual	WDEQ Protocol	2008-2059	80b			Frank Shrier 503-813-6629	
Habitat Complexity & Cover	PacifiCorp	NF Lewis Basin	habitat protection and improvement for salmon/steelhead/ bull trout	annual	Aquatic fund distribution and land purchase	2008-2060	46c			Frank Shrier 503-813-6630	
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	BPA monitoring and databases, GIS data, P.I.T. databases	NA	NA	NA	NA			www.psmfc.org/	
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	StreamNet database	NA	NA	NA	NA			www.psmfc.org/	
Water Quality	Port of Vancouver	Lower Columbia Basin	Pollution monitoring	ongoing	TMDL	?	74h			Patty Boyden 360-992-1103 www.portvanusa.com	
?	SRFB	Lower Columbia Basin	Survey of environmental monitoring programs and associated databases within Washington state		Review of all RM&E efforts in Lower Columbia River by State, County, and Local agencies	NA	NA			http://www.iac.wa.gov/	
Riparian Conditions & Function	Skamania County	Washougal Basin	?	ongoing			56o			Karen Witherspoon www.skamaniacounty.org	
?	State Noxious Weed Control Board	Lower Columbia Basin	Region 8 Class B Weed Designates	NA	WSNWB advises the Washington State Department of Agriculture about noxious weed control in Washington State. It also serves as the state's noxious weed coordination center.	NA				www.nwcb.wa.gov or noxiousweeds@agr.wa.gov	
Channel morphology and complexity	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003	NA			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov	
Riparian Conditions & Function	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003	NA			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Blocked Habitat	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003	NA			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov	
Watershed Conditions & Hillslope Processes	State Parks	Lower Columbia Basin	Salmon Recovery Program – Resource Stewardship (2001-2003)	NA	Assess salmonid habitat statewide in properties owned and/or managed by State Parks.	2001-2003	NA			Rob Thimble 360-902-8592 rob.thimbel@parks.wa.gov	
Water Quality	Tacoma Power	Cowlitz Basin	Temperature Monitoring	ongoing	WDEQ Protocol		NA			Paul LaRivierre	
Biological Attributes	Tacoma Power	Cowlitz Basin	Fish Passage				80d			Paul LaRivierre	
Water Quality	Underwood CD	Wind Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992	NA			Jim White 503-493-1936 ucd@gorge.net	
?	USACE	Lower Columbia Basin	Monitoring of aquatic and wetland mitigation efforts	ongoing	Monitoring of aquatic and wetland mitigation efforts as required by permit conditions.	NA	NA			Chris L. McAuliffe chris.l.mcauliffe@usace.army.m	
?	USACE	Lower Columbia Basin	Endangered Species Act Programmatic Consultation Compliance Monitoring	NA	Individual project monitoring of compliance with ESA programmatic consultation requirements by submitting reports on revegetation success, pollution, and erosion control measures, fish capture and release, and overall project success for restoration activities.	NA	NA			Cindy Barger cindy.s.barger@usace.army.mil	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	USFS	Toutle Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1985 - Present				Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest RegionR6 Regional Office, USDA Forest ServicePhone:(503) 808-2676; Fax:(503) 808-2469email: dkonnoff@fs.fed.usData available on NRIS	
Riparian Conditions & Function	USFS	Toutle Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/	
Channel morphology and complexity	USFS	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present				Rick Henderson - Project Leader PIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 ph: 435-755-3578 cell: 435-757-5737 rhenderson01@fs.fed.us	
Riparian Conditions & Function	BLM	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present				Rick Henderson - Project LeaderPIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 ph: 435-755-3578 cell: 435-757-5737 rhenderson01@fs.fed.us	
Channel morphology and complexity	BLM	Lower Columbia Basin	PACFISH/INFISH Habitat Monitoring	annual	PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO)	1994 - Present				Rick Henderson - Project Leader PIBO Effectiveness Monitoring Program, USDA Forest Service, Forestry Sciences Lab, Logan, UT 84321 ph: 435-755-3578 cell: 435-757-5737 rhenderson01@fs.fed.us	
Channel morphology and complexity	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/	
Riparian Conditions & Function	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/	
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1994 - Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us http://www.reo.gov/monitoring/watershed/	
Channel morphology and complexity	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	What are the existing aquatic and Riparian conditions? What are the factors limiting the productive capabilities of habitats? Are Stream habitat objectives being met? What are the cumulative watershed effects?	1985 - Present				Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest Region R6 Regional Office, USDA Forest Service Phone:(503) 808-2676; Fax:(503) 808-2469 email: dkonnoff@fs.fed.us Data available on NRIS	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Riparian Conditions & Function	USFS	Lower Columbia Basin	Stream/Riparian Surveys	annual	What are the existing aquatic and Riparian conditions?What are the factors limiting the productive capabilities of habitats?Are Stream habitat objectives being met?What are the cumulative watershed effects?	1985 - Present				Deborah KonnoffFish Habitat Relationships CoordinatorPacific Northwest RegionR6 Regional Office, USDA Forest ServicePhone: (503) 808-2676; Fax:(503) 808-2469email: dkonnoff@fs.fed.usData available on NRIS	
Riparian Conditions & Function	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	Classify and determine the condition of in-stream habitat. Stream habitat information is collected for land use and project planning purposes, assessing environmental baseline conditions for ESA consultations, NEPA analysis, and assessing stream habitat conditions for grazing management.	1985 - Present				Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	BLM	Lower Columbia Basin	Stream/Riparian Surveys	annual	Classify and determine the condition of in-stream habitat. Stream habitat information is collected for land use and project planning purposes, assessing environmental baseline conditions for ESA consultations, NEPA analysis, and assessing stream habitat conditions for grazing management.	1985 - Present				Al DoelkerAssistant Fisheries Program LeadOregon State Office333 SW 1st Ave.Portland, OR 97208Ph: 503-808-6067 Al_Doelker@or.blm.gov	
Water Quality	USFS	Cowlitz Basin	Temperature	annual	WDEQ Protocol	1996-Present					
Water Quality	USFS	Cispus Basin	Temperature	annual	WDEQ Protocol	1996-Present					
Water Quality	USFS	Lewis Basin	Temperature	annual	WDEQ Protocol	1994-Present					
Water Quality	USFS	Washougal Basin	Temperature	annual	WDEQ Protocol	1994-present				Mark Kreiter 541-308-1744 mkreiter@fs.fed.us	
Water Quality	USFS	Bonneville Tributaries	Temperature	annual	WDEQ Protocol	1994-present				Mark Kreiter 541-308-1744 mkreiter@fs.fed.us	
Water Quality	USFS	Little White Salmon	Temperature	annual	WDEQ Protocol	1994-present				Mark Kreiter 541-308-1744 mkreiter@fs.fed.us	
Riparian Conditions & Function	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1987-Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us	
Channel morphology and complexity	USFS	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	NW Forest Plan Aquatic & Riparian Effectiveness Monitoring Program (AREMP)	1987-Present				Steve Lanigan 503-808-2261 slanigan@fs.fed.us	
Water Quality	USFS	EF Lewis Basin	Temperature	annual	WDEQ Protocol	1996-Present					

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	USFS	Little White Salmon	Temperature	annual	WDEQ Protocol	1998-Present					
Biological Attributes	USFS- CGSA	Washougal, Bonneville Tributaries, Wind, Little White.	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present				Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us	
Biological Attributes	USFS- CGSA	Bonneville Tributaries	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present				Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us	
Biological Attributes	USFS- CGSA	Wind Basin	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present				Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us	
Biological Attributes	USFS- CGSA	Little White Salmon	Spawning Surveys	Intermittent	Visual Assessment, Total Redds, live, dead, (Chinook, Steelhead, coho, other)	1994-Present				Chuti Fiedler 541-308-1718 cfiedler@fs.fed.us	
Biological Attributes	USFS-Mt. St. Helens	Toutle Basin	Population Monitoring							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Channel morphology and complexity	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Channel morphology and complexity	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Riparian Conditions & Function	USFS-Mt. St. Helens	Toutle Basin	Stream Channel Habitat & Bank Stability,							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Blocked Habitat	USFS-Mt. St. Helens	Toutle Basin	Passage Assessment							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Water Quality	USFS-Mt. St. Helens	Toutle Basin	Water Quality							Charlie Crisafully 360-449-7800 ccrisafully@fs.fed.us	
Water Quality	USFWS	Lower Gorge Basin, Wind River	Temperature		WDEQ Protocol		NA				

