



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

Refer to NMFS No: WCRO-2018-00389

May 31, 2019

Lt. Col. Christian N. Dietz
U.S. Army Corps of Engineers
Walla Walla District
201 North Third Avenue
Walla Walla, Washington 99362

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Aquatic Pest Management Program in the Walla Walla District, HUCs 17020016, 17030003, 17070101, 17070102, 17060103, 17060107, 17060108, 17060110, 17060306, Washington, Oregon, and Idaho

Dear Lt. Col. Dietz:

Thank you for your letter of December 14, 2018, transmitting a biological assessment and requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Aquatic Pest Management Program (APMP). The enclosed document contains a biological opinion (Opinion) prepared by NMFS on the effects of the U.S. Army Corps of Engineers' (COE) APMP. In this Opinion, NMFS concludes that the action, as described, is not likely to jeopardize the continued existence of Snake River Basin steelhead, Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, Upper Columbia River spring Chinook salmon, Upper Columbia River steelhead, Middle Columbia River steelhead, nor result in the destruction or adverse modification of designated critical habitat for these species.

As required by section 7 of the ESA, NMFS provided an incidental take statement (ITS) with the Opinion. The ITS describes reasonable and prudent measures (RPMs) NMFS considers necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the federal agency and any person who performs the action must comply with to carry out the RPMs. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

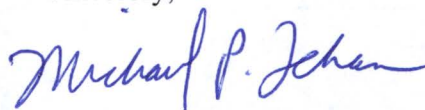


This document also includes the results of our analysis of the action's likely effects on essential fish habitat (EFH) pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and includes eight conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. These conservation recommendations are not identical to the ESA terms and conditions. Section 305(b)(4)(B) of the MSA requires federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

If the response is inconsistent with the EFH conservation recommendations, the COE must explain why the recommendations will not be followed, including the justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, we ask that you clearly identify the number of conservation recommendations accepted.

Please contact David Arthaud, Northern Snake Branch, (208) 883-8747, david.arthaud@noaa.gov if you have any questions concerning this section 7 consultation, or if you require additional information.

Sincerely,



Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office
NOAA Fisheries, West Coast Region

Enclosure

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Z. Swearingen – IDFG
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**Reinitiation of the Endangered Species Act Biological Opinion
and
Magnuson-Stevens Fishery Conservation and Management Act
Essential Fish Habitat Consultation**

Aquatic Pest Management Program
HUC #17020016, 17030003, 17070101, 17070102, 17060103, 17060107, 17060108, 17060110,
17060306
Washington, Oregon, and Idaho

NMFS Consultation Numbers: WCRO-2018-00389

Action Agencies: U.S. Department of Defense, Army Corps of Engineers, Walla Walla District

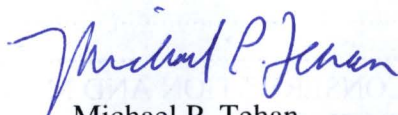
Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Snake River Basin steelhead (<i>Oncorhynchus mykiss</i>)	Threatened	Yes	No	No
Snake River spring/summer Chinook salmon (<i>O. tshawytscha</i>)	Threatened	Yes	No	No
Snake River fall Chinook salmon (<i>O. tshawytscha</i>)	Threatened	Yes	No	No
Snake River sockeye salmon (<i>O. nerka</i>)	Endangered	Yes	No	No
Upper Columbia River spring Chinook salmon (<i>O. tshawytscha</i>)	Endangered	Yes	No	No
Upper Columbia River steelhead (<i>O. mykiss</i>)	Threatened	Yes	No	No
Middle Columbia River steelhead (<i>O. mykiss</i>)	Threatened	Yes	No	No

Fishery Management Plan Describing EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:



Michael P. Tehan
Assistant Regional Administrator

Date:

May 31, 2019

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ACRONYMS

ACRONYM	DEFINITION
µg/L	micrograms per liter
a.i.	active ingredient
AMPA	Aminomethyl Phosphonic Acid
AOR	Areas of Responsibility
APMP	Aquatic Pest Management Program
AQL	Acceptable Quality Level
ATVs	All-terrain Vehicles
BA	Biological Assessment
BMP	Best Management Practices
COE	U.S. Army Corps of Engineers
CRS	Columbia River System
District	Walla Walla District
DNA	Deoxyribonucleic Acid
DO	Dissolved Oxygen
DPS	Distinct Population Segment
DQA	Data Quality Act
EDRR	Early Detection and Rapid Response
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FL	Fork Length
GBH	Glyphosate-Based-Herbicides
GIS	Geographic Information System