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	USGS	Grays/Grays Bay Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1977	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Skamokawa Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1980	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Elochoman Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-77	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Lower Cowlitz Basins	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-86	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Coweeman Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-1975	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Toutle Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1960-2002	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Cowlitz Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1964-85, 2002	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Cispus Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1971-72, 1980-81	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Tilton Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1968	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Kalama Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1961-70, 1972-80	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	NF Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1962-73, 1976-86, 1994	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1970-71, 1976, 1980-2002	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	EF Lewis Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1976-80, 1980	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Salmon Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1968-73, 1978, 1980, 1997-98	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Washougal Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1964-70, 1974-77, 1981	NA			http://wa.water.usgs.gov/data/	
Water Quality	USGS	Lower Gorge Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1981	NA			http://wa.water.usgs.gov/data/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	USGS	Wind Basin	Temperature, nutrients, contaminants	NI	WDEQ Protocol	1972-1980	NA			http://wa.water.usgs.gov/data/	
Biological Attributes	USGS-Columbia River Research Lab	Wind Basin	Chinook Spawning Surveys	NI		1998-present	NA			Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov	
Water Quality	USGS	Wind Basin	Nutrients	annual	Salmon Carcass analog study monitoring the effects of carcass nutrient enrichment in the upper Wind River. Water Quality and Chemistry monitoring. Macroinvertebrate response, juvenile salmonid response	2003-2006	NA			Matt Messa 503-538-2299 ext 246 matt_mesa@usgs.gov	
Water Quality	USGS	Kalama Basin	Temperature	annual	WDEQ Protocol	1984-Present	NA				
Instream Flows	USGS	Kalama Basin	Stream Gage	Annual	WDEQ Protocol		NA			Gary Turney 253-428-3600, ext. 2 http://wa.water.usgs.gov/realtime/waterdata.sw.html	
Instream Flows	USGS	Little White Salmon	Stream Gage	Annual	WDEQ Protocol		NA			Gary Turney 253-428-3600, ext. 2 http://wa.water.usgs.gov/realtime/waterdata.sw.html	
Channel morphology and complexity	USGS-Columbia River Research Lab	Wind Basin	Stream/Riparian Surveys	annual	Gradient, Riparian Condition, LWD, Pool Frequency					Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov	
Blocked Habitat	USGS-Columbia River Research Lab	Cowlitz Basin	Fish Passage Study @ Cowlitz Falls Dam							Dennis Rondorf 509-538-2299 dennis_rondorf@usgs.gov	
Blocked Habitat	USGS-Columbia River Research Lab	Lower Columbia Basin	Movement & Behavior of Juvenile Salmonids at Bonneville Dam Columbia River							Noah Adams 509-538-2299 noah_adams@usgs.gov	
Water Quality	USGS-Columbia River Research Lab	Wind Basin	Temperature Monitoring	annual	USGS	2001-present				Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Instream Flows	USGS-Columbia River Research Lab	Wind Basin	Stream Gage	annual	WDEQ Protocol	1998-Present	NA			Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov	
Biological Attributes	USGS-Columbia River Research Lab	Wind Basin	Snorkel Surveys, Electrofishing for abundance	annual		1998-Present	NA			Patrick Connolly 503-538-2299 patrick_connolly@usgs.gov	
Channel morphology and complexity	Wahkiakum CD	Grays/Grays Bay Basin	Stream/Riparian Surveys		Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Channel morphology and complexity	Wahkiakum CD	Skamokawa Basin	Stream/Riparian Surveys	Intermittent	Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996-2003	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Channel morphology and complexity	Wahkiakum CD	Elochoman Basin	Stream/Riparian Surveys	Intermittent	Stream Surveys that have not been surveyed by other agencies and have non-industrial or non-governmental ownership.	1996-2003	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Grays/Grays Bay Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA				
Water Quality	Wahkiakum CD	Skamokawa Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Elochoman Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Mill Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Abernathy Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	Wahkiakum CD	Germany Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Lower Cowlitz Basins	Temperature	annual	WDEQ Protocol	1999-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Water Quality	Wahkiakum CD	Coweeman Basin	Temperature	annual	WDEQ Protocol	2002-Present	NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Blocked Habitat	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Culvert & Tidegate inventories in Cowlitz and Wahkiakum Counties		WDFW Culvert Assessment Protocol		33d			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Watershed Conditions & Hillslope Processes	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Grays River Watershed Road Survey		Road surveys were conducted to provide road surface, cutslope, and hillslope conditions.		NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Watershed Conditions & Hillslope Processes	Wahkiakum CD	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Watershed Characteristic Portfolios for Cowlitz & Wahkiakum Counties		Stream types, soils, climate, geology, land use, ownership, and topography.		NA			Darren Haupt 360-425-1880 wahkiakum@wa.nacdnet.org	
Blocked Habitat	Wahkiakum County	Grays/Grays Bay Basin, Elochoman River, Abernathy, Mill, Germany Creeks	Fish Passage Barrier Identification and removal				33d			Pete Ringer 360-795-3301	
Floodplain and wetland function; channel migration processes	WDFW	Lower Columbia Basin	review of hydromodifications including anthropogenic structures that prohibit natural alluvial processes	NA	SSHIAP	NA	NA			http://wdfw.wa.gov/hab/sshiap/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	WDFW	Lower Columbia Basin	Stream/Riparian Surveys	NA	SSHIAP	NA	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Skamokawa Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1996-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Elochoman Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1996-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Mill Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1999-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Abernathy Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1997-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Germany Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1997-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Coweeman Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1995-2000	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Kalama Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1990, 2002-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	NF Lewis Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1999-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	EF Lewis Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1991-Present (2004?)	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Salmon Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	2002-2003	NA			http://wdfw.wa.gov/hab/sshiap/	
Channel morphology and complexity	WDFW	Washougal Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	2002-2003	NA			http://wdfw.wa.gov/hab/sshiap/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	WDFW	Wind Basin	Stream/Riparian Surveys	Intermittent	SSHIAP	1988-Present	NA			http://wdfw.wa.gov/hab/sshiap/	
Water Quality	WDFW	Kalama Basin	Temperature	annual	WDEQ Protocol	1984-Present	NA				
Biological Attributes	WDFW	Lower Columbia Basin	Commercial Fish Tickets	annual	Capture information related to all commercial harvest of food fish and/or shellfish landed in the state.	? - Present	NA			Lee Hoines 360-902-2310 Hoineljh@dfw.wa.gov	
Biological Attributes	WDFW	Lower Columbia Basin	Coded Wire Tag Recoveries	annual	Provides counts of the observed and estimated numbers of returning CWT salmon and steelhead which are harvested or collected in Washington waters.	? - Present	NA			Susan Markey 360-902-2777 www.rmis.org	
Biological Attributes	WDFW	Washougal	Coded Wire Tag Recoveries	annual	Provides counts of the observed and estimated numbers of returning CWT salmon and steelhead which return to the Washougal and Skamania Hatcheries	? - Present	NA				
Biological Attributes	WDFW	Lower Columbia Basin	Hatcheries Data	annual	Hatchery - disease, genetics; Hatchery - fish release, capture	? - Present	NA			Kyle Adicks 360-902-2669 adickvka@dfw.wa.gov	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Biological Attributes	WDFW	Lower Columbia Basin	Salmonid Spawning Ground Survey Database	annual	The Salmonid Spawning Ground Survey Database is built from a series of seasonal, systematic surveys of both index and "supplemental" stream sections for evidence of adult salmonid spawning activity. This database contains historical and current data from Puget Sound, the Straits of Juan de Fuca, and the Washington Coast. Counts of adult fish and redds (nests) are recorded, which provide some of the raw material for generating spawner escapement estimates by species and stock.	? - Present	NA			Dick O'Connor 360-902-2778 oconnrjo@dfw.wa.gov	
Biological Attributes	WDFW	Lower Columbia Basin	Salmonid Stock Inventory Database (SaSi)	NA	The SaSI database provides information on individual salmonid stocks including spawning location, spawn timing, genetics information, stock status and data used to assess status (escapements, juvenile data, harvest) and agency contacts.	? - Present				Ann Blakley 360-902-2712 wdfw.wa.gov/fish/sasi/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Biological Attributes	WDFW	Lower Columbia Basin	Smolt Monitoring	NA	Samonscape Database Quantifies the annual freshwater production of selected species and stocks of wild salmon.	? - Present	NA			Mark Hino 360-902-2753 www.wdfw.wa.gov/mapping/salmonscape/	
Biological Attributes	WDFW	Lower Columbia Basin	Sport Catch Estimates from catch record cards	annual	Annual post harvest estimates of salmon caught by recreational anglers. The estimates are produced using the harvest reported on sport catch record cards which are required to be returned to WDFW at the end of the fishing year.	? - Present	NA			Terrie Manning mannitam@dfw.wa.gov	
Biological Attributes	WDFW	Kalama Basin	Sport Catch Estimates from catch record cards	annual	Annual post harvest estimates of salmon caught by recreational anglers. The estimates are produced using the harvest reported on sport catch record cards which are required to be returned to WDFW at the end of the fishing year.	? - Present	NA			Terrie Manning mannitam@dfw.wa.gov	
Biological Attributes	WDFW	Lower Columbia Basin	StreamNet Fish Presence/Use Data	NA	StreamNet Database salmonid presence, spawning, and rearing reaches compiled onto the 1:100,000 resolution routed streams layer for Washington state.	? - Present	NA			Martin Hudson www.streamnet.org/online-data/GISData.html	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Biological Attributes	WDFW	Lower Columbia Basin	Washington State Fish Passage Barrier and Surface Water Diversion Screening Database (SSHEAR)	NA	SSHEARbase includes data compiled from several WDFW and non-WDFW barrier and screening inventory efforts. The inventory efforts are intended to locate, identify, and prioritize correction of man-made fish Blocked Habitat and improperly screened surface water diversions. Identifying and correcting fish Blocked Habitat and improperly screened diversions are key components of salmon recovery.	? - Present	NA			http://wdfw.wa.gov/hab/engineer/fishbarr.htm	
Blocked Habitat	WDFW	Lower Columbia Basin	comprehensive fish barrier coverage	NA	SSHIAP	NA	NA				
Biological Attributes	WDFW	Cowlitz River Basin, Grays River, Beaver Creek (Grays River Basin), Kalama River, Toutle, Washougal, Lewis River	Nutrient Enrichment, Carcass Inputs		(refer to basin)	? - Present	NA			WDFW works with various NGO's	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	WDNR	Lower Columbia Basin	Dredged Material Management Program	NA	Dredged materials destined for open water disposal are evaluated for suitability, dredging and disposal activities are monitored for conformity to permit specifics, and disposal sites are environmentally monitored to evaluate environmental impacts.	NA	NA			Robert Brenner robert.brenner@wadnr.gov	
Watershed Conditions & Hillslope Processes	WDNR	Lower Columbia Basin	Hazard Zonation-Landslide Inventory	NA	Create a statewide GIS-based dataset of all available landslide inventories.	NA	NA			Laura Vaugeois laura.vaugeois@wadnr.gov	
Biological Attributes	WDNR	Lower Columbia Basin	Natural Heritage Information System	NA	Maintain GIS and tabular information on the state's significant ecological features, including rare species and high quality terrestrial and aquatic communities.	NA	NA			Sandy Moody Sandra.moody@wadnr.gov & NHIC webpage	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	WDNR	Lower Columbia Basin	TFW Cooperative Monitoring, Evaluation and Research	NA	CMER examines ways in which forestry activities such as timber harvest and road construction impact fish, wildlife and water quality; providing the technical and informational framework for making and evaluating resource management decisions; promoting understanding of ecosystem interactions.	NA	NA			Geoffrey McNaughton geoffrey.mcnaughton@wadnr.gov	
Watershed Conditions & Hillslope Processes	WDNR	Lower Columbia Basin	GIS Hydrography Data Layer	NA	Provide a statewide geographic information data layer of surface water features for data analysis and mapping in support of natural resource management.	NA	NA			Sandra Bahr sandra.bahr@wadnr.gov	
Water Quality	WDNR	Lower Columbia Basin	Transportation Database	NA	GIS, Transportation Route Structures, e.g. bridges, culverts and gates; Fish Passage Barrier Evaluations, that facilitate addressing Forest and Fish requirements; Road Engineering Projects.	NA	NA			Sandra Bahr sandra.bahr@wadnr.gov	
Water Quality	WDOE	Grays/Grays Bay Basin	Temperature, nutrients, contaminants	annual	TMDL	1973, 1976-7, 1998	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Water Quality	WDOE	Elochoman Basin	Temperature, nutrients, contaminants	annual	TMDL	1960, 1973, 1976-7, 1998	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	Lower Cowlitz Basins	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	Kalama Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	EF Lewis Basin	Temperature, nutrients, contaminants	annual	TMDL	1960 - Present	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	Salmon Basin	Temperature, nutrients, contaminants	annual	TMDL	1973, 2004 (Burnt Br. Creek)	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	Lower Gorge Basin	Temperature, nutrients, contaminants	annual	TMDL	1992, 2002 (Campen & Gibbons Creek)	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Water Quality	WDOE	Wind Basin	Temperature, nutrients, contaminants	annual	TMDL	1973 1976-83, 1995	NA			Rob Plotnikoff 360-407-6687 www.ecy.wa.gov/programs/eap/fw_riv/rv_main	
Instream Flows	WDOE	Grays/Grays Bay Basin	Stream Gage	annual	WDEQ Protocol	1949-1975	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Elochoman Basin	Stream Gage	annual	WDEQ Protocol	1940-1970	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Mill Basin	Stream Gage	annual	WDEQ Protocol	1949-1956	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Instream Flows	WDOE	Abernathy Basin	Stream Gage	annual	WDEQ Protocol	1949-1957	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Lower Cowlitz Basins	Stream Gage	annual	WDEQ Protocol	1926-Present (2004?)	NA			?	
Instream Flows	WDOE	Coweeman Basin	Stream Gage	annual	WDEQ Protocol	1950-1982	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Toutle Basin	Stream Gage	annual	WDEQ Protocol	1909-Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Cowlitz Basin	Stream Gage	annual	WDEQ Protocol	1911 - Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Cispus Basin	Stream Gage	annual	WDEQ Protocol	1910 - Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Tilton Basin	Stream Gage	annual	WDEQ Protocol	1941-Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Kalama Basin	Stream Gage	annual	WDEQ Protocol	1911-1982	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	NF Lewis Basin	Stream Gage	annual	WDEQ Protocol	1909-Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Lewis Basin	Stream Gage	annual	WDEQ Protocol	1927-1970	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Salmon Basin	Stream Gage	annual	WDEQ Protocol	1943-1990	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Instream Flows	WDOE	Wind Basin	Stream Gage	annual	WDEQ Protocol	1934-Present	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Instream Flows	WDOE	Little White Salmon	Stream Gage	annual	WDEQ Protocol	1944-1977	NA			Brad Hopkins www.ecy.wa.gov/programs/eap/flow/shu_main	
Water Quality	WDOE	Lower Columbia Basin	Toxic Pollution Studies & Nonpoint Source Pollution Studies	annual	TMDL	1960-present	NA			Will Kendra 360-407-6698 www.ecy.wa.gov/pubs.shtm	
Floodplain and wetland function; channel migration processes	WDOE	West Coast	Environmental Monitoring and Assessment Program (EMAP) – West Coast Pilot	annual	EMAP's monitoring and assessment tools to provide Water column measurements are combined with information about sediment characteristics and chemistry, benthic organisms, and data from fish trawls to describe the current estuarine condition.	1973-present	NA			http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html	
Water Quality	WDOE	West Coast	Well Log Imaging System	annual	Intranet/Web Access to Well Log Data and Images	?-present	NA			http://aww.ads/welllog/	
?	WSDOT	Lower Columbia Basin	WSDOT Wetland Mitigation Monitoring Program	NA	Compliance monitoring of WSDOT affected wetlands	NA				http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm	
Blocked Habitat	WSDOT	Lower Columbia Basin	Fish Passage Barrier Identification and removal	NA	WSDOT cooperates with WDFW to identify, prioritize, design and construct fish passage barrier removal projects (i.e., culvert replacements) that achieve the greatest possible benefits with limited funding.	NA	33- 1			Brook Hamilton http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm	
Biological Attributes	Lower Columbia Fish Recovery Board (LCFRB)	Lower Columbia Basin	Mill/Abernathy/Germany Sub-basin Stock Summary and Habitat Priorities	ongoing	NA	2004	701a			Steve Manlow 360-425-1552 www.LCFRB.org	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Channel morphology and complexity	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Riparian Conditions & Function	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Channel morphology and complexity	WDFW	EF Lewis Basin	Watershed Analysis	annual	EDT Model	2002-2005	NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	EF Lewis Basin	Juvenile Steelhead Densities & Biomass				NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Wind Basin	Juvenile Steelhead Densities & Biomass				NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Riparian Conditions & Function	Skamania County	Wind Basin	Riparian setback monitoring	ongoing			56o			Karen Witherspoon skamaniacounty.org	
Biological Attributes	WDFW	Washougal Basin	Summer Steelhead mark-resight snorkel surveys		mark-resight snorkel surveys		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Wind Basin	smolt trapping		mark recapture weir		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Kalama Basin	Summer & Winter Steelhead mark-resight snorkel surveys		mark-resight snorkel surveys		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Kalama Basin	winter & summer weir counts		weir counts		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Toutle Basin	winter steelhead		weir counts		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Toutle Basin	Spawning Surveys	annual	cumulative (AUC) curves		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	Coweeman Basin	escapement surveys for Fall Chinook	annual	carcass tagging		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	EF Lewis Basin	escapement surveys for Fall Chinook	annual	carcass tagging		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Biological Attributes	WDFW	NF Lewis Basin	escapement surveys for Fall Chinook	annual	carcass tagging		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Biological Attributes	WDFW	Grays/ Grays Bay Basin	escapement surveys for Chum Salmon	annual	carcass tagging expansion & AUC		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Water Quality	Underwood CD	White Salmon Basin	Temperature, Chemistry	annual	WDEQ Protocol	annual, since 1992	NA			Jim White 503-493-1936 ucd@gorge.net	
Biological Attributes	WDFW	Wind Basin	spawning surveys		TFW - Spawning module		NA			Dan Rawding 360-906-6747 rawdidr@dfw.wa.gov	
Watershed Conditions & Hillslope Processes		White Salmon Basin	EDT Analysis		The objectives of this Ecosystem Diagnosis and Treatment (EDT) assessment of the White Salmon Watershed will help develop and prioritize alternative riparian and in-stream habitat projects.						
Floodplain and wetland function; channel migration processes	NOAA	Lower Columbia Basin	Recovery Plan		Monitoring						
	SRFB	Lower Columbia Basin	Washington State Salmon Recovery Funding Board Reach-Scale Effectiveness Monitoring Program 2005 Annual Progress Report		Review of SRFB effectiveness monitoring	NA	NA			http://www.iac.wa.gov/	
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Lower Columbia Basin	Spawning Surveys & Coded Wire Tag Recoveries	NA	Staff conduct spawning ground surveys, marking redd sites, and collecting coded wire tags from returned spawners					www.psmfc.org/	
Biological Attributes	Pacific State Marine Fisheries Commission (PSMFC)	Kalama Basin	Spawning Surveys & Coded Wire Tag Recoveries	NA	Staff conduct spawning ground surveys, marking redd sites, and collecting coded wire tags from returned spawners					www.psmfc.org/	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Biological Attributes	WDFW	Lower Columbia Basin	fish distribution by species, life stages	Intermittent	SSHIAP	?	NA			http://wdfw.wa.gov/hab/sshiap/	
Water Quality	USFS	Lower Columbia Basin	TMDL/303D Listing	annual	Clean Water Act and State water quality statues	1985-Present				Available from each forest or district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905	
Water Quality	BLM	Lower Columbia Basin	TMDL/303D Listing	annual	Clean Water Act and State water quality statues	1985-Present				Available from each district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905	
Water Quality	BLM	Lower Columbia Basin	Best Management Practices (BMPs): Implementation and Effectiveness	annual	Clean Water Act and Forest Service MOA with states	2005-Present				Available from each district. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905	
Water Quality	BLM	Lower Columbia Basin	Best Management Practices (BMPs): Effectiveness Monitoring	NA		2005-Present				Rosy Mazaika rmazaika@or.blm.gov 503-808-6076	
Water Quality	USFS	Lower Columbia Basin	Best Management Practices (BMPs): Implementation and Effectiveness	annual	Clean Water Act and Forest Service MOA with states	2005-Present				Available from each Forest or District. Or contact Trish Carroll Regional Water Quality and Water Rights Program Manager tcarroll@fs.fed.us 503.808.2905	
Blocked Habitat	USFS	Lower Columbia Basin	fish distribution by species, life stages	ongoing	What is the species composition of the fish assemblage? What is the distribution of ESA listed and special status fish species?	Present				Data is partially available on NRIS database Deborah Konnoff Fish Habitat Relationships Coordinator Pacific Northwest Region R6 Regional Office, USDA Forest Service Phone:(503) 808-2676; Fax:(503) 808-2469 email: dkonnoff@fs.fed.us	

Limiting Factor	Entity	Locations	Variable or Measurement	Frequency	Protocol	Period	Action	Program Name	Project Name	Contact Information	Additional Entity Participation
Blocked Habitat	BLM	Lower Columbia Basin	fish distribution by species, life stages	ongoing	What is the species composition of the fish assemblage? What is the distribution of ESA listed and special status fish species?	Present				Data available upon request. Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov	
Blocked Habitat	BLM	Lower Columbia Basin	fish passage assessment on all roads	ongoing	Fish passage through BLM culverts is assessed using a common state-wide protocol and is the same protocol that USFS R6 uses.	Present				Data available upon request. Al Doelker Assistant Fisheries Program Lead Oregon State Office 333 SW 1st Ave. Portland, OR 97208 Ph: 503-808-6067 Al_Doelker@or.blm.gov	
Blocked Habitat	USFS	Lower Columbia Basin	fish passage assessment on all roads	2001-2005	Fish passage through BLM culverts is assessed using a common state-wide protocol and is the same protocol that USFS R6 uses.	Present				Dave Heller R6 Fish Program Manager d.heller@fs.fed.us 503.808.2994 Data available upon request.	
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Riparian planting	ongoing			32a			clarkpublicutilities.com	
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Temperature Monitoring	ongoing			32a			clarkpublicutilities.com	
Channel morphology and complexity	Clark County Public Utility District	Salmon Creek Watershed	Water Quality	ongoing			32a			clarkpublicutilities.com	
Biological Attributes	FERC	Cowlitz Basin	NF Lewis (Pacific Corp & Cowlitz PUD), Cowlitz River Basin (Cowlitz and Lewis PUD, Tacoma City Light	NA	monitors for compliance with license permit (see specific license)	NA	48c			Patrick Regan 503-522-2741 www.ferc.gov	

Sources: *1. Salmon Recovery Funding Board: http://www.iac.wa.gov/Documents/SRFB/Monitoring/Environmental_Monitoring_Survey.pdf*
2. Washington Department of Fish & Wildlife, SSHIAP: http://wdfw.wa.gov/hab/sshiap/
3. StreamNet: http://www.streamnet.org/
4. Ned Library: http://www.nwcouncil.org/ned/Default.asp
5. Personal Communication with entities listed above (May 2006)

Appendix L
Salmon-Washougal and Lewis Watersheds Technical Memorandum No. 13 (WQAP, Barber 2004)

Technical Memorandum No. 13 (Task 4)
Surface Water Quality Monitoring Strategy
for WRIAs 27 and 28

Presented by:

Michael E. Barber

In association with:

Economic and Engineering Services

May 26, 2004

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1.0 Introduction

The WRIA 27/28 Planning Unit is developing a Watershed Management Plan under the State of Washington's Watershed Management Act (Chapter 90.82 RCW). One element of the plan is to address surface water quality issues within Water Resource Inventory Areas (WRIAs) 27 and 28, the Lewis River and Salmon-Washougal River watersheds.

A previous technical memorandum prepared for the Planning Unit addressed priorities for surface water cleanup plans (a.k.a. Total Maximum Daily Loads, or TMDLs). That memorandum also reviewed existing water quality monitoring activities being conducted by local, state, and federal agencies. From this review, it was apparent that water quality monitoring activities currently in place are designed to meet specific needs of various programs, but are not comprehensive in terms of either the network of streams or the types of parameters monitored. In the absence of a comprehensive monitoring framework at the regional scale, it is difficult to identify impaired water bodies, characterize status and trends in surface water quality or develop effective approaches to improving water quality.

This technical memorandum offers a proposed strategy for improving water quality data collected. Sampling strategies and options were discussed with the Planning Unit. Upon consideration of the objectives and economics of the alternatives a single Water Quality Analysis Plan (WQAP) was proposed. It is recognized that the Plan may be modified over time to respond to local priorities or availability of funding.

This technical memorandum focuses on the monitoring program itself, including elements such as water quality parameters, streams to be monitored, and frequency of sampling events. Implementation issues such as funding, inter-agency coordination and data management are identified, but not resolved at this time. These implementation issues will need to be addressed through further discussion, within the framework of the overall Watershed Management Plan.

2.0 Overview of Sample Analysis Plan

The selection of an appropriate monitoring plan requires a clear statement of criteria or objectives. For WRIAs 27/28, the Planning Unit identified the three primary reasons for monitoring water quality in their watersheds as being able to determine the effects on:

a) human health via drinking water systems relying on surface water,
b) human health through contact recreation, and
c) fish species listed under the Endangered Species Act (ESA) and other aquatic life.

These criteria are primarily associated with monitoring for 1) identifying specific existing or emerging water quality problems and 2) characterizing waters and identifying changes or trends in water quality over time. In addition, the current 303(d) listings show temperature to be a parameter of concern throughout the watershed. As temperature is also a concern for anadromous fish, all monitoring sites would be equipped with temperature gages. It should be specifically noted that a premise of the sampling design was that collecting information for improved fisheries management (particularly those listed under ESA) was an essential driver. Many of the proposed sites pose little to no threat to drinking water supplies even under projected population growth estimates. Consequently, the number of locations could be substantially reduced if human health issues were the only ones considered. Furthermore, many of parameters would be unnecessary and the frequency of sampling would be different if only human health problems were considered.

A range of options was discussed with the Planning Unit members in order to determine the practical scope of the monitoring plan in terms of what could be expected given funding limitations. It became apparent that given the size of the watersheds in WRIAs 27 & 28, sampling each waterbody for parameters such as macroinvertebrates, pesticides, and heavy metals would be too expensive.

The proposed ***Water Quality Analysis Plan*** (WQAP) would monitor core water quality information related to flow, temperature, nutrients, and several other parameters at as many as 28 different stream segments (not all parameters measured at each segment) listed in Tables 13 and 14. The types of monitoring objectives that the WQAP would be good at addressing are those concerned with baseline information and background information for identifying long-term trends.

The estimated cost of this plan includes: 1) upfront equipment and installation costs, and 2) annual sample analysis costs and coordination costs. Annual data processing and data management costs were not included in the budget. This plan assumes that a half-time staff person would be hired in order to coordinate monitoring activities. The upfront equipment costs of the WQAP are $65,650. The annual cost is $154,650. The total first year cost for the WQAP is $214,600. This cost could be reduced if volunteers were used to collect samples.

The WQAP addresses watershed scale issues. It is anticipated that many of the sample locations would be located near the mouths of the streams. It is recognized, however, that it is often difficult to assess changes occurring from multiple land use or remediation activities along the stream using single point monitoring. For example, a stream temperature gage at one location in a watershed may indicate whether there is a problem somewhere within the watershed. However, multiple sites are needed if there is going to be an attempt to isolate the cause of the problem. For that reason, a select few rivers have more than one proposed sampling location.

The goal was to provide a range of alternatives that fill data gaps currently existing. The EES technical memorandum on TMDL priorities summarized existing monitoring efforts. Every attempt was made not to duplicate ongoing long-term monitoring efforts with either plan. For example, no flow stations were requested for the Lewis River mainstem because, as illustrated in Figure 4, the USGS already has several stations on that river. Because there are practically an infinite number of viable plans, the final plan adopted by the Planning Unit may be somewhat different than the plan discussed in this document. The Planning Unit may mix and match parameters and locations according to available funding and ongoing projects. Opportunities to partner with other agencies may dictate some priorities and shift monitoring activities. There may also be opportunities to convert existing short-term activities into long-term efforts.

3.0 Monitoring Objectives

Monitoring is the systematic process of collecting and storing data related to particular natural and human systems at some specified locations and times. A critical question that must be raised is: "Why is the monitoring being conducted?" Monitoring can be conducted for several different purposes (Ward, 1990) including:

1. identify specific existing or emerging water quality problems;
2. characterize waters and identify changes or trends in water quality over time;
3. gather information to design specific pollution prevention or remediation programs;
4. determine whether program goals -- such as compliance with pollution regulations or implementation of effective pollution control actions -- are being met; and
5. respond to emergencies, such as spills and floods.

Monitoring can be used to document the status and trends of elements within the ecosystem over a range of temporal and spatial scales, and provide feedback that can be used to assess whether the predicted results are being achieved. It also provides information that can be used to help refine or modify actions to ensure that the targets for the project are being met. The main objective of many environmental monitoring programs is to detect change or lack of change over time, and to provide information sufficient to understand the causes of these patterns so that appropriate actions can be taken to manage the ecosystem for a desired condition. Related monitoring activities, including determining the types of pollution and the sampling frequency, need to correspond with the current and foreseeable goals of the program. Some types of monitoring activities can meet several purposes at once; others are specifically designed for one reason.

The selection of an appropriate monitoring plan requires a clear statement of criteria or objectives. For WRIAs 27/28, the Planning Unit identified the three primary reasons for monitoring water quality in their watersheds as being able to determine the effects on:

a) human health via drinking water systems relying on surface water,
b) human health through contact recreation, and
c) fish species listed under the Endangered Species Act (ESA) and other aquatic life.

These criteria are primarily associated with monitoring for 1) identifying specific existing or emerging water quality problems and 2) characterizing waters and identifying changes or trends in water quality over time.

3.1 Existing Water Quality Problems

As required by section 303(d) of the federal Clean Water Act (CWA), every two years each state must identify its polluted waterbody segments and submit a list of these water quality limited estuaries, lakes, and streams to the U.S. Environmental Protection Agency (EPA). To qualify for the list, it must be determined through water quality monitoring that the waterbody segment does not meet state surface water quality standards and that water quality is not expected to improve within the next four years. Under this definition, ten water-body segments located in WRIA 27 and thirty-seven segments in WRIA 28 were included on Washington State Department of Ecology's 1998 303(d) list. Nineteen additional Columbia River listings are NOT included in this assessment. Furthermore, these sites are not included in the monitoring plan because of the likelihood that implementation strategies for these locations would require activities outside the geographic confines of the WRIAs. The locations of the impaired segments in WRIA 27 are shown in Figure 1. Eight of the 303(d) listings occur in the East Fork Lewis River system and two occur in the Kalama River basin. Similarly, the impaired stream segments in WRIA 28 are shown in Figure 2. The 303(d) listings in this WRIA are distributed primarily between the Salmon Creek, Burnt Bridge Creek, Lake River, and Lacamas Creek systems.

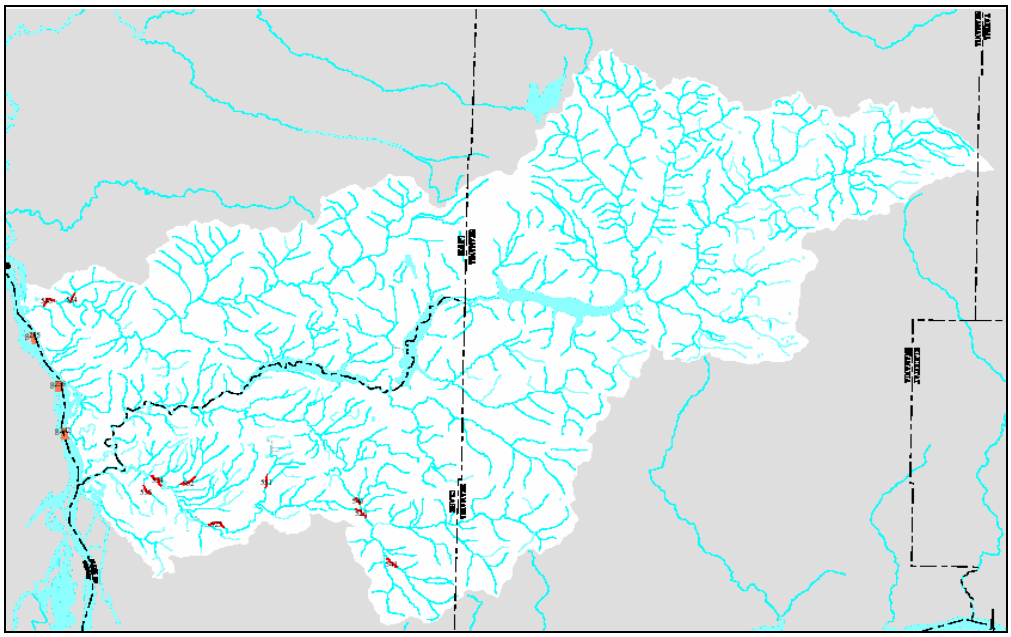


Figure 1. WRIA 27 303(d) listed site locations.

Fecal coliform and/or water temperature violations created all ten of the listed segments within WRIA 27. The problems identified in WRIA 28 were more diversified. Segments were listed because of fecal coliform, temperature, dissolved oxygen, pH, turbidity, and sediment bioassays. Several segments in both WRIAs were listed for more than one parameter. Because these forty-seven sites may ultimately require a clean-up plan (TMDL study), each of these segments needs to be considered as a potential sampling location. In some instances, where sites are on the same stream, one monitoring station may actually provide information for one or more impaired segments. Table 1 summarizes the 303(d) listed segments in WRIAs 27 and 28. The water body identification number list in the table may correspond to several locations along the stream where violations are known to occur. For example, in Table 1, Burnt Bridge Creek (GB90VP) is shown with violations of dissolved oxygen, pH, temperature, and fecal coliform. However, as illustrated in Figure 2, there are seven locations that have been monitored along the Creek. Not all of the listed violations occurred at each of these locations. Some only had two or three parameters out of compliance.

It should also be noted that the 303(d) list has not been updated since 1998. The WDOE is currently in the process of a major update of the 303(d) list. Table 2 provides a brief summary of the new process. Additional information regarding the process and data requirements is available on-line (Green and Butkus, 2002). The revised 2002/2004 303(d) list should be used as guidance to help determine current priorities and parameters. This may require rethinking of the strategy proposed in this document; however at the present time it is necessary to address the currently defined impaired stream segments.

The list of 303(d) impaired waterbody segments in WRIAs 27 and 28 should not be considered an exhaustive inventory of all segments in the study area with water quality impairments, but only those that met criteria established by Ecology and were then approved by EPA. Agencies have limited resources to monitor water quality conditions; therefore, water quality data are not available for many waterbody segments in the planning area. The data that are available are often based on permit requirements and specific agency monitoring objectives. Also, parameters and numbers of stations are subject to these limitations, and not presently designed to give the best assessment of water quality conditions in all waterbody segments.

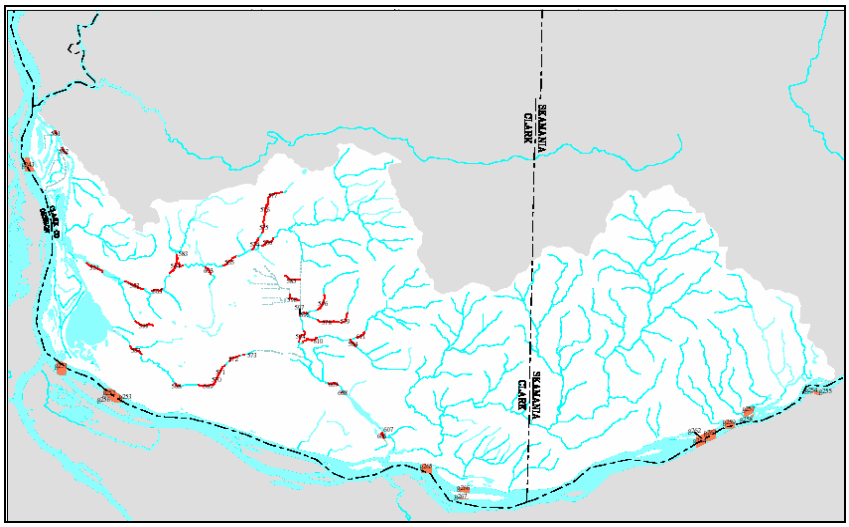


Figure 2. WRIA 28 303(d) listed site locations.

There are a few other known problems or potential problems within the basin. According to the Level 1 Assessment (LCFRB, 2001), Gibbons Creek suffers water quality deterioration due to stormwater runoff. Water column constituents of concern include pH, hexavalent and total chromium, fecal coliform, and turbidity. Sediment quality concerns include many heavy metals compounds including arsenic, cadmium, copper, chromium and zinc. Increased urbanization may contribute to additional loading of these parameters. An interesting problem was also documented on Cedar Creek within the Lewis River watershed. A WDOE study found that benthic macroinvertebrates (as measured by B-IBI) received a poor rating of 26 (Summers, 2001). No reason was specified but lack of food sources may impact salmonid growth.

3.2 Emerging Water Quality Parameters

As illustrated in Figure 3, the Lewis River Basin (WRIA #27) encompasses nearly 837,431 acres along the lower Columbia River. Although seasonal variations are evident, on average the watershed receives approximately 90 inches of rainfall per year. In 2000, there were approximately 71,512 people living in the Lewis River WRIA. Population projections derived from County data estimate that 98,866 people will live in the watershed by 2020 representing a change of roughly 38% (EES, 2002). There are relatively few cities within WRIA 27. Only 7,500 people live within the Cities of Kalama and Woodland. Another 14,550 have water service provided by Clark Public Utilities or other public water systems. Consequently, much of the population (over 49,000 people) lives in unincorporated regions of the WRIA and receives water from individual wells. Projections indicate that this will be the largest area of growth over the next 20 years with over 16,000 new residents in unincorporated areas by 2020. Many of those are expected to reside in Clark County.

The Salmon-Washougal Basin (WRIA #28) is also shown in Figure 3. The WRIA encompasses approximately 316,365 acres of land and is subject to an average annual rainfall of 63 inches per year. There were approximately 289,838 people living in the Salmon-Washougal Basin in 2000. The primary population centers are Vancouver, Camas, Battle Ground, and Washougal with populations of 155521, 12636, 9234, and 9400, respectively (EES, 2002). Population projections indicate there will be nearly 428,350 people living in WRIA 28 by 2020. Of this 138,500 increase, the City of Vancouver is expected to have the largest total growth increasing by approximately 47,500 people. The Cities of Camas and Battle Ground are expected to more than double in size with Camas increasing by over 16,000 and Battle Ground increasing by nearly 20,000 additional residents. Furthermore, an additional 8,400 people are expected to live in Washougal. Clark Public Utilities is expected to serve an additional 32,000 people and individual wells in the unincorporated parts of the WRIA will account for an additional 8,000.

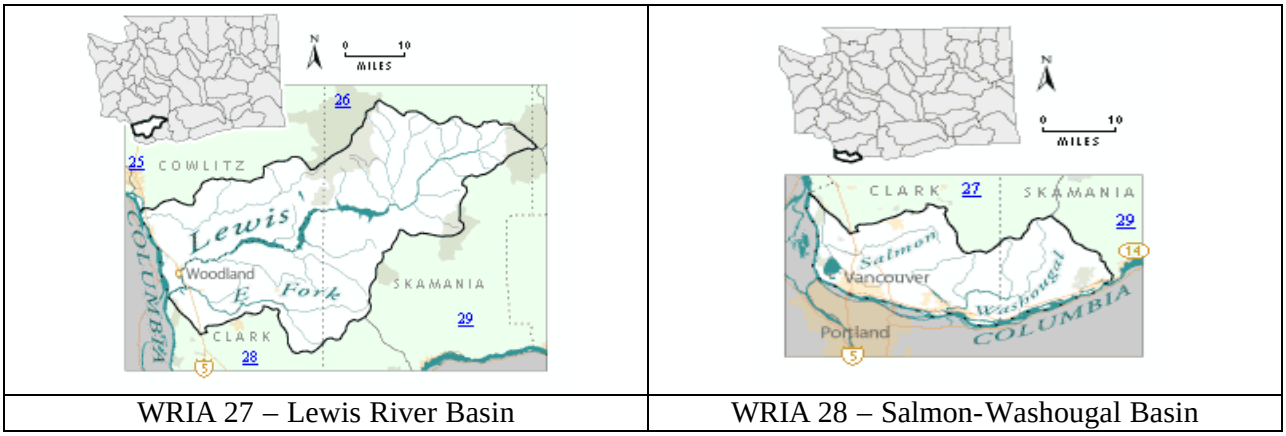
Table 1. Summary of 303(d) listings in WRIAs 27 and 28 (After EES, 2003)

Listed Waterbody Segment	Parameter(s)[2] in Violation of Water Quality Standards	Waterbody Identification Number
Kalama River Sub-basin		
Hatchery (Fallert) Creek	Temp	FX65ID
Kalama River	Temp	QB311V
East Fork Lewis River Sub-basin		
East Fork Lewis River	Temp, FC	EI60MF
Lockwood Creek	FC	YD45JI
McCormick Creek	Temp, FC	GF76XA
Rock Creek (lower)	FC	MI81KO
Rock Creek (upper)	FC	XD64JB
Yacolt Creek	FC	KS71ST
Burnt Bridge Creek Sub-basin		
Burnt Bridge Creek	DO, Temp, pH, FC	GB90VP
Salmon Creek Sub-basin		
Cougar Canyon Creek	DO	RU61ZG
Curtin Creek	FC	XU25TT
Lake River	Temp, FC, Sediment Bioassay	IQ64OU
Mill Creek	FC	IQ96OD
Salmon Creek[3]	Temp, FC, Turbidity	FP99QE
Weaver (Woodin) Creek[3, 5]	FC	HO68MC
Lacamas Creek Sub-basin		
China Ditch	DO, Temp	QY97TT
China Lateral	DO, Temp	RP10YQ
Cowpie Creek	DO	KE32SQ
Dwyer Creek	DO, pH	YQ90IX
Fifth Plain Creek	DO, Temp, pH, FC	QO04UK
Lacamas Creek	DO, Temp, pH, FC	YQ90IX
Matney Creek	DO, Temp, pH	JY73PR
Mill Ditch	DO, Temp, pH	YI74SA
Shanghai Creek	DO, Temp, pH	IA24XE
Columbia River Tributaries Sub-basin		
Gibbons Creek[4]	FC	ZT56LK

[1] From the 1998 303(d) List; Department of Ecology, State of Washington.
[2] Parameter Abbreviations: Temp (Temperature); FC (Fecal Coliform); DO (Dissolved Oxygen).
[3] TMDL was written to address fecal coliform and turbidity on Salmon Creek and fecal coliform on Weaver Creek.
[4] A TMDL was written to address fecal coliform for Gibbons Creek in 1996.
[5] USEPA approved a TMDL for biological oxygen demand and ammonia TMDL for Weaver Creek in 1993.

Table 2. Ecology Procedure for Categorizing Water Bodies

Classification	Condition
Category 1	Waters that meet current standards
Category 2	Waters of concern
Category 3	Waters with no data available
Category 4	Impaired waters but one of the following exits: Category 4A: Water has a TMDL Category 4B: Water has a pollution control plan Category 4C: Water is impaired by a non-pollutant
Category 5	On the 303(d) list



WRIA 27 – Lewis River Basin	WRIA 28 – Salmon-Washougal Basin

Figure 3. General Locations of WRIAs 27 and 28

While projecting demographics is not an exact science, the forecasted population increases are expected to result in significant expansion of existing urban centers in WRIA 28. This means that urban pollution problems may warrant attention in this watershed. Pollutants found in stormwater runoff, including metals, nutrients, and fecal coliform, are expected to cause the greatest concern. Conversely, WRIA 27 will see only modest pressures on water infrastructure caused by population growth. This means that unincorporated portions of the watersheds will continue to be developed. With this increase comes the possibility of contamination from septic systems as well as the potential for improper animal waste disposal and misuse of pesticides on hobby farms. As a result of this development trend, it may be prudent to include screening level analysis of fecal coliform and *E. coli* bacteria at locations where human contact is anticipated. Although considerably more expensive than bacteria analyses, it may also necessary to screen for widely used pesticides near areas zoned for small development tracts.

3.3 Characterizing Waters and Identifying Trends

Characterizing waters and identifying trends within the WRIAs are the first steps in establishing baseline information necessary to evaluate impacts of growth and management activities within the basins. Baseline information provides the benchmark against which the progress of any restoration plan can be measured, and to understand the ranges of natural variability necessary to confirm when change has actually occurred. There are two types of change generally associated with this analysis. The first type involves determining the differences or changes in water quality between two or more locations. The second type involves determining the gradual change over time at a specific location.

It is important to understand that trends may take years to identify because of the complex interaction between variables. As a general rule of thumb, 10 years of data is required to identify an annual trend with any degree of confidence. For example, to evaluate the impact of tree plantings in a riparian area on stream temperature the trees must mature and the impacts of air temperature, diversions, reservoir operations, and other associated changes in the watershed must be factored into the analysis. With anadromous fish spending several years outside the watershed, encompassing outside factors becomes even more difficult so the length of monitoring may be even longer.

Monitoring and research spatial design should be integrated. It is not efficient to have separate designs for hydrologic, water quality, and biological networks – these should be part of an integrated monitoring system to the extent possible. Appendix A identifies the typical matrix of water quality related monitoring activities. In addition to identifying the types of activities, this table also describes the data objectives for each activity, the resources needed to conduct the sampling, and the Quality Assurance/Quality Control (QA/QC) plan requirements. This also fits with the monitoring goals established by the Planning Unit. While human health standards for drinking water or recreational activities is typically defined by concentrations, the protection of fish species listed under the ESA requires qualitative and quantitative information about habitat and benthic communities (food supply).

4.0 Questions, Assumptions, and Philosophy of Water Quality Monitoring Plan

In addition to the question "Why is the monitoring being conducted?" there are several other important questions that should be taken into consideration before implementing a monitoring plan. The following questions were incorporated into the monitoring plan based on assumptions described below:

1. Who will use the data?
2. How will the data be used?
3. How good does the data need to be?
4. How will the data be managed and presented?
5. What QA/QC procedures will be adopted to insure data is credible?
6. What performance measures will be used?