ACRONYM	DEFINITION
GPS	Global Positioning System
IPM	Integrated Pest Management
ITS	Incidental Take Statement
lbs/ ac ft	pounds per acre feet
LGD	Lower Granite Dam
LOEC	Lowest Observable Effect Concentration
LWD	Large Woody Debris
MCR	Middle Columbia River
mg a.i./L	milligrams liter of active ingredient
mg/L	milligrams per liter
mm	millimeters
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
Opinion	Biological Opinion
PAH	Polycyclic Aromatic Hydrocarbons
PBF	Physical and Biological Feature
PCB	Polychlorinated Biphenyls
PCE	Primary Constituent Element
PGP	Pesticides General Permit
ppb	parts per billion
ppm	parts per million
pt/ac	pints per acre
RM	River Mile
RPM	Reasonable and Prudent Measures
SCP	Sodium Carbonate Peroxyhydrate
SMP	Shoreline Management Plan
SR	Snake River
SRB	Snake River Basin
UCR	Upper Columbia River
USFWS	U.S. Fish and Wildlife Service
VSP	Viable Salmonid Population

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). A complete record of this consultation is on file at Snake Basin Area Office.

1.2 Consultation History

The U.S. Army Corps of Engineers (COE) Walla Walla District (District) proposes to control riparian and aquatic invasive plants in the lower Snake and middle Columbia Rivers and Mill Creek using herbicides and other methods as part of an integrated pest management program. Control of invasive plants in aquatic and riparian habitats of large river systems across multiple jurisdictions has ramifications at regional and national scales.

In 2008, NMFS entered into a settlement agreement to complete consultations on the product registrations of 37 active ingredients under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Toward that end, NMFS has completed biological opinions, covering 27 active ingredients registered under FIFRA (<http://www.nmfs.noaa.gov/pr/consultation/pesticides.htm>). Of those active ingredients considered in product registration consultations with U.S. Environmental Protection Agency (EPA) to date, only 2,4-D is proposed for use in the proposed Aquatic Pest Management Program (APMP) action. The other chemicals proposed for aquatic use in APMP have not yet been consulted on by EPA for those product registrations under FIFRA. NMFS (2011b) determined that 2,4-D ester formulations were likely to jeopardize listed Pacific salmonids but not result in adverse modifications of critical habitat. Aquatic applications of ester formulations (i.e., 2,4-D BEE) for the control of aquatic weeds weighed heavily in NMFS' (2011b) determination. In the reasonable and prudent alternative that avoids jeopardy, element 3 requires 2,4-D BEE not be applied to any surface waters accessible to listed salmonids, but did allow for aquatic applications of lower risk formulations of 2,4-D in limited situations. The proposed APMP action differs substantively from the registration action in that only aquatic amine formulations of 2,4-D are proposed for use.

Following the ESA-listings and designations of critical habitat for seven evolutionary significant units (ESUs) between 1991 and 1999, the District had requested section 7 consultations on some localized herbicide applications beginning in 2004.

On May 13, 2010, NMFS concurred with the COEs' not likely to adversely affect finding for a consultation request regarding the herbicide control of algae and aquatic vegetation in Pasco levee pond (12-1), where ESA-listed fish were not present and had no access, but treated water would discharge to the Columbia River (NMFS 2010).

NMFS received a request for consultation from the District on February 8, 2010 concerning its pest management (control of terrestrial plants) program. NMFS determined the request contained insufficient information to initiate consultation. To clarify its concerns, NMFS sent a letter to the COE on April 7, 2011. On February 8, 2012, NMFS received an updated and revised request for consultation, using the EPA Pesticides General Permit (PGP) and related NMFS' Opinion as a partial basis for the request. On April 9, 2012, NMFS sent a letter to the COE noting there was insufficient information to initiate consultation, suggesting changes and additions, and dropping the use of the PGP as a basis for the consultation due to the PGP not yet being suitable for this type of consultation. A modified consultation request was received from the COE by NMFS on July 5, 2012. NMFS concluded on August 23, 2012 that sufficient information was presented to initiate consultation and concurred August 29, 2012, that the action was not likely to adversely affect ESA-listed species under NMFS' jurisdiction (NMFS 2012). A complete record of the consultation is on file at the NMFS Office in Lacey, Washington.

On March 31, 2014, NMFS received a biological assessment (BA) and request for formal consultation from the COE on a program for controlling riparian and aquatic vegetation. In their BA, the COE concluded that the proposed action *may affect, and is likely to adversely affect* Upper Columbia River (UCR) spring Chinook salmon, Snake River (SR) spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon, Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin (SRB) steelhead, and their associated critical habitats. NMFS responded with letters initiating formal consultation (April 18, 2014), noting the large-scale and sensitive nature of the proposed action, that FIFRA consultations were not completed for proposed herbicides (except 2,4-D), and requesting additional information (August 1, 2014). The COE, NMFS, and the U.S. Fish and Wildlife Service (USFWS) met in Boise on August 26, 2014 and agreed to extend the consultation until various technical issues were resolved.

The consultation work group met in La Grande, Oregon on September 26, 2014, and reached consensus that certain chemicals, methods, and locations involved substantial risk that could be reduced. Work to amend the original BA consisted of more clearly defining the proposed action, developing the program framework, and constructing protective measures. Additional actions would be used to address sensitive habitats, control methods with potentially higher risk or information needs, and newly invading plants.