4.1 Data Users

It was assumed that the primary users of this data would be various federal, state, and local government agencies for the purposes previously discussed. Furthermore, since much of the information would be used to satisfy TMDL requirements and assessments that required the approval of the Washington State Department of Ecology, every attempt should be made to follow their accepted procedures for data collection, analysis, format, and assurance. Other State and federal agencies such as the Washington State Department of Fish and Wildlife, the Washington State Department of Health, the US EPA, the National Marine Fisheries Service, Conservation Districts, local schools, tribal interests, and other users would be given access to the data. However, each of these users will likely have different data requirements. BPA could also use this information to help prioritize their salmon recovery programs. In the future, program coordinators may want to contact as many potential information users as possible to determine their data needs and protocols.

4.2 Primary Uses of the Data

The data would be used to influence local planning decisions about where to implement stream restoration projects, prioritize TMDL mitigation procedures, and to publicize any water quality problems and seek community solutions. Educational aspects for the local community and K-12 schools may also be likely users of the data. Getting the schools involved is a way to raise the visibility of the planning unit, recruit parents as volunteers for monitoring, and educate future volunteers.

4.3 Data Quality

The question of how good does the data need to be may dictate the methods and the cost of monitoring as much as any other concern. Data quality is measured in five ways: accuracy, precision, completeness, representativeness, and comparability.

a. Accuracy is the degree of agreement between the sampling result and the true value of the parameter or condition being measured. Accuracy is most affected by the equipment and the procedure used to measure the parameter.

b. Precision refers to how well you are able to reproduce the result on the same sample, regardless of accuracy. Human error in sampling techniques plays an important role in estimating precision.

c. Representativeness is the degree to which collected data actually represent the stream condition being monitored. It is most affected by site location although timing with respect to flow conditions should also be considered.

d. Completeness is a measure of the amount of valid data actually obtained vs. the amount expected to be obtained as a specified in the original sampling design. It is usually expressed as a percentage. For example, if 100 samples were scheduled but only 90 samples were collected due to bad weather or broken equipment, the completeness record would be 90 percent.

e. Comparability represents how well data from one stream or stream site can be compared to data from another. Most managers or data users will want to compare data from one site to other sites across the WRIAs as part of a statewide (e.g., a report to WDOE) or regional (e.g., a report to local governments) report on the monitoring program; therefore, sampling methods should be the same from site to site. This is especially true when using different people to collect water samples at different locations. For example, if one person consistently collects a sample in the morning on the way to work and another in the evening on the way home, timing may prevent direct comparison of data at the two sites. Another common example of conditions that prevent direct comparison is when individuals collect samples at different locations within the stream. If one person collects a sample from the middle of the stream and another collects a sample from the stream bank, discrepancies in the data can limit its usability.

Field monitoring and laboratory methods must be standardized to reduce the uncertainty and improve the data quality. A QA/QC plan can help address this potential problem.

For this monitoring plan, it was assumed that the data quality should be as high as practical. Therefore it was assumed that State-certified water quality laboratories would be used to determine pollutant concentrations. These labs will undoubtedly use procedures specified in "Standard Methods" (APHA, 1998) or other widely adopted methodologies. Water Quality kits with less accuracy were not considered even though the costs may be considerably less. These kits, sometimes referred to as Hach Kits, may be a reasonable choice as long as volunteers are properly trained, data users agree to the levels of accuracy needed, and samples are routinely sent to independent laboratories for comparison.

4.4 Data Management and Analysis

Development of appropriate database systems, data analysis protocols and outputs, and a data driven web interface are keys to the successful implementation of the adaptive assessment process. Data storage should allow the Planning Unit the ability to create an annual assessment report in a consistent format. Data management and analysis costs were not factored into the monitoring strategy.

The monitoring strategy in this report defines a **core** set of indicators (e.g., water quality parameters) for each water resource type that include physical/habitat, chemical/toxicological, and biological/ecological endpoints (response variables) as appropriate, that reflect designated uses, and that can be used routinely to assess attainment with applicable water quality standards. This core set of indicators should be monitored to provide the Planning Unit with basin and/or watershed level information on the fundamental attributes of the aquatic environment and to assess water quality standards attainment/impairment status.

Currently, chemical and physical indicators are emphasized; however, biological monitoring and assessment are beginning to assume a more prominent role in monitoring strategies. In the future, it may be necessary to consider these biological markers.

The report also describes a process for identifying **supplemental** indicators to monitor when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern. Supplemental indicators are often key to identifying causes and sources of impairments and targeting appropriate source controls. These supplemental indicators may include each water quality criteria in the State's water quality standards, any pollutants controlled by the National Pollutant Discharge Elimination System (NPDES), and any other constituents or indicators of concern. At the present time, the cost of adding the supplemental parameters on numerous watersheds was determined to be prohibitive. Again, however, there may be opportunities or rationale to include additional parameters in the future.

Monitoring locations are discussed based on general stream reach. Determining the precise locations was outside the scope of this analysis. Site selection can be based on established protocols such as the EPA's Environmental Monitoring and Assessment Program (EMAP) (probabilistic site selection using simple random, stratified, or nested designs) and the U.S. Geological Survey's National Water Quality Assessment program (targeted, judgmental design based on land use, geological setting, and other natural and human influences).

4.5 QA/QC Protocol

Credible data are required to meet the specific needs of the end users. Quality Assurance/ Quality Control (QA/QC) procedures are necessary components of any monitoring plan. Other steps include:

- Properly training, testing, and retraining monitoring personnel
- Evaluating the program's success after an initial pilot stage and making any necessary adjustments
- Assigning specific quality assurance tasks to qualified individuals in the program
- Documenting in a written plan all the steps taken to sample, analyze, store, manage, and present data

A written plan, commonly referred to as a quality assurance project plan, can be simple or elaborate depending on the desires of the Planning Unit. However, it is essential that the plan document how the data are to be generated. Without such knowledge, the data cannot be used with confidence in the future. The members of the Planning Unit or the field workers collecting the data may change over time and this plan provides continuity.

4.6 Water Quality Performance Measures

Another important consideration in designing a monitoring plan is determining which water quality performance measures will be used to evaluate the data. The complex linkages between water quality, hydrology, and biology require that performance measures be robust and allowed to change with the adaptive management strategy of the watershed. For the Planning Unit's first two monitoring objectives (human health via drinking water and human health via contact recreation), State and national criteria can be used as performance measures which helps limit the breadth of parameters necessary in the sample analysis plan. Even here, however, there are likely to be some discrepancies. For example, Washington State may not list arsenic as a pollutant on the 303(d) list in systems relatively free of significant anthropogenic sources of arsenic even though background concentrations might exceed the criteria values specified by the EPA National Toxics Rule (40 CFR Part 131). The rationale is that there are no man-made sources to remediate in a TMDL plan.

The third monitoring objective (protection of fish species) is considerably more difficult because of all the interaction between variables. In some ways, this objective argues for numerous parameters at many temporal and spatial scales. However, long-term monitoring and assessment efforts fail if they are too large, too complicated, too expensive, or if the results cannot be interpreted within the context of the key hypotheses.

Although not technically considered a water quality parameter, streamflow is an important variable that needs to be measured. Because many water quality parameters are correlated to runoff, having flow information is essential in interpreting results. Nonpoint sources of pollutants such as TSS and nutrients may vary significantly between a wet water year and a low water year.

5.0 Current Water Quality Monitoring within WRIAs 27 and 28

Water quality monitoring is occurring throughout the basin under the auspices of various local, State, and Federal programs and regulations. A compendium of known local, State, and Federal monitoring programs in the study area is included in this technical memorandum as Appendix B. These activities include (EES, 2003):

> Clark County is monitoring water quality at ten long-term index stations on the East Fork Lewis River, North Fork Lewis, Washougal River, and Lacamas Creek (see Table 5 for details of parameters).
>
> Clark County is also monitoring water quality in the Salmon Creek sub-basin, a program that was started in 1995 by Clark Public Utilities.
>
> Ecology, through its statewide long-term assessment program, is monitoring water quality in the Kalama River near the City of Kalama (27B070) and in the East Fork Lewis River near Dollar Corner (27D090) on a monthly basis. Three other stations (28B110, 28G070, and 28H070) are also being monitored but the history seems to suggest that these are not sampled every year.
>
> U.S. Forest Service, under the Northwest Forest Plan, is monitoring water temperature at 23 stations in the headwaters of the North Fork Lewis and East Fork Lewis Rivers every 30 minutes from June through September.

Over the years, the US Geological Survey has collected a considerable amount of flow data from stations throughout WRIAs 27 and 28. A review of USGS surface water resources found that 29 sites had been monitored with 12 having periods of record of at least 10 years. Using this information, average flows at twelve long-term watersheds were determined. These values are presented in Table 3. Unfortunately, many of these locations have been discontinued. Figure 4 shows the locations of the active USGS stream gages located primarily in the Lewis River watershed.

Given the concerns over drinking and ESA water quality requirements, the list of ongoing monitoring programs is extremely short. Additional monitoring in various subbasins within WRIAs 27/28 would provide valuable information to address the water quality objectives expressed by the Planning Unit. Incorporating "good science" into policy decisions will require more information in light of the number of streams in the WRIAs. As part of the watershed planning process, this technical memorandum has been prepared to address the need for additional water quality monitoring activities that could improve the status of water quality information.

The US EPA (2003a) compiled a list of "core" and "supplemental" parameters that they recommend for different beneficial use types. This list is presented in Table 4. Similarly, Table 5 indicates the water quality parameters that were sampled as part of a monitoring plan for the East Fork Lewis River watershed. The parameters are broad in nature in order to identify a wide range of potential problems. In addition to these variables, benthic macroinvertebrates, habitat, and flow information were collected at many of these sites, at least on a limited basis. In order to be consistent, any additional monitoring must consider the pollutants listed in Table 5. Except where TMDL data or screening information suggest otherwise, most emphasis in the proposed monitoring plans will focus on these parameters. Furthermore, the WRIA 27/28 Planning Unit prioritized the cleanup plan for local TMDLs. This prioritization is shown in Table 6. Monitoring will be suggested to aid in effectiveness monitoring in those watershed. Washington DOE is in the process of updating its 303(d) list for the WRIA 27/28 subbasins. It may be necessary to update the list of existing data and important pollutants based on this study. The list should be carefully reviewed as soon as it becomes available.

Table 3. Statistics of Twelve Long-term Discharge Monitoring Locations in WRIAs 27 and 28

Gage Name	Drainage Area (acres)	Start Year	End Year	No. of Years	Monthly Average Gage Flow (cfs)		
					Min.	Max.	Mean
Canyon Creek near Amboy	40,832	1922	1934	12	38.4	893.0	425.0
Cedar Creek near Ariel	26,112	1951	1969	12	16.3	455.0	170.0
East Fork Lewis River near Heisson	80,000	1929	2002	73	82.5	1,489.0	773.0
Kalama River near Kalama	114,560	1911	1932	17	263.0	1,910.0	1,075.0
Kalama River below Italian Creek	126,720	1946	1982	29	311.0	2,321.0	1,263.0
Lewis River near Amboy	425,600	1910	1931	20	1,373.0	5,961.0	4,039.0
Lewis River at Ariel	467,840	1909	2002	80	1,293.0	8,101.0	4,800.0
Lewis River near Cougar	307,840	1924	1958	34	859.0	4,456.0	2,890.0
Pine Creek near Cougar	14,336	1957	1970	13	126.0	244.0	192.0
Salmon Creek near Battle Ground	11,712	1943	1990	34	4.5	153.0	62.9
Speelyai Creek near Cougar	8,064	1959	2002	43	8.7	206.0	103.7
Washougal River near Washougal	69,120	1944	1981	37	106.0	1,770.0	876.0

In terms of pressing water quality needs, the Level 1 Assessment ranked the watershed in the following order of preference (LCFRB, 2001):

1. Burnt Bridge Creek
2. Salmon Creek
3. East Fork Lewis River
4. Lacamas Creek
5. Washougal River
6. Columbia River Tributaries
7. North Fork Lewis River
8. Kalama River

This prioritization reflects the future growth pressures described in the population projections. For example, 96 % of the Kalama River watershed is owned by commercial forestry companies so growth in the watershed will be limited to lands near the mouth of the basin. This was factored into the proposed monitoring plans.

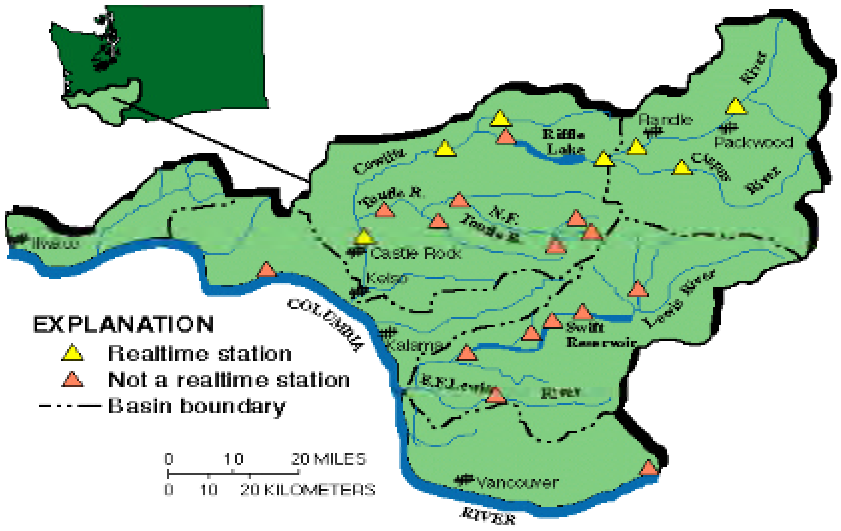


Figure 4. Existing USGS Flow Gages in WRIAs 27 and 28

Table 4. Recommended Water Quality Indicators for General Designated Use Categories. (After USEPA, 2003a)

	Beneficial Use Category			
	Drinking Water	Recreation	Aquatic Life	Fish & Shellfish Consumption
Core Indicators	• Flow • Landscape uses • Nitrate • Pathogens[1] • Salinity • Sediment/TDS • Trace metals	• Chlorophyll • Flow • Landscape uses • Nutrients • Pathogens[1] • Nuisance plant growth	• Condition of biological communities (EPA recommends use of at least two assemblages) • Conductivity • Dissolved oxygen • Flow • pH • Habitat assessment • Landscape uses • Nutrients • Temperature	• Chlordane • DDT • Landscape uses • Mercury • Pathogens • PCBs
Supplemental Indicators	• Algae • Hydrophyllic pesticides • Nutrients • VOCs (in reservoirs) • Other chemicals of concern in water column or sediment	• Aesthetics • Hazardous chemicals • Other chemicals of concern in water column or sediment	• Ambient toxicity • Health of organisms • Sediment toxicity • Other chemicals of concern in water column or sediment	• Other chemicals of concern in water column or sediment

[1] *E. coli*, enterococci

Table 5. Surface water quality parameters for the East Fork Lewis River
(Pacific Groundwater Group and Clark Public Utilities, 2002)

Water Quality Parameter	Locations
Field Samples Flow Dissolved Oxygen pH Specific conductance Temperature	Brezee Creek at La Center Bottoms Cedar Creek downstream of NE Amboy Road Culvert Cedar Creek upstream of NE Amboy Road Culvert East Fork Lewis River near Heisson East Fork Lewis River below Daybreak Park East Fork Lewis River above La Center Lockwood Creek below Lockwood Creek Road Mason Creek McCormick Creek Rock Creek North at DNR land above Gabriel Road Yacolt Creek above Yacolt Yacolt Creek at NE Railroad Avenue
Laboratory Analyses Ammonia (NH3) *E. coli* Fecal coliform Nitrate + Nitrite Phosphorus (total) Total Dissolved Solids (TDS) Turbidity	

Table 6. TMDL priority cleanup plan (EES, 2003)

Priority for Cleanup Plan (TMDL)	Water Quality Impaired Subbasin	Basis
1st	East Fork Lewis River	• Significant development anticipated • Water quality threatens listed salmon species • Potential human health impacts from contact recreation
2nd	Salmon Creek*	• Significant development anticipated • Water quality threatens listed salmon species • Potential human health impacts from contact recreation
3rd	Lacamas Creek	• Significant development anticipated • Potential human health impacts from contact recreation
4th	Burnt Bridge Creek	• Programs in place to address water quality impacts for Burnt Bridge Creek
5th	Kalama River	• Limited temperature impairments in Kalama River

* Ranked 2nd because a TMDL is already developed in Salmon Creek for turbidity and fecal coliform.

6.0 Fish Habitat Considerations in Monitoring Plan

One of the primary factors driving the need for additional water quality information identified by the Planning Unit is the desire to better understand the implications of various watershed activities on fish species listed under the Endangered Species Act (ESA) and other aquatic life. Of paramount importance in developing a monitoring plan that addresses these issues is the understanding of the life cycle associated with the various anadromous and resident fish species. In developing the water quality monitoring plan, summary information was reviewed on life stages and timing of fish presence from another technical memorandum prepared for the WRIA 25/26 Planning Unit (EES, 2003) and from Weinheimer et al., 2002. More detailed information is under development by LCFRB as part of its salmon recovery planning efforts, and this information should be consulted prior to implementation of this monitoring effort.

7.0 Measurement of Temperature, Stream Discharge, and Biological Parameters

7.1 Temperature

It has been widely documented that human activities negatively impact water temperatures in many watersheds. Detrimental activities include:

1) Removal of streamside vegetation reduces the amount of shade and increases solar heating of streams. Examples of human activities that reduce shade include forest harvesting, agricultural land clearing, livestock grazing, and urban development.
2) Removal of streamside vegetation also reduces bank stability thereby causing bank erosion and increased sediment loads. Bank erosion and increased sedimentation results in wider and shallower streams, which increases stream temperature by increasing the surface area subject to solar radiation and atmospheric heat exchange.
3) Withdrawals from rivers for agricultural irrigation, urban/municipal consumption, and industrial uses result in less river volume and slower moving water. The temperatures of rivers with smaller volumes equilibrate faster to warmer air temperatures, which leads to higher maximum water temperatures in the summer.
4) Water discharges from industrial facilities and wastewater treatment facilities can be warmer than receiving streams.
5) Channeling, straightening, or diking rivers for flood control and/or urban and agricultural land development reduces or eliminates cooler groundwater flows into rivers that help moderate summertime water temperatures.
6) Removal of upland vegetation and the creation of impervious surfaces associated with urban development increases storm runoff and reduces the amount of groundwater that is stored in the watershed and slowly filters back to the stream in the summer to cool water temperatures.
7) Dams and reservoirs can affect thermal patterns in a number of ways. They can increase maximum temperatures by holding waters in reservoirs to warm. Due to their increased volume of water, reservoirs are more resistant to temperature change which results in reduced diurnal temperature variation and prolonged periods of warm water. For example, reservoirs can delay the natural late summer-early fall cooling, thereby harming late summer-fall migration runs. Reservoirs also inundate alluvial river segments, thereby diminishing the groundwater exchange between the river and the riverbed that cools the river and provides cold water refugia during the summer. Further, dams can significantly reduce the river flow rate, thereby causing juvenile migrants to be exposed to high temperatures for a much longer time than they would under a natural flow regime. However, it should also be noted that some dams may help alleviate temperature problems when cold water is released from the bottom of a thermally stratified reservoir.

Water temperature is generally not considered an impairment that threatens human health even though some pathogens are thought to survive better in warmer waters. In the Pacific Northwest, temperature concerns are primarily related to the negative impacts on salmon and other endangered fish species. These chronic and sub-lethal effects include reduced juvenile growth, increased incidence of disease, reduced viability of gametes in adults prior to spawning, increased susceptibility to predation and competition, and suppressed or reversed smoltification (US EPA, 2003b).

Each salmonid species and life stage has a different optimal temperature range which may not be easy to quantify. Optimum physiological temperatures are those where physiological functions (e.g., growth, swimming, heart performance) are optimized. Optimum ecological temperatures are those where fish do best in the natural environment considering food availability, competition, predation, and fluctuating temperatures.

In the State of Washington, water quality standards for temperature are currently set at 16°C for Class "AA" and 18°C for Class "A" waters. As indicated in Table 7, according to the State's 1998 303(d) list, there are currently twenty-eight known waterbody segments in violation of these temperature standards within WRIAs 27/28. Not all of the impaired segments have unique segment numbers. The numbers of identified stream reaches are given in the parentheses.

There is concern that the State of Washington's standards for temperature are inadequate when it comes to the protection of the various life cycles of anadromous fish species. The US EPA is authorized under the Clean Water Act to recommend water quality criteria for adoption into State and Tribal water quality standards. For temperature impacts on salmonid species, EPA compiled a list of ranges as illustrated in Table 8. Based on this information, EPA proposed the criteria listed in Table 9.

The EPA recommended metric for each of the criteria listed in Table 9 is the maximum 7-day average of the daily maximum (7DADM) temperature. This particular metric is suggested because it describes the maximum temperature in a stream, but it is not overly influenced by the maximum temperature of any individual day. Thus, it reflects an average of maximum temperature that fish are exposed to over a weeklong period. For example, Figure 5 illustrates the cyclic nature of air and water temperatures for the summer months of 2002 at the Kalama River near Kalama, WA continuous temperature recorder. Although the maximum instantaneous temperature of 19.1°C occurred on August 14th the 7DADM is cooler.

The 7DADM criteria assume that summer temperatures are more critical than thermal conditions occurring in late spring or early fall. This may not be true for all stream reaches. Salmonid uses that are more temperature- sensitive (e.g., spawning, egg incubation, and steelhead smoltification) that occur in the spring-early summer or late summer-fall may not be protected by meeting the summer criterion. Consequently, EPA recommends additional criteria be adopted to protect these more temperature-sensitive uses when and where they occur.

EPA also recognized that thermal variability is a natural phenomenon and that standards should be flexible enough to account for rare events. Therefore, the proposed numeric temperature criteria are based on the 90th percentile of the yearly maximum 7DADM values calculated from a yearly set of values of 10 years or more. The need for long-term continuous temperature data in support of the temperatures proposed in Table 8 and summarized in Table 9, means that temperature monitoring should be conducted continuously at least during summer months or other periods of concern.

Table 7. 1998 303(d) List of temperature impaired waterbody segments in WRIAs 27 and 28(After EES, 2003)

Listed Waterbody Segment	Waterbody Identification Number
Burnt Bridge Creek Subbasin	
Burnt Bridge Creek (7)	GP90VP
East Fork Lewis River Subbasin	
East Fork Lewis River (2)	EI60MF
McCormick Creek (1)	GF76XA
Kalama Subbasin	
Hatchery Creek (1)	FX65ID
Kalama River (1)	QB31IV
Lacamas Creek Subbasin	
China Ditch (1)	QY97TT
China Lateral (1)	RP10YQ
Fifth Plain Creek (2)	QO04UK
Lacamas Creek (4)	YQ90IX
Matney Creek (1)	JY73PR
Mill Ditch (1)	YI74SA
Shanghai Creek (1)	IA24XE
Lake River Subbasin Lake River (1)	IQ64OU
Salmon Creek Subbasin Salmon Creek (4)	FP99QE

Table 8. Basis for EPA Region 10 recommended water temperature criteria(After US EPA, 2003b)

Species	Life Stage	Temperature Consideration	Temperature(°C)	Unit
Salmonids	Spawning and Egg Incubation	* Temperature range at which spawning is most frequently observed in the field	4 – 14	Daily average
		* Egg incubation studies		
		- good survival	4 – 12	Constant
		- optimal range	6 – 10	Constant
		* Reduced viability of gametes in holding adults	> 13	Constant
	Juvenile Rearing	* Lethal temperature		
		- 1 week exposure	23 - 26	Constant
		* Optimal growth		
		- unlimited food	13 - 20	Constant
		- limited food	10 – 16	Constant
		* Rearing preference temperature in Lab and field studies	10 - 17	Constant
		* Impairment to smoltification	< 18	7DADM
		* Impairment to steelhead smoltification	12 - 15	Constant
		* Disease risk (lab studies)	> 12	Constant
		- High	> 18 - 20	Constant
		- Elevated	14 – 17	Constant
		- Minimized	12 - 13	Constant
	Adult Migration	* Lethal Temperature		
		- 1 week exposure	21- 22	Constant
		* Migration blockage and migration delay	21 - 22	Average
		* Disease risk (lab studies)		
		- High	> 18 - 20	Constant
		- Elevated	14 - 17	Constant
		- Minimized	12 - 13	Constant
		* Adult swimming performance		
		- Reduced	> 20	Constant
		- Optimal	15 - 19	Constant
		* Overall reduction in migration fitness due to cumulative stressed	> 17-18	Prolonged exposures
Bull Trout	Spawning and Egg Incubation	* Spawning initiation	< 9	Constant
		* Temperature at which peak spawning occurs	< 7	Constant
		* Optimal temperature for egg incubation	2 - 6	Constant
		* Substantially reduced egg survival and size	6 - 8	Constant
	Juvenile Rearing	* Lethal temperature		
		- 1 week exposure	22 – 23	Constant
		* Optimal growth		
		- unlimited food	12 – 16	Constant
		- limited food	8 - 12	Constant
		* Highest probability to occur in the field	12 - 13	Daily maximum
		* Competition disadvantage	>12	Constant

Note: *7-Day Average of the Daily Maximum (7DADM)*

Table 9. EPA Region 10 suggestions for water temperature standards (After US EPA, 2003b)

Life Stage	Temperature	Unit
Bull Trout Spawning	9°C (48°F)	7DADM
Bull Trout Juvenile Rearing	12°C (55°F)	7DADM
Bull Trout Foraging and Migration	16°C (61°F)	7DADM
Salmon/Trout Spawning, Egg Incubation, and Fry Emergence	13°C (55°F)	7DADM
Salmon/Trout Core[a] Juvenile Rearing	16°C (61°F)	7DADM
Salmon/Trout Migration plus non-Core[b] Juvenile Rearing	18°C (64°F)	7DADM
Salmon/Trout Migration (exclusively)	20°C (68°C)[c]	7DADM
Adult Salmon Holding Prior to Spawning	16°C (61°F)	7DADM
Steelhead Smoltification	14°C (57°F)	7DADM

a – medium to high density of juvenile salmonids
b – low to medium density of juvenile salmonids
c – plus a provision to protect and, where feasible, restore the natural thermal regime

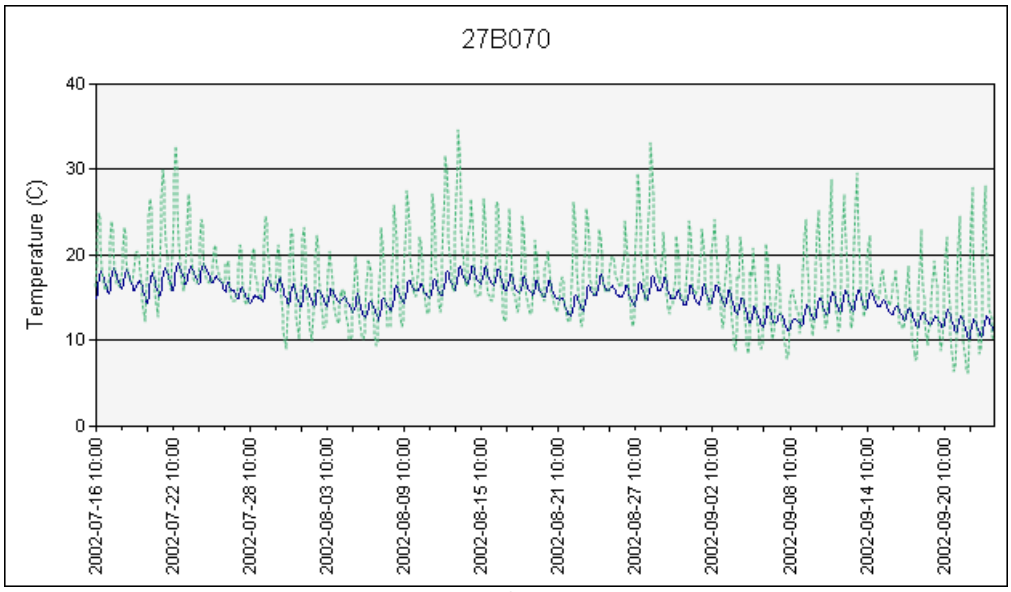


Figure 5. Air and water temperature variability for summer 2002 on Kalama River near Kalama

Two important facts can be derived from the EPA regulations and the Kalama River data. First, EPA wants to have the maximum daily temperature for the worst 7 consecutive days. In examining the continuous temperature data (every 30 minutes) shown in Figure 5, it should be evident that discrete temperature sampling can not be timed to insure the peak temperature is recorded. In fact, based on a WY 2001 study of 42 stations where continuous temperature instruments were deployed, Hallock and Enhinger (2003) reported that grab sample temperature values underestimated the summer maximum water temperature by 3.7°C and underestimated the 7-day average of daily maximums by 2.9°C. Consequently, temperature loggers should be used to record temperatures. Second, EPA expects 10 years worth of data to help establish baseline conditions. Consequently, resources must be maintained such that long-term monitoring efforts can be sustained.

ONSET Computer Corporation (http://www.onsetcomp.com/) manufactures relatively economical temperature loggers. Their product line includes several temperature probes. The Onset Optic StowAway Temperature Logger is perhaps the simplest choice for stream environments. As illustrated in Figure 6, the entire unit is 5.2" long x 0.8" tall x 1.0" thick and weighs 1.9 oz. It has a user-definable sampling interval ranging from 0.5 seconds up to 9 hours and costs between $129-$189 depending on the amount of storage capacity that is required. At 30-minute intervals (48 samples per day), the basic unit can store an entire summer's worth of data although it is recommended that you download the information more frequently if possible.

Some people prefer the StowAway Tidbit unit over the Optic StowAway. Also shown in Figure 6, the Tidbit is a small round unit measuring 1.2" wide x 1.6" tall x 0.65" thick and weighing 0.8 oz. The unit stores 32,520 values and costs $119. The main difference is that it comes with a 5-year non-replaceable battery whereas the Optic StowAway comes with a 6-year replaceable battery. At the rate this technology has been changing, it is difficult to know if it will be cheaper to buy a new unit in 5 years or replace the battery.

A pair of Onset StowAway temperature loggers should be deployed at each station, one in water and one in air. All loggers should be shaded and installed in a location representative of the surrounding environment. Stream loggers should be installed about six inches off the stream bottom to prevent sedimentation from affecting the results. Loggers should be placed in a free flowing location at a depth to avoid exposure to air resulting from low flows.

There are some minor additional costs associated with data retrieval for any of the Onset systems. Temperature data can easily be stored and downloaded. The best way to transfer information to a laptop in

the field is by using a $199 Optic Shuttle, $95 Boxcar software, and a $59 USB cable. It should be noted that these are one-time costs as they can be reused at each logger.

Optic StowAway	Tidbit StowAway

Figure 6. ONSET temperature probes.

7.2 Flow

Although strictly speaking, flow measurement comes under the heading of physical parameter rather than water quality, it is often necessary to have discharge measurements at the same general sample locations. For this reason, this section briefly discusses options for flow measurement.

The simplest form of flow measurement device is called a staff gage. A staff gage is essentially a long ruler placed at a fixed location in the stream or lake in order to provide a consistent frame of reference for the water surface elevation. Depending on style, a 3-ft long staff gage costs around $40. By developing a stage-discharge relationship (stage-volume may be more useful for lakes), the discharge can be determined by knowing the water stage (depth). A staff gage requires someone measure streamflows at several different levels in order to develop a "rating curve" (aka stage-discharge relationship). It should be noted that changes in channel geometry due to flood events may shift the rating curve so the stage-discharge relationship must be periodically verified.

The advantage of using a staff gage is the initial cost. The disadvantage is that since someone has to be there to read the stage, continuous monitoring is not feasible. Consequently, the impacts of storm events on water quality parameters may be more difficult to track. Even diurnal fluctuations will most likely be missed.

A relatively low-cost option that has started to become very popular is the Water Level Logger (WL15) from Global Water Instrumentation (http://www.globalw.com/index.html). This instrument records pressure (water stage) at a user-defined time interval. As shown in Figure 7, the standard unit consists of a pressure transducer, 25-feet of cable, and a data logger. The unit fits inside a 2-inch PVC housing for easy installation (also shown in Figure 6). The basic WL15 unit costs $795 and comes with a 9V lithium battery good for up to 3 years depending on recording frequency. At 30-minute intervals the theoretical battery life is 424 days but the battery should be checked every 6 months or so and replaced as necessary. The data can be downloaded to a PC with software and cables supplied with the unit or even a Palm with special $200 software.

Like the staff gage, this requires that a stage-discharge relationship be developed. However, unlike the staff gage, this device is capable of near continuous discharge measurements at a reasonable price. It is important to note that there are several makers of similar devices that would be just as acceptable as the WL15 device.

The "drawback" to these types of systems is that someone has to physically travel to the location and download the data. This has lead to automated monitoring stations. Some stations are being fully equipped with telemetry data so that information can be sent via satellite, radio, or cell phone to a base station in the office. This generally requires solar panels, antenna, large storage units, and other expensive equipment. In addition to complexity, the expense of these types of systems may not be warranted for some watershed planning activities. The cost of telemetry is quite variable. For example, as reported in the EES Task 5 Technical Memorandum, although installation costs for stream gages are highly variable, the USGS estimates the range of costs for installing a permanent, continuous recording gaging station is from $8,000 to $15,000. Operation and maintenance costs for a permanent, continuous recording gaging station are $11,000 per year, plus an additional cost of $2,000 per year if the station is a telemetry station. Operation

and maintenance costs for a permanent, continuous recording station that has stage data only is $3,300 per year, plus an additional cost of $2,000 per year for telemetry. Operation and maintenance costs for a staff gage, with eight flow measurements per year provided, is $2,200 per year. Operation and maintenance costs for a permanent recording station where only seasonal low flow data is collected are 65% of the costs of a permanent, continuous recording station. If the seasonal data collected is high flow data, the cost is 80% of the continuous data.

However, in Colorado, $30,000 was requested for 6 fully equipped satellite monitoring stations ($5,000/per station) whereas in California, $391,500 was provided for the purchase installation, operation, and maintenance of 19 new telemetry stations ($20,600/station).

Some of the variation depends on the housing used for the instruments. Such systems are highly susceptible to vandalism so some agencies design expensive enclosures to hold the equipment.

Real-time data may be valuable for early flood warning and other activities so there may be some ability to share costs with other agencies. However, the complexity and cost of installing, maintaining, and operating telemetry stations may not be warranted if the sole purpose is long-term watershed planning. Moreover, rating curves must still be established for these sites so field crews must routinely visit the site anyway. Downloading the data at that time does not add a lot of cost to the stream gaging.

Figure 7. Global Water Pressure Transducer and Logger

Finally, except for the installation of calibrated weirs, most procedures involve stream gaging to produce the rating curve. For wadeable streams, a typical AA-current meter costs around $1,250. Miscellaneous expenses for waders, tape measure, and waterproof stopwatch, should also be included. In larger rivers or during flood events, the cost of sampling increases dramatically. If bridge access in close to the sample location it may be possible to use a modified version of the stream current meter. A crane, sounding reel, and weight system can be purchased for around $3,500. If access is not readily available, the RiverCat system from SonTek is an integrated river discharge measurement system, complete with catamaran, GPS interface, and radio modem interface that can be used. However, this complete unit (and other similar devices) runs around $25,000.

Spatial and temporal rainfall patterns in this region create some wide fluctuations in stream discharges that can complicate the development of a rating curve. Figure 8 illustrates this phenomenon on Salmon Creek. During its 10 years of operation, the gage consistently fluctuated between 4 and 400 cfs with even larger extremes. It may not be safe to wade across the stream at all ranges of flow nor may it be necessary. The need for accuracy during high flow season may not be important if the study is focused on minimum instream flow requirements for fish species.

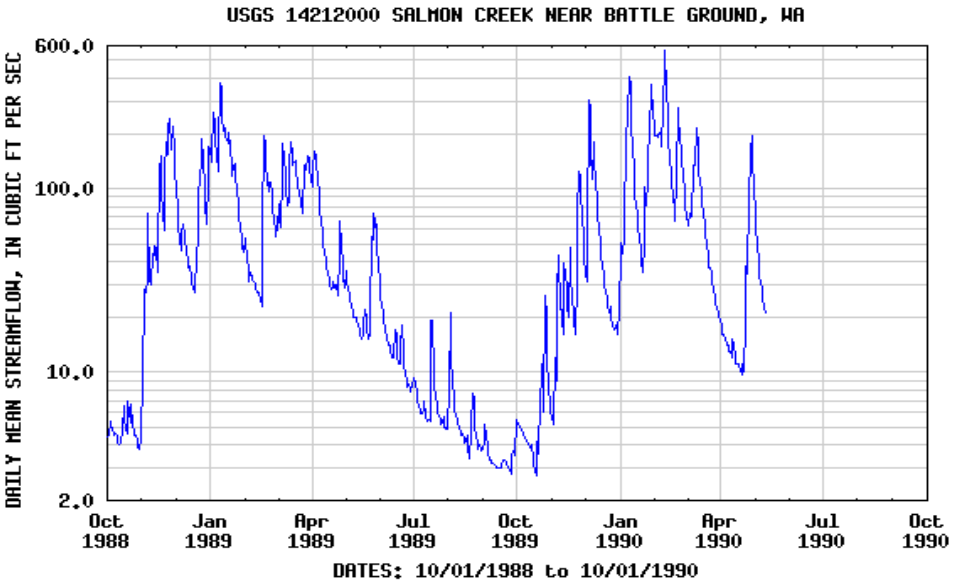


Figure 8. Seasonal Variations in Discharge on Salmon Creek near Battle Ground

7.3 Biologic Indicators

Commonly specified biologic indicators typically revolve around the use of periphyton (attached and floating algae), benthic macroinvertebrate (aquatic insects), and fish assemblages (Barbour et al., 1999). Unlike chemical or physical characteristics, Wiseman (2003) states that biological evaluation of surface waters provides a broader approach that supplements chemical evaluation by:

1. Directly measuring the most sensitive resources at risk,
2. Measuring stream components that integrate and reflect human influences over time, and
3. Providing a diagnostic tool that synthesizes chemical, physical, and biological perturbations.

Of the three possible assemblages, benthic macroinvertebrate indices are probably the most widely used for assessment of aquatic communities. The assessment is often performed using a multi-metric approach commonly referred to as the Benthic Index of Biotic Integrity (B-IBI).

The use of B-IBI has been proven to reflect the ecological health of streams (Barbour et al., 1999). For example, as illustrated in Figure 9, the percent of urbanization in a watershed has a decidedly negative impact on the B-IBI thus indicating that development causes impairment. Several researchers have now duplicated this type of analysis for regional B-IBI projects (Karr and Chu, 1999; Morley, 2000). However, to truly use this information for watershed planning purposes, the user should know what metrics were used to create the B-IBI.

The process of selecting metrics can be somewhat difficult as nearly any variable tied to the health of the stream can be used so long as the rank correlation coefficient between any two metrics is not too strong. Wiseman (2003) recommends that when two metrics have a correlation coefficient greater than 0.8-0.9, the one with the lower discrimination efficiency be dropped from the index. A composite list of the best candidate benthic metrics and predicted direction of metric response to increasing perturbation is presented in Table 10 (Barbour et al., 1999). However, while EPA seems to endorse this list, other candidate metrics have also been used.

Dr. James Karr, Dr. Billie Kerans, and Leska Fore developed the multi-metrics shown in Table 10 for streams and rivers in the Pacific Northwest. Scoring each of the nine metrics shown in Table 11 as a 1, 3, or 5 means a possible range of 9 to 45 points. This project developed the ranges of 33-45 as good (near natural biological condition), 21-32 as fair (some impairment), and 9-20 as poor (obvious impairment of biological condition).

Sampling procedures are beyond the scope of this document. However, Klemm et al (1990) provide a thorough review of sampling techniques commonly used.

Sampling just for benthic macroinvertebrates is not an expensive endeavor. Kick nets and/or dip nets can be purchased for less than $200. Gear such as waders, sample trays, and other minor supplies are also relatively inexpensive. The biggest cost will likely be in the sorting and counting of organisms especially if definition past the family level is required. Voshell (2001) provides a very good reference for identifying freshwater macroinvertebrates.

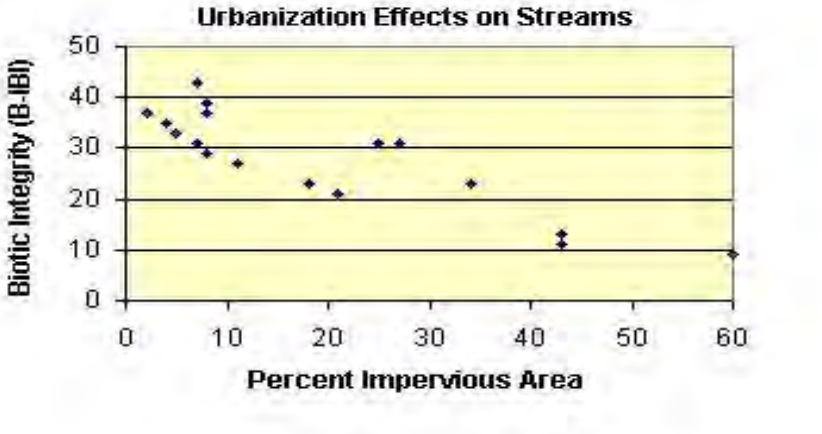


Figure 9. Effect of Urbanization on B-IBI

Table 10. Definitions of Best Candidate Benthic Metrics and Predicted Direction of Metric Response to Increasing Perturbation (After Barbour et al., 1999)

Measure	Metric	Definition	Predicted response to increasing perturbation
Richness	Total number of taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	Number of EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	Number of Ephemeroptera taxa	Number of mayfly taxa (genus or species level)	Decrease
	Number of Plecoptera Taxa	Number of stonefly taxa (genus of species level)	Decrease
	Number of Trichoptera Taxa	Number of caddisfly taxa (genus or species level)	Decrease
Composition	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance or Intolerance	Number of Intolerant Taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding	% Filterers	Percent of the macrobenthos that filter FPOM from either the water column or sediment	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habit	Number of Clinger Taxa	Number of taxa of insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

Table 11. Example Multi-Metric Variables for Pacific Northwest Streams and Rivers

Biometric	Predicted Response	Score		
		1	3	5
		Parameter Range		
Total number of taxa	decrease indicates degradation	< 10	10 – 20	> 20
Number of ephemeroptera taxa	decrease indicates degradation	< 3	3 – 5.5	> 5.5
Number of plecoptera taxa	decrease indicates degradation	< 3	3 – 5.5	> 5.5
Number of trichoptera taxa	decrease indicates degradation	< 2	3 – 4.5	> 4.5
Number of long-lived taxa	decrease indicates degradation	< 0.5	0.5 - 2	> 2
Number of intolerant taxa	decrease indicates degradation	< 0.5	0.5 - 2	> 2
Percent of individuals in tolerant taxa	increase indicates degradation	>50	20 - 50	< 20
Number of predator individuals	decrease indicates degradation	< 5	5 - 10	> 10
Percent dominance (2 or 3 taxa)	increase indicates degradation	> 75	50 - 75	< 50

Site selection for biomonitoring can either be "targeted" or "probabilistic." Most studies conducted by water quality agencies for identification of problems and sensitive waters are done with a targeted design. In this case, sampling sites are selected based on knowledge of an existing problem or an upcoming event that will affect the waterbody such as a development project, deforestation, installation of a BMP, or a habitat restoration project. In a probabilistic or random sampling regime, stream characteristics may be highly dissimilar among the sites, but will provide a more accurate assessment of biological condition throughout the area than a targeted design. Selecting sites randomly provides an unbiased assessment of the condition of the waterbody at a scale above the individual site or stream. Studies for aquatic life use determination and those related to TMDLs can be done with a targeted (site-specific) or a random (watershed or higher level) design (Barbour et al., 1999).

To meaningfully evaluate biological condition in a targeted design, sampling locations must be similar enough to have similar biological expectations, which in turn, provides a basis for comparison of impairment. If the goal of an assessment is to evaluate the effects of water chemistry degradation, comparable physical habitat should be sampled at all stations, otherwise, the differences in the biology attributable to a degraded habitat will be difficult to separate from those resulting from chemical pollution water quality degradation.

Sites are generally in riffle areas because these are good locations for benthic feeder to reside but it also results in a practical constraint in terms of sampling plan. The fast moving waters in riffle or glide reaches make it essentially impossible to sample for macroinvertebrates if the water is over 3 feet deep. For this reason, samples are often not taken during peak runoff periods.

8.0 General Water Quality Characteristics of Nonpoint Pollution

Nonpoint source pollution is the term associated with diffuse sources of contaminants. There are many types of pollutants that fall within this category. Table 12 contains many of the commonly listed contaminants, potential sources, and implications. Most of the categories listed in Table 12 represent pollutants that are directly associated with water quality impairment. Therefore, interpretation of the results is usually straightforward. The exception is the fecal bacteria and pathogens group. Because it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, so-called indicator organisms have been developed. Coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk.

Sources of fecal contamination to surface waters include wastewater treatment plants, septic systems, domestic and wild animal manure, and storm runoff. The most commonly tested fecal bacteria indicators are Total coliforms, Fecal coliforms, *Escherichia coli (E. coli)*, Fecal Streptococci, and Enterococci. All but *E. coli* are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior; *E. coli* is a single species in the fecal coliform group. Fecal coliforms, a subset of total coliform bacteria, are more fecal-specific in origin. However, even this group contains a genus, *Klebsiella*, with species that are not necessarily fecal in origin. *Klebsiella* are commonly associated with textile and pulp and paper mill wastes.

While many states (including the State of Washington) still use fecal coliform as their indicator bacteria, EPA currently recommends *E. coli* and *Enterococci* as the best indicators of health risks from water contact in recreational waters. *E. coli* is a better indicator in fresh water systems and *Enterococci* is slightly better in salt water regions. *E. coli* is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. *Enterococci* are a subgroup within the fecal streptococcus group. *Enterococci* are typically more human-specific than the larger fecal streptococcus group.

As one of the stated goals of the Planning Unit is to protect human health, it may be scientifically more beneficial to sample for *E. coli* than fecal coliform. However, consideration must also be given to who will use the data. At present, the WDOE does not use *E. coli* in their 303(d) listings. Consequently, fecal coliform data may be more valuable.

Table 12. Common Nonpoint Source Pollutants and Their Implications to Water Quality

Pollutant	Potential Sources	Water Quality Implications
Fecal bacteria and pathogens	Agriculture (livestock) Forestry Urban runoff (pets) Septic systems Wildlife	▪ Create human health hazards ▪ Increase costs of treating drinking water ▪ Reduce recreational value
Heavy metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, zinc)	Urban runoff Industrial runoff Mining Automobile use	▪ Adversely affect reproduction rates and life spans of aquatic organisms ▪ Adversely disrupt food chain in aquatic environments ▪ Accumulate in bottom sediments, posing risks to bottom feeding organisms ▪ Accumulate in tissues of plants, macroinvertebrates, and fish ▪ Reduce water quality
Nutrients (nitrogen and phosphorus)	Agriculture Forestry Urban runoff Construction Fish Hatcheries	▪ Over-stimulate growth of algae and aquatic plants that later, through their decay, cause: - reduced oxygen levels that adversely affects fish and other aquatic organisms - turbid conditions that eliminate habitat and food sources for aquatic organisms - reduced recreational opportunities - reduced water quality and increased costs of treatment - a decline in sensitive fish species and an overabundance of nutrient-tolerant fish species, decreasing overall diversity of the fish community
Pesticides and herbicides	Agriculture Forestry Urban runoff	▪ Kill aquatic organisms that are not targets ▪ Adversely affect reproduction, growth, respiration, and development in organisms ▪ Reduce food supply and destroy habitat of aquatic species ▪ Accumulate in plants, macroinvertebrates, and fish tissues ▪ Decreases photosynthesis in aquatic plants ▪ Some are carcinogenic, mutagenic, or teratogenic (cause birth defects) ▪ Create health hazards for humans consuming fish or drinking water ▪ Lower organisms' resistance to diseases and environmental stress
Petroleum hydrocarbons	Urban runoff	▪ Water soluble components can be toxic to aquatic life ▪ Portions may adhere to organic matter and be deposited in sediment ▪ May adversely affect biological functions
Polychlorinated biphenyls (PCBs)	Urban runoff Landfills	▪ Accumulate in plants, macroinvertebrates, and fish tissues ▪ Toxic to aquatic life ▪ Adhere to sediments; persist in environments longer than most chlorinated compounds
Polycyclic aromatic hydrocarbons (PAHs)	Urban runoff	▪ Accumulate in plants, macroinvertebrates, and fish tissues ▪ Causes carcinogenic substances when digested ▪ Toxic to aquatic life
Radionuclides	Mining and ore processing Nuclear powerplant fuel and wastes Commercial/industry	▪ Release radioactive substances into streams ▪ Some are toxic, carcinogenic, and mutagenic ▪ Some persist in the environment for centuries and continue to emit radiation ▪ Accumulate in tissues, bones and organs
Salts	Agriculture Mining Urban runoff	▪ Eliminate salt intolerant species ▪ Reduce crop yield ▪ Decrease quality of drinking water ▪ Impact stream habitats and plants which are food sources for macroinvertebrates ▪ Can fluctuate in concentration, adversely affecting both tolerant and intolerant species ▪ Affect habitat suitability for salmonids
Sediment	Agriculture – crops & grazing Forestry Urban runoff Construction Mining	▪ Decreases water clarity and light transmission through water column which: - cause a decrease in aquatic plant production - obscures sources of food, habitats, refuges, and nesting sites of fish - interferes with fish behaviors which rely on site such as mating activities ▪ Adversely affects respiration of fish by clogging gills ▪ Fills gravel spaces in stream bottoms, smothering fish eggs and juveniles ▪ Inhibits feeding and respiration of macroinvertebrates ▪ Decreases quality of drinking water ▪ Decreases recreational, commercial, and aesthetic values of streams
Sulfates	Mining Industrial runoff	▪ Lower pH in streams which stresses the aquatic life and leaches toxic metals out of sediments and rocks ▪ High acidity and concentrations of heavy metals can be fatal to aquatic organisms
Temperature	Forestry Agriculture Urban runoff	▪ Detrimental to salmonid fish species ▪ Impact reaction rates for metabolic processes ▪ Lower DO saturation concentration

9.0 Water Quality Monitoring Plan for WRIAs 27 and 28

Along with the identification of essential parameters to monitor, a monitoring network must be logistically economical, provide quantitative data, apply a standardized monitoring and data management protocol, and ensure that data analysis is done in such a manner that trends can be correctly recognized and tracked over time with confidence. Furthermore, a spatial framework for the monitoring network needs to be defined that coincides with existing and future development locations. The temptation is to collect every parameter possible at frequent intervals and many locations. While this reduces the uncertainty, the economics and logistics make implementing such a plan infeasible. However, in order to address the three main reasons for monitoring specified by the Planning Unit (drinking water, recreation, and fish), the plans proposed in this report are fairly comprehensive. An underlying premise of the sampling design was that information for improved fisheries management (particularly those listed under ESA) was needed. This influenced the selection of parameters, the locations, and the frequency of collection. Simpler, less costly plans could be implemented for human health concerns (drinking water and recreation). Many of the proposed sites pose little to no threat to public drinking water supplies even under projected population growth estimates. If public drinking water were the only consideration, the breadth of parameters could be dramatically reduced to perhaps little more than fecal coliform and *E. coli*.

Another consideration is the potential for duplication of effort. Every attempt was made not to duplicate ongoing long-term monitoring efforts with either plan. For example, no flow stations were requested for the Lewis River mainstem because, as illustrated in Figure 4, the USGS already has several stations on that river. The same can be said about the parameters and locations presented in Table 4. Since EES (2003) reported that Clark County is monitoring water quality at ten long-term stations in WRIA 28, the number of additional sites was reduced. However, it is possible that the same stream will be monitored in more than one location with the County collecting at one site and someone else collecting at a second site. Any cost savings for potentially teaming with existing operations were not considered. As a result, the monitoring plans suggested represent new information required for satisfying long-term monitoring objectives.

There are literally dozens of options that could be implemented in WRIAs 27 and 28 that would help fill the existing data gaps. Based on the goals of the Planning Unit and the discussion presented in this document, a comprehensive water quality monitoring plan would include habitat assessments, benthic macroinvertebrate analyses, temperature, dissolved oxygen, pH, specific conductivity, flow, nutrients (ammonia, nitrate, total nitrogen and total phosphorus), fecal coliform, *E. coli*, total suspended solids (or turbidity), total dissolved solids, metals, and pesticides. Depending on the temporal and spatial coverage of these measurements, these parameters encompass a wide range of options. Only one distinct option is discussed in this document. However, because there are practically an infinite number of viable plans, the final plan adopted by the Planning Unit may be modified from the option discussed in this document.

Land use changes were considered as important as spatial coverage at this phase and level of site selection. When actual monitoring locations are being selected, much more emphasis should be placed on existing and zoned land uses. Consideration was given to the use of a statistical approach for selecting a subset of streams that would be assumed to be representative of the larger basin. Such an approach reduces bias by not focusing on streams with known problems and using them to draw the conclusion that all watersheds have poor water quality. In the end, however, a targeted approach was used over a broad range of waterbodies. The reason was that in order to sustain a long-term monitoring program, especially with volunteers, definable problems are needed to maintain the energy and commitments necessary.

9.1 Water Quality Analysis Plan

In order to provide basic information for the protection of human health (drinking water and contact recreation) and the protection of endangered fish species, Table 4 identified several core parameters recommended by the USEPA. This list was also compared to those currently being sampled on the East Fork of the Lewis River (Table 5). The rationale is that other watersheds in the vicinity should be somewhat similar in terms of data requirements. Only core field and laboratory samples are included in this WQAP.

Because of the scope of a long-term monitoring plan, some locations were chosen that were low priority in the Planning Unit's TMDL priorities ranking of streams. For example, Burnt Bridge Creek scored relatively low because programs are already in place to address water quality impacts. However, this stream provides an opportunity to perform effectiveness monitoring to see how the prescribed BMPs are working and to determine if they would be applicable to other parts of the WRIAs. Consequently, several locations are still recommended. Furthermore, it was assumed that the main regions of interest would be those areas most likely subject to urban and suburban growth pressures in the foreseeable future. High-mountain watersheds with little to no anthropogenic sources of pollutants were not included in the study plan. These habitats may be important to aquatic species but since development activities at these sites are not likely, the need to mitigate future activities was not considered as important and therefore the need for data not as urgent.

It should be noted that the locations selected specifically EXCLUDED sites that are currently being monitored by other ongoing activities. Specifically, Clark County is sampling Matney Creek in the Lacamas Creek subbasin, Gee and Whipple Creeks in the Lake River subbasin, and Cougar Canyon, Curtin, and Rock Creek in the Salmon Creek subbasin. As was indicated in Table 5 and Appendix B, Pacific Groundwater Group and Clark Public Utilities have also been sampling at several locations in the East Fork Lewis River subbasin including Mason Creek, McCormick Creek, and 3 locations on the East Fork. As a result, none of these locations are included in Tables 13 and 14. If these programs do not continue, additional sites may need to be added depending on whether the data suggested a current problem or long-term trend toward decreasing water quality at the sampling locations.

Field parameters are those collected *in situ* and do not involve shipping water samples to a facility for laboratory analysis. Table 13 lists typical core parameters that would be measured in the field. The codes used in the Table represent number of locations and frequency. Thus, a code of 1-M indicates 1 site on the tributary that is sampled monthly. A variety of factors were considered in determining sample locations and frequency. Factors such as existing land use, watershed drainage area, hatchery presence, existing data, known fish populations, similarities to other watersheds, and access have been included. However, local experience may necessitate a change to some of these recommendations. Moreover, because there is a lack of data on many tributaries, numerous stream segments are currently listed. After some preliminary data has been collected, several of the upstream tributary streams draining only forest lands may be dropped from future consideration thus reducing the number of stream segments in the table.

It is anticipated that continuous flow recorders will be installed at the flow monitoring location; quarterly refers to the frequency of downloading data and gaging the stream for rating curve points. Flow locations and strategies are discussed in another Technical Memorandum (EES, 2004) and will not be emphasized in this document. Some location recommendations are made in order to tie water quality data to runoff. Gages were not proposed where existing USGS gages are in operation.

As discussed in previous sections of this document, the potential for using macroinvertebrate communities as an indicator of stream quality is rapidly gaining acceptance. Considerable deliberation occurred regarding whether or not benthic macroinvertebrates and habitat assessments should be conducted on an annual basis throughout the watershed in order to monitor progress in improving survival of ESA listed salmon species. The discussions focused on the methodology, benefits, and costs. At each location, a minimum of three typical riffle or glide areas would have to be sampled. In addition, it would be better to have seasonal trends rather than a summer-time snapshot. However, it may not be cost effective to sample more frequently and, since field staff must wade across the streams, it may not be feasible to sample during

high flow periods. Given the costs associated with such an endeavor, it was decided not to include macroinvertebrate sampling in this phase of the WQAP.

Parameters such as dissolved oxygen, pH, and conductivity can be measured with calibrated probes. Another overriding concern of the analysis plan is the 28 existing 303(d) list temperature violations. It illustrates a pattern that requires additional stream temperature data at these and other locations within the watershed. As a result, it is recommended that continuous temperature loggers be installed at all of the proposed monitoring locations. Temperature should also be collected at each field location independently of any continuous temperature probes installed.

Table 14 illustrates the core water quality analyses that should be conducted using a WDOE certified laboratory. These parameters include TSS, *E. Coli*, fecal coliform, total nitrogen, and total phosphorus. This list is consistent with the study on the East Fork Lewis River that was presented in Table 5. The frequency of analysis is shown in Table 14.

The Planning Unit discussed analysis of total nitrogen as an alternative to testing separately for ammonia and nitrate. Total nitrogen was selected based on cost savings of over $11,000. If results indicate impairments from nitrogen, then additional sampling may be needed at selected locations to determine which forms of nitrogen are present. Having a laboratory analyze water samples for total nitrogen or total phosphorus is consistent with EPA's upcoming nutrient criteria although it does not provide the same level of detail as samples tested for ammonia, nitrate, and nitrite.

Not all analyses would need to be conducted routinely or at every site. If, after three or four sampling events a pollutant is not found in significantly high concentrations, it could be dropped from the sampling plan. In addition, several new stations could be added each year to help spread out the startup costs. A GIS layer of land uses should be obtained for the project website. This layer should be updated every 3-5 years.

The WQAP does not cover every water quality consideration. For example, detailed habitat assessments could be added, including light attenuation, bedload transport, periphyton, fish assemblages, and riparian characteristics. Riparian vegetation, stream bank properties, large woody debris, and shading could be addressed, particularly at or near proposed or recent development sites. Aquatic vegetation could be sampled in lakes such as Vancouver Lake and Lacamas Lake. These elements are not included in the plan presented herein, but could be considered in the future if related to specific monitoring objectives.

The monitoring plan ultimately selected for implementation by the Planning Unit could reflect different choices of site, frequency and parameters from the option presented above. There are numerous combinations of parameter sampling plans (including frequency and location) that could meet Planning Unit needs. The Planning Unit may mix and match according to available funding and ongoing projects. Opportunities to partner with other agencies may dictate some priorities and shift monitoring activities.

Table 13. Summary of Field Parameters for the Water Quality Analysis Plan

Waterbody Segment	Field Sites (locations-frequency)				
	Flow[1]	Dissolved Oxygen	pH	Specific Conductance	Temperature[2]
Burnt Bridge Creek Subbasin					
Burnt Bridge Creek	3-Q	3-M	3-M	3-M	3-M
Columbia River Tributaries					
Gibbons Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Greenleaf Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Kalama Subbasin					
Kalama River	1-Q	1-T	1-T	1-T	1-T
Little Kalama River	1-Q	1-T	1-T	1-T	1-T
Lacamas Creek Subbasin					
China Ditch		1-T	1-T	1-T	1-T
China Lateral		1-T	1-T	1-T	1-T
Fifth Plain Creek	1-Q	1-M	1-M	1-M	1-M
Lacamas Creek	2-Q	2-M	2-M	2-M	2-M
Mill Ditch	1-Q	1-M	1-M	1-M	1-M
Shanghai Creek		1-M	1-M	1-M	1-M
Lake River Subbasin					
Lake River		2-M	2-M	2-M	2-M
Lewis River Subbasin					
Lewis River		2-T	2-T	2-T	2-T
Burris Creek		1-Q	1-Q	1-Q	1-Q
Salmon Creek Subbasin					
Mill Creek	1-Q	1-M	1-M	1-M	1-M
Morgan Creek	2-Q	1-T	1-T	1-T	1-T
Salmon Creek	1-Q	2-M	2-M	2-M	2-M
Weaver Creek		1-M	1-M	1-M	1-M
Washougal Subbasin					
Canyon Creek	1-Q	1-T	1-T	1-T	1-T
Little Washougal River	1-Q	1-T	1-T	1-T	1-T
Washougal River		1-T	1-T	1-T	1-T
West Fork Washougal		1-T	1-T	1-T	1-T

A – annually, C – continuously, M – monthly, T – two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled

[1] Download of continuous stage recorder and rating curve development
[2] Verification of continuous temperature loggers
Note: Monitoring shown here is in addition to active, ongoing monitoring activities (see Appendix B)

Table 14. Summary of Laboratory Parameters for Water Quality Analysis Plan

Waterbody Segment	Field Sites (locations and frequency)				
	TSS	*E. Coli*	Fecal Coliform	Total Nitrogen	Total Phosphorus
Burnt Bridge Creek Subbasin					
Burnt Bridge Creek	3-M	3-M	3-M	3-M	3-M
Columbia River Tributaries					
Gibbons Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Greenleaf Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Kalama Subbasin					
Kalama River	1-T	1-T	1-T	1-T	1-T
Little Kalama River	1-T	1-T	1-T	1-T	1-T
Lacamas Creek Subbasin					
China Ditch	1-T	1-T	1-T	1-T	1-T
China Lateral	1-T	1-T	1-T	1-T	1-T
Fifth Plain Creek	1-M	1-M	1-M	1-M	1-M
Lacamas Creek	2-M	2-M	2-M	2-M	2-M
Mill Ditch	1-M	1-M	1-M	1-M	1-M
Shanghai Creek	1-M	1-M	1-M	1-M	1-M
Lake River Subbasin					
Lake River	2-M	2-M	2-M	2-M	2-M
Lewis River Subbasin					
Lewis River	2-T	2-T	2-T	2-T	2-T
Burris Creek	1-Q	1-Q	1-Q	1-Q	1-Q
Salmon Creek Subbasin					
Mill Creek	1-M	1-M	1-M	1-M	1-M
Morgan Creek	1-T	1-T	1-T	1-T	1-T
Salmon Creek	2-M	2-M	2-M	2-M	2-M
Weaver Creek	1-M	1-M	1-M	1-M	1-M
Washougal Subbasin					
Canyon Creek	1-T	1-T	1-T	1-T	1-T
Little Washougal River	1-T	1-T	1-T	1-T	1-T
Washougal River	1-T	1-T	1-T	1-T	1-T
West Fork Washougal	1-T	1-T	1-T	1-T	1-T

A – annually, M – monthly, S – semiannually, T- every two months, Q – quarterly
Numbers (1, 2, etc.) refer to number of sites to be sampled
Note: Monitoring shown here is in addition to active, ongoing monitoring activities (see Appendix B).

The locations and parameters presented in Tables 13 and 14 represent our best estimate for filling data gaps associated with water supply, recreation, and anadromous fish protection and other aquatic life in eight major watersheds within WRIAs 27 and 28. The proposed 2002/2004 303(d) list identifies 35 stream segments in WRIA 27 and 62 segments in WRIA 28 as Category 5 (impaired-needs TMDL). These segments encompass 17 waterbodies in WRIA 27 and 19 in WRIA 28 (excluding the mainstem Columbia). The majority of the listings are for temperature, fecal coliform, dissolved oxygen, pH, and total phosphorus. The Burnt Bridge Creek, Lacamas Creek, Lake River, and Salmon Creek watersheds are urbanized watersheds and exhibit many of the traditional problems associated with land development. Dissolved oxygen, fecal coliform, and pH are typically mentioned in the 303(d) list. In proposing the monitoring strategy shown in Tables 13 and 14, these listings were taken into consideration. Furthermore, many of these pollutants are interdependent with other parameters. For example, dissolved oxygen concentrations are most often a function of temperature, nutrients and suspended sediments. Similarly, pH problems occur because of excessive plant growth, which may also be a function of temperature, nutrients and suspended solids. Nutrients and bacteria can be used as indicators of human contamination. Fecal coliform can sometimes be related to temperature and turbidity but its relationship to flow can overwhelm correlations to other parameters. In addition, although Ecology still uses fecal coliform as the standard, *e. coli* is considered to be a better indicator of contamination from human sources. Because the solution will likely depend on the ultimate source of the bacteria contamination (health risks are greater from human sources), both fecal coliform and *e. coli* were recommended.

The Kalama is a less developed watershed but growth in the lower sections could lead to problems along the same lines as the urbanized drainages. The city of Kalama receives its drinking water through shallow wells near/beneath the river so there is also some minor concern about the threat to drinking water supplies.

Although relatively little water quality information is available, the Columbia River tributaries are thought to be important habitat for salmonid species. Three tributaries were proposed to gather base line information relative to salmonid survival. The Burris Creek tributary crosses the I-5 corridor and may be subject to future growth pressures, Gibbons Creek is currently on the 303(d) list for chromium. However, rather than collect expensive metals samples, basic water quality information may be used to help identify other sources of contamination. Greenleaf Creek runs through North Bonneville, Washington and appeared to have camping, golf course, and recreational development in the area.

The Lewis River and Washougal River subbasins are less developed but important recreation and salmon producing streams. The information collected here would help assess long-term trends associated with suburban development. The Lewis River is currently listed for temperature and total dissolved gas (TDG). TDG is a function of the operation of the dams on the system and was considered outside the scope of this plan. As noted previously (see Table 5), the East Fork Lewis River is already the subject of water quality monitoring and is not included here to avoid duplication of effort. The Washougal River is listed for fecal coliform, which may be associated with nutrients and human waste parameters.

9.2 Utilizing and Responsibility for the Data

The LCFRB, along with NOAA Fisheries and WDFW, will be able to use much of the data collected in this plan for prioritizing fish recovery efforts. Conservation Districts will also be able to use this information to help establish critical riparian buffer areas and farm plans. The WDOE will use this information to help update its 303(d) list including the determination of cost-effective restoration alternatives and de-listing of pollutants. County governments may be able to use this data to inform land-use decisions. There is also a hydrologic model being developed for the Planning Unit, to analyze hydrologic conditions in the watershed. There is the possibility that the model could be used to reduce the number of stream gaging stations. Conversely, installation of the gages could help improve model calibration and validation.

Because of the long-term requirement of successful monitoring plans, the ultimate responsibility for the data is a critical decision. Stability and access to the data even if project funds are no longer available are concerns. Local governments, Conservation Districts, the Washington State Department of Ecology, or Universities may be willing to host a website that provides unrestricted access to the information. Ecology has indicated a willingness to act as a data provider for a number of locations.

9.3 Costs Associated with Implementation

Implementation costs are very important considerations in the design of any water quality monitoring plan. There are start-up costs associated with equipment purchases and installation as well as annual costs associated with operation and maintenance, and analysis costs (both laboratory and statistical). For equipment purchases, stream gages are intended to be pressure transducers that measure stage and should cost less than $2,500 to purchase and labor to install. Temperature probes are assumed to be the Onset gages at approximately $200 including shipping and taxes. It is assumed that meters and probes can be shared at 1 set per 10 field sites. A good DO meter, such as the YSI Model 55 with 25 feet of cable, costs around $750. Similarly, an Oakton pH/Conductivity meter costs approximately $600. A flow meter is $1,500. Each team should have access to spare meters. The cost is relatively small compared to the problems associated with faulty equipment. That does not mean every field team needs two sets, just that there be a backup plan for conducting monitoring in times of equipment failure. The expense of laboratory analyses can vary significantly depending on the number of samples, procedure, and frequency. The nutrients and coliform samples are roughly $30-45 per sample. Additional Quality Assurance/ Quality Control (QA/QC) samples were assumed to be approximately 10% of the sample cost. Travel and personnel costs for visiting each site are ongoing expenses related to collection of this information.

It is recommended that the agency responsible for coordinating efforts plan on funding one half-time staff person to facilitate the monitoring plan. Funding for this position could come from several sources. The person would need to be capable of applying for and tracking several grants. Also, within the WRIAs there are several cities, county, State and federal jurisdictions that may be responsible for different aspects of the plan. Coordination with these parties would be necessary. Depending on who was charged with carrying out the data collection, this staff person would also be responsible for training the field personnel, data entry, QA/QC, and dissemination. Annual costs for this half-time position would be on the order of $30,000 (salary plus benefits).

Based on these general values, the following cost estimates can be generated for the two options described above. As indicated in Table 15, the first year costs for the WQAP total approximately $214,600. This includes the total upfront costs ($65,650) and the annual costs less equipment replacement. Subsequent year costs for the WQAP would be $154,650. Additional costs will be incurred for data processing and data management.

For sample collection, there are 28 sites in the WQAP. Of these, 17 sites involve flow measurement. These sites will require 2 people because of work requirements and safety issues involved in taking depth and velocity measurements. One of these people could be the permanent staff person but it would require a lot of coordination. A reasonable estimate is 4 hours per station including downloading stage data, gaging the stream, and reducing the data. Performed quarterly, as proposed in the WQAP, this amounts to 544 person-hours. Assuming volunteers are free but professionals would charge $45/hr, the cost of collecting flow data would either be zero or $24,480. In addition to stream gaging, in the WQAP, there are 14 monthly site visits, 3 quarterly visits, and 11 sites that are visited every two months to collect water quality samples. Allowing for 2 hrs and 2 people per site, the WQAP has an additional 984 hrs of collection time. At $45/hr, this could cost as much as $44,280.

Table 15. Summary of Monitoring Plan Costs

Category	Number of Sites	Annual Samples	Cost [1]
Upfront costs:			
Stream gages	17	68	42,500.
Temperature gages	28	246	5,600.
Probes and flow meters			8,550.
Installation & supplies			9,000.
Total Upfront Costs:			65,650.
Annual costs:			
Equipment replacement			5,700.
Core laboratory analysis			
Bacteria	28	246	12,300.
Nitrogen and Phosphorus	28	246	18,450.
TSS	28	246	3,690.
QA/QC ~ 10%			4,550.
Sample collection labor, travel, & shipping			79,960[3]
Data processing & mg't			TBD[4]
Monitoring Coordinator [2]	N/A		30,000
Total Annual Costs			154,650
Total Year 1 Costs[5]			214,600

[1] Actual bid estimates may be lower when dealing with high volume samples
[2] Technical staff, 0.5-FTE, salary and benefits
[3] Costs for professional services are used. If volunteers are used, cost of this item would be reduced by 90%.
[4] Not determined at this time. Depends on implementation framework for monitoring plan.
[5] Excludes equipment replacement, since that would not be needed in year 1. Also excludes data processing and management (see footnote).

Travel and shipping costs are included. Volunteers would likely select sites near their home or work and so travel costs may be minimal. However, professionals will like charge around $0.35/mile. Some sites are located considerable distances from population centers. A very rough estimate is that travel could range from $200 to $14,000 per year depending on whether or not volunteers were reimbursed for travel costs. Assuming approximately $250/site/year, the travel costs are $7,000. There are local laboratories in the Vancouver area capable of analyzing these samples, however, it may be more economical to send the samples elsewhere. Shipping costs would depend on how far the coolers would be sent. Sampling protocols generally require that the samples be shipped via over-night carrier. An estimated $4,200 has been included in the budget for these types of expenditures. Equipment represents a one time fixed cost although 10 % replacement costs may be anticipated in subsequent years.

Reducing Costs

Eliminating parameters, limiting the frequency of sampling events, and reducing the number of locations are three commonly employed techniques for reducing costs. Unfortunately, there is no simple formula for balancing these options. What might be a valid approach for some parameters may not be acceptable for other pollutants. For instance, limiting collection of temperature data to July and August may be acceptable if the goal is only to determine the 7DADM associated with the current temperature TMDLs. However, to adequately address all of the criteria discussed in Tables 8 and 9, the life-cycle information for salmonids suggests that other months may be critical to spawning adults even when current water quality standards are not violated. This requires that the data collection window include additional months. Furthermore, determining statistically-significant trends is difficult if the frequency of data collection is inadequate. On the other hand, there are justifiable reasons for sampling only portions of the year. Eliminating parameters is an option that also should be explored.

Another way to reduce costs is to elicit the help of local volunteers rather than professional staff to collect the samples. There are numerous examples of successful monitoring networks throughout the

country relying on volunteers. The US EPA has even produced a methods manual aimed at volunteer stream monitoring (USEPA 1997). It is important to realize, however, that in a survey of failed monitoring plans, Reid (2001) reported that nearly 40 percent of the failures could be attributed to "nonideal field workers." In other words, the goals of the sampling plan were not realized because personnel were not adequately trained or motivated to conduct the sampling. Conducting routine workshops and field training activities will help produce more accurate data. Explaining the importance of the monitoring plan in setting local policy also provides enthusiasm and motivation for field personnel. Writing out procedures in the QA/QC plan and providing resources for properly educating the field personnel are essential, if this approach is used. It is important to keep in mind that a successful monitoring plan can span a period of 10-20 years, so sample procedures need to be easily followed by a number of potential volunteers or field staff.

Data management and analysis costs were not estimated at this time. Prior to implementation, decisions must be made on where the data will be housed, what format it will be stored in, who will manage the information, who will analyze the data, and who will write up the annual reports. These costs may be significant because professional services are often needed to establish and maintain databases (or input data into state or national databases), create GIS layers, perform statistical tests for trends and outliers, publish reports, attend meetings, and disseminate information. Depending on the skills of the staff recommended to coordinate activities, this may become part of their duties. Likely, however, some professional services will be required.

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Appendix A : Matrix of Monitoring Activities
(After USDA, 2003)

Monitoring Activities	Data Objectives	Types of Activities	Resources Needed			
			Materials	Education and Training	Monitoring Frequency	QA/QC Plan
Biotic survey	Educational; awareness; problem identification or screening; baseline data; trend analysis; local decision-making; 305(b) reports; targeting sites for additional study or restoration	Qualitative and/or quantitative survey of organisms, typically includes macroinvertebrates, frogs, fish, and/or macrophytes	Nets, rakes, buckets, bags, identification keys, field data sheets Optional: maps, camera, GPS unit	Training in protocols used to collect and identify the organisms is required, as well as in how to complete field data sheets	Several times a year during different seasons or flow regimes is preferred	Basic written plan – assessment purpose, methods, sites, and schedule. A formal QA plan and the use of protocols and indices may be required by some data users
Exotic species	Educational; general awareness; gross problem identification or screening; baseline data; 305(b) Reports; targeting sites for additional study or restoration	Identification of specific aquatic species; can be simple presence/absence or mapping or other quantitative measures	Identification card or key Optional: GPS unit, data sheets, maps, collection or preservation materials	Training in identification of the target organisms and differentiation from similar non-target species is required. Optional training: collection and preservation methods, mapping, and field data sheet preparation	Species dependent: may be part of regular water activities or a more formal monitoring effort	Depends on the data objectives. Can range from none to formal AQ plan with adherence to approved monitoring methods
Habitat assessment	Educational; general awareness; gross problem identification; baseline data; targeting sites for	Visual assessment of critical habitat features; may include measurements of some features.	Map of waterbody, field data sheets, measuring tape, measuring stick	Understanding of maps and features of concern. Training in evaluating habitat features and in how	Ideally, several times a year during different seasons, however, less often is typical.	Basic written plan - assessment purpose, methods, sites, and schedule.

	additional study or restoration	Intensive surveys measure channel depths, sinuosity, etc.	Optional: camera, GPS unit, permission to access private properties	to complete maps and data sheets recommended.	Many programs only assess habitat annual.	
Physical characteristics	Educational; baseline data collection; trend analysis; local decision-making; 305(b) Reports; targeting sites for additional study or restoration	Measurements of parameters such as stream flow, turbidity or sedimentation in streams; water clarity, depth, or basin features in lakes and ponds	Map of waterbody, field data sheets, measuring tape, measuring stick, stopwatch, flow meter, turbidity meter, sample bottles, settling dishes for sedimentation. Lakes: secchi disk, boat, depth meter	Training in protocols used to collect water samples and in using field meters or testing kits is required, as well as how to complete field data sheets. Training in calibration and maintenance procedures is also necessary for any field equipment.	Depends on data needs. Typically at least monthly. Ideally, weekly monitoring during growing season	Basic written plan – monitoring purpose, methods, sites, and schedule. A formal QA plan and the use of specific protocols and indices, and/or use of certified laboratories may be required by some data users
Sediment analysis	Educational; baseline data collection; trend analysis; local decision-making; 305(b) Reports; targeting sites for additional study or restoration	Using calibrated meters for field measures; collecting sediment samples for laboratory or field analyses	Sample bottles or bags as appropriate for analyses; sediment collection sampler, cooler, ice packs, field data sheets	Training in sampling procedures is required. May require supervision or assistance from a professional	Depends on data needs. May be annually, seasonally, monthly or more frequent	Basic written plan – monitoring purpose, methods, sites, and schedule. A formal QA plan and the use of specific protocols and indices, and/or use of certified laboratories may be required by some data users

Water chemistry	Educational; baseline data collection; trend analysis; local decision-making; 305(b) Reports; targeting sites for additional study or restoration	Using calibrated meters for field measurements; collecting water samples for laboratory or field analyses	Sample bottles appropriate for analyses; water collection samplers, cooler, ice packs, field data sheets. Optional: field meters, field testing kits	Training in protocols used to collect water samples and in using any field meters or testing kits is required. Training in calibration and maintenance procedures is also necessary for projects using field meters.	Depends on data needs. Typically at least monthly. Ideally, weekly monitoring during growing season	Basic written plan – monitoring purpose, methods, sites, and schedule. A formal QA plan and the use of specific protocols and indices may be required by some data users
Watershed assessment	Educational; general awareness; gross problem identification or screening; baseline data; targeting sites for additional study	Field observations, watershed wide land use assessment, ID potential sources of pollutants	Map of watershed, field data sheets. Optional: camera, GPS unit, permission to access private properties	Understanding of maps and features of concern. Can be self-taught or require training depending on complexity of system and data sheets	Annually	No formal QA/QC plan required. Field observation on standard forms often helpful

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
State											
Ecology[4]	27	Kalama River	27B070	Kalama River near Kalama	lat.46.0475, long.122.8361	Cond, FC, NH3-N, NO2-NO3, OPDIS, Oxygen, pH, Press, TSS, Temp, TPP, TPN, Turb.	72,73,76,77,80-92,95-02	Monthly (Long-term)	Statewide and regional assessment	Dept. of Ecology	Per Ecology Standards [1]
Ecology[4]	27	North Fork Lewis River	27E070	Cedar Creek near Etna	lat.45.93605, long.122.6179	same as above	95	Monthly (Basin)	same as above	same as above	same as above
Ecology[4]	27	North Fork Lewis River	27C080	North Fork Lewis River @ Co Rd 16	lat.45.90583, long.122.7361	same as above	92	Monthly (Basin)	same as above	same as above	same as above
Ecology[4]	27	East Fork Lewis River	27D090	East Fork Lewis River near Dollar Corner	lat.45.81472, long.122.5906	same as above	77-92,95-02	Monthly (Long-term)	same as above	same as above	same as above
Ecology[4]	27	Lake River	27F070	Gee Creek @ Ridgefield	lat.45.81892, long.122.7377	same as above	95	Monthly (Basin)	same as above	same as above	same as above
Ecology[4]	28	Lake River	28F070	Lake River near Ridgefield	lat.45.8075, long.122.7392	same as above	92	same as above	same as above	same as above	same as above
Ecology[4]	28	Washougal River	28B110	Washougal River below Canyon Creek	lat.45.60722, long.122.2303	same as above	95,98,00	same as above	same as above	same as above	same as above
Ecology[4]	28	Washougal River	28B070	Washougal River @ Washougal	lat.45.58639, long.122.3528	same as above	69,70,72,73,76,77,92	same as above	same as above	same as above	same as above
Ecology[4]	28	Columbia River Tributaries	28H070	Campen Creek	lat.45.5775, long.122.3142	same as above	02	same as above	same as above	same as above	same as above
Ecology[4]	28	Columbia River Tributaries	28G070	Gibbons Creek	lat.45.575, long.122.3142	same as above	92,02	same as above	same as above	same as above	same as above

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Federal											
USFS [5]	27	North Fork Lewis	-	Lewis River above Quartz Creek	NA	Temp	01	Every 30 mins. - June-Sept.	Compliance w/ Clean Water Act and Northwest Forest Plan	US Forest Service	NA
USFS [5]	27	North Fork Lewis	-	Quartz Creek above Platnum Creek	NA	same as above	99-01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Quartz Creek below Platnum Creek	NA	same as above	77-88, 82, 84, 88, 97-01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	North Fork Lewis River above Curly Creek	NA	same as above	75-88, 91, 96-00	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	North Fork Lewis River above Big Creek	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Big Creek tributary above Scookum Meadows	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Big Creek @ Gaging Station	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Muddy River above Clear Creek	NA	same as above	91, 96-01	same as above	same as above	same as above	NA

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
USFS [5]	27	North Fork Lewis	-	Clearwater Creek 8 mi. above Muddy River	NA	same as above	98-99, 01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Clearwater Creek near confluence above Muddy River	NA	same as above	96-98	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Muddy River below Clear Creek confluence	NA	same as above	91, 97-01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Canyon Creek above Jakes Creek	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	North Fork Lewis	-	Canyon Creek above Big Rock Creek	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis River above Green Fork Creek	NA	same as above	99-01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	Green Fork Creek one mile above East Fork Lewis River	NA	same as above	01	same as above	same as above	same as above	NA

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
USFS [5]	27	East Fork Lewis River	-	Green Fork Creek 0.5 mile above East Fork Lewis River	NA	same as above	97-98, 00	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis River below Green Fork Creek	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis River below Little Creek	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis River above Slide Creek	NA		01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	Slide Creek 0.25 mi. above East Fork Lewis River	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis Rive below Sunset Falls campground	NA	same as above	01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	Copper Creek above Bolin Creek	NA	same as above	77-81, 96-01	same as above	same as above	same as above	NA
USFS [5]	27	East Fork Lewis River	-	East Fork Lewis River above Niccolls Creek	NA	same as above	97, 99-01	same as above	same as above	same as above	NA

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Local											
Clark Co. [6]	27	North Fork Lewis River	CHL010	Chelatchie Creek upstream of SR 503	T5N R3E S16	Cond, FC, DO, pH, Temp, Turb, E.coli, TP, NH3-N, NO2-NO3, TSS	01-	Monthly (Started October 2001)	Long term index, Trend	Clark County stormwater fees	Level 4 - per Ecology standards
Clark Co. [6]	27	East Fork Lewis River	RCN050	Rock Creek North upstream of Gabriel Road	T4N R2E S02	same as above	01-	same as above	Long term index, Trend	same as above	same as above
Clark Co. [6]	27	East Fork Lewis River	EF1	McCormick Creek @ NW Lacenter Rd	T4N R1E S09	Temp, pH, DO, Turb, FC, NH3-N, TSS, NO2-NO3, TP	91-92	Monthly	East Fork Lewis Watershed Plan	Centennial Grant	same as above
Clark Co. [6]	27	East Fork Lewis River	EF2	East Fork Lewis River @ Pollock Rd	T4N R1E S03	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co. [6]	27	East Fork Lewis River	EF3	Lockwood Creek @ NE Lockwood Creek Rd	T4N R1E S01	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co. [6]	27	East Fork Lewis River	EF4	Mason Creek @ J.A. Moore Rd	T4N R1E S13	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co. [6]	27	East Fork Lewis River	EF5	East Fork Lewis @ Day Break Rd	T4N R2E S20	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co. [6]	27	East Fork Lewis River	EF6	Rock Creek North @ Rock Creek Rd	T4N R2E S02	same as above	91-92	same as above	same as above	same as above	same as above

Appendix B

Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Clark Co.[6]	27	East Fork Lewis River	EF7	East Fork Lewis River @ Moulton Falls	T4N R3E S13	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co.[6]	27	East Fork Lewis River	EF8	Yacolt Creek @ NE Railroad Ave	T4N R3E S12	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co.[6]	27	East Fork Lewis River	EF9	Rock Creek South @ Dole Valley Rd	T3N R4E S05	same as above	91-92	same as above	same as above	same as above	same as above
Clark Co.[6]	27	East Fork Lewis River	BRZ010	Breeze Cr upstream of LaCenter Btms bridge	T4N R1E S03	Cond, FC, DO, pH, Temp, Turb, E.coli, TP, NH3-N, NO2-NO3, TSS	01-	Monthly (Started October 2001)	Long term index, Trend	Clark County stormwater fees	same as above
Clark Co.[6]	28	Gee Creek	GEE050	Gee Cr dnstrm of Royle Road	T4N R1E S29	same as above	01-	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Whipple Creek	WPL050	Whipple Cr upstream of NW 179th Street	T3N R1E S08	same as above	01-	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Salmon Creek	CGR050	Cougar Cr dnstrm of NW 99th Street	T2N R1E S34	same as above	01 only	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Salmon Creek	MIL010	Mill Cr upstream of Salmon Creek Avenue	T3N R1E S24	same as above	01-	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Salmon Creek	CUR020	Curtin Cr dnstrm of NE 139th Street	T3N R2E S20	same as above	01-	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Salmon Creek	CGR020	Cougar Cr upstream of NW 119th Street	T3N R1E S33	same as above	02-	same as above	same as above	same as above	same as above

Appendix B
Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Clark Co.[6]	28	Lacamas Creek	MAT 010	Matney Cr upstream of NE 68th Street	T2N R3E S09	same as above	01-	same as above	same as above	same as above	same as above
Clark Co.[6]	28	Lacamas Creek	C1	Lacamas Creek upstream of Matney Creek	T2N R3E S09	same as above	83-92	~monthly	Lacamas Lake Monitoring	DOE Centennial Clean Water Fund	Addressed in Lacamas Lake Restoration Program
Clark Co.[6]	28	Lacamas Creek	C2	Matney Creek @ NE 68th St.	T2N R3E S09	same as above	83-91	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	C3	Fifth Plain Creek @ Fourth Plain Rd	T2N R3E S07	same as above	83-84	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	C4	Lacamas Creek @ Fourth Plain Rd	T2N R3E S07	same as above	83-85	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	C5	Lacamas Creek @ Goodwin Rd	T2N R3E S20	same as above	83-86	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	C6	Lacamas Creek @ Zellerbach	T2N R3E S02	same as above	83-90	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	LL1	Lacamas Lake @ NE shore	T2N R3E S27	same as above	83-87	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	LL2	Lacamas Lake @ Boat launch	T2N R3E S34	same as above	83-88	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	RL1	Round Lake @ North shore	T1N R3E S02	same as above	83-89	same as above	same as above	same as above	
Clark Co.[6]	28	Lacamas Creek	A1 (current name LAC050)	Lacamas Cr at Goodwin Road	T2N R3E S20	TSS, TP	99-	Monthly (some seasonal)	Long-term WQ status, effects of pollution loading (Ecology grant for Phase 1)[2]	same as above	same as above

Appendix B
Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Clark Co. [6]	28	Lacamas Creek	L1 (current name LACL11)	Lacamas Lk at center near deepest area	T2N R3E S27	Cond, Temp, pH, DO, TP, OP, TSS, NH3-N, NO2-NO3, TKN	99-	Monthly (some seasonal)	same as above	same as above	same as above
Clark Co. [6]	28	Lacamas Creek	L0 (current name LACL00)	Lacamas Lk outlet at SR 503	T1N R3E S02	TSS, TP	99-	Weekly (some seasonal)	same as above	same as above	same as above
Clark Co. [6]	28	Washougal River	JNS060	Jones Cr upstream of Camas water intake	T2N R4E S03	Cond, FC, DO, pH, Temp, Turb, E.coli, TP, NH3-N, NO2-NO3, TSS	01-	Monthly (Started October 2001)	Long term index, Trend	Clark County stormwater fees	Level 4 - per Ecology standards
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Salmon Creek at NW 36th St.	T3N R1E S20	DO, pH, temp, cond, FC, turb, TSS, TKN, Cl-, S03, NO2-NO3, OPDIS, TPP	95-01	Monthly and Quarterly (Long-term)	TMDL Study - Salmon Creek Monitoring	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Cougar Creek at NE 119th St.	T3N R1E S33	same as above	95-01	Monthly (Long-term)	same as above	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Salmon Creek @ Salmon Rd	T3N R1E S24	same as above	95-01	same as above	TMDL Study - Salmon Creek Monitoring	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Mill Creek @ Salmon Rd	T3N R1E S24	same as above	95-01	same as above	same as above	same as above	same as above

Appendix B
Water Quality Monitoring Activities in WRIAs 27 and 28 (Cont.)

Agency	WRIA	Watershed	Site No.	Monitoring Location	Lat/Long-TRS	Parameters	Yrs. Monitored	Test Frequency	Monitoring Objectives	Funding Sources	Data Mngt/ QA/QC
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Curtin Creek @ NE 139th St.	T3N R2E S20	same as above	95-01	same as above	same as above	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Salmon Creek at NE 122nd St.	T3N R2E S15	same as above	95-01	same as above	same as above	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Woodin Creek @ NE 122nd Av	T3N R2E S15	same as above	95-01	same as above	same as above	same as above	same as above
Clark Public Utilities [3, 7, 8]	28	Salmon Creek	-	Salmon Creek @ 199th St.	T3N R3E S03	same as above	95-01	same as above	same as above	same as above	same as above

Long-term - data collected every year. Basin - data collected for one year and may be revisited every five years.

Abbreviations: Cond (Conductivity), DO (Dissolved Oxygen), FC (Fecal Coliform), NH3-N (Ammonia Nitrogen), NO2-NO3(Nitrite-Nitrate), OPDIS (Phosphorous Soil Reaction), Press (Barometric Pressure), TSS (Total Suspended Solids), Temp (Temperature), TPP (Total Phosphorous), TPN (Total Persulf Nitrogen), Turb.(Turbidity), TP (Total Phosphorous), Cl- (Chloride), S03 (Sulfate), TKN (Total Kjeldah Nitrogen)

Notes:

1 Ecology monitoring protocols can be found in Ecology's publication "Stream Sampling Protocols for the Environmental Monitoring Trends Section"

2 Lacamas Lake Restoration Program: WY 2000 and WY 2001 Water Quality Monitoring, Clark Co. Public Works, Water Resources Section.

3 Monitoring of these sites is now the responsibility of the Clark County

4 Data from the Washington State Department of Ecology's websitewww.ecy.wa.gov/apps/watersheds/riv/stationlistbywria.asp?wria=28

5 Data from the Eleventh Annual Monitoring and Evaluation Report for the Gifford Pinchot National Forest for the fiscal year 2001.

6 Data from a Clark County Spreadsheet titled Water Resources Site Inventory and from a document titled Long-Term Index Site Monitoring Project: 2001 Data Summary by Clark County Public Works Water Resources Section

7 Data from the Salmon Creek Basin Monitoring and Management Implementation Plan Technical Memorandum Report, 2000, dated May 2001 prepared by Pacific Groundwater Group

8 Monitoring was changed during 2002, but is still ongoing. Monitoring at this site is being performed by Clark County rather than Clark County Public Utilities; the parameter list has changed slightly, and the sites have new station names to match the County's system.