An eradication-based rapid response (without chemical application) to reduce the apparent new and active downstream spread of flowering rush in the Columbia River was tested and applied

during 2015. The COE developed a BA and completed informal consultation with NMFS (WCR-2014-1706).

Consultation for manual control methods and a subset of aquatic-use herbicides (2,4-D amine, imazapyr, and sodium carbonate peroxyhydrate) was initiated on January 5, 2016. NMFS completed the APMP Opinion on April 19, 2016.

During fall 2016, the COE changed the APMP action in ways that would increase treatment size. NMFS agreed to reinstate the April 19, 2016, Opinion to address these changes. On December 22, 2016, the COE added information to the BA and drafted amendments to their proposed action, which was finalized on January 27, 2017. NMFS completed the reinstatement Opinion on March 21, 2017.

On May 29, 2018 the COE submitted an amended BA and request for informal consultation that the proposed action *is not likely to adversely affect* seven species listed as threatened or endangered or critical habitats designated under the ESA. NMFS responded on June 28, 2018 that it could not concur with the COE's not likely to adversely affect determination and requested clarification of the proposed action. On December 7, 2018, the COE hosted a meeting in Walla Walla, Washington with the Services wherein the proposed action was clarified and conservation measures added.

On December 14, 2018, the COE submitted a revised BA, concluding that the proposed action *may affect, and is not likely to adversely affect* UCR spring Chinook salmon, SR spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon, MCR steelhead, UCR steelhead, SRB steelhead, and their associated critical habitats. NMFS initiated consultation on January 30, 2019. Drafts of the proposed action and terms and conditions sections were submitted to the COE on March 22, 2019 and May 10, 2019. The draft proposed action and terms and conditions were submitted to Yakama, Umatilla, Nez Perce, and Shoshone-Bannock Tribes on May 10, 2019 for review and comment. The tribes did not comment.

The current proposed action includes more treatment options (e.g., six additional herbicides, additional submerged applications of herbicides, additional mechanical techniques, biological controls, larger application areas, and increased total acres per year that may be treated) than previous APMP actions (April 19, 2016 and March 21, 2017), along with several clarifications regarding treatment locations and methods, and an integrated set of conservation measures. The proposed action is designed to extend ten years and replace all previous APMP actions and consultations. A complete record of this consultation is on file at the Snake Basin Area Office in Boise, Idaho.

1.2.1 Key conservation measures adopted by the COE during consultation

1. Removed highly toxic monopotassium (e.g., Hydrothol 191) forms of endothall from the proposed action.
2. Adjuvants were limited to aquatic-approved and lower toxicity formulations, without metals, petroleum, and esters.

3. Milfoil will be controlled only in nuisance situations, naturalized and/or hybridized milfoil will not be treated at-large throughout the District.
4. Chemical and mechanical treatment areas and seasons were substantially reduced and limited to midsummer periods in Mill Creek.
5. Emergent treatments along shorelines and floodplain waters were reduced during spring.
6. Diquat applications to emergent vegetation were reduced during early spring and limited to spot-spraying, or broadcast application with check-in and approval by the Services.
7. Maximum daily and area treatment rates, and replanting requirements were identified.
8. Herbicide concentrations in water were estimated for initial (unmixed) and target (mixed) applications in submerged, emergent, and riparian habitats.
9. Chemical retreatment was extended to 3 weeks and included in annual acreage.
10. Native plant control measures were included in the proposed action. Native plants throughout the District will be protected, except for nuisance situations.
11. At-depth, pressurized nozzles will be used in deeper water applications for flowering rush and other invasive plant targets to maximize effectiveness while minimizing near-surface concentrations of herbicide.
12. Grazing in riparian habitat was removed from the proposed action.
13. Mechanical and biological control measures were added.
14. Broadcast applications were defined, limited to monocultures of invasive plant targets, and limited during spring.

Those measures and other aspects of the proposed APMP are described more specifically in the Proposed Action section, below.

1.3 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02).

The COE has a mission to manage natural resources and act as a steward of its lands and waters. Vegetation control is part of the COE’s natural resources management mission to “manage and conserve those natural resources, consistent with ecosystem management principles, while providing good quality public outdoor recreation experiences to serve the needs of present and future generations.” The specific proposed action addressed in this consultation is the District’s APMP, which is designed to control invasive plants and to eradicate or limit the spread of

invasive plants in riparian and aquatic habitats on District land. Areas of responsibility (AORs), where most plant control treatments will occur, include project operations areas, habitat management units, recreation areas, and outgrant areas (Appendix A). The APMP is designed to complement an existing terrestrial weed control action (NMFS 2012) that does not cover submerged COE lands. The APMP addresses lands not covered by the terrestrial weed control action, so that integrated control activities may occur across COE-owned aquatic, riparian, and terrestrial areas in a coordinated manner.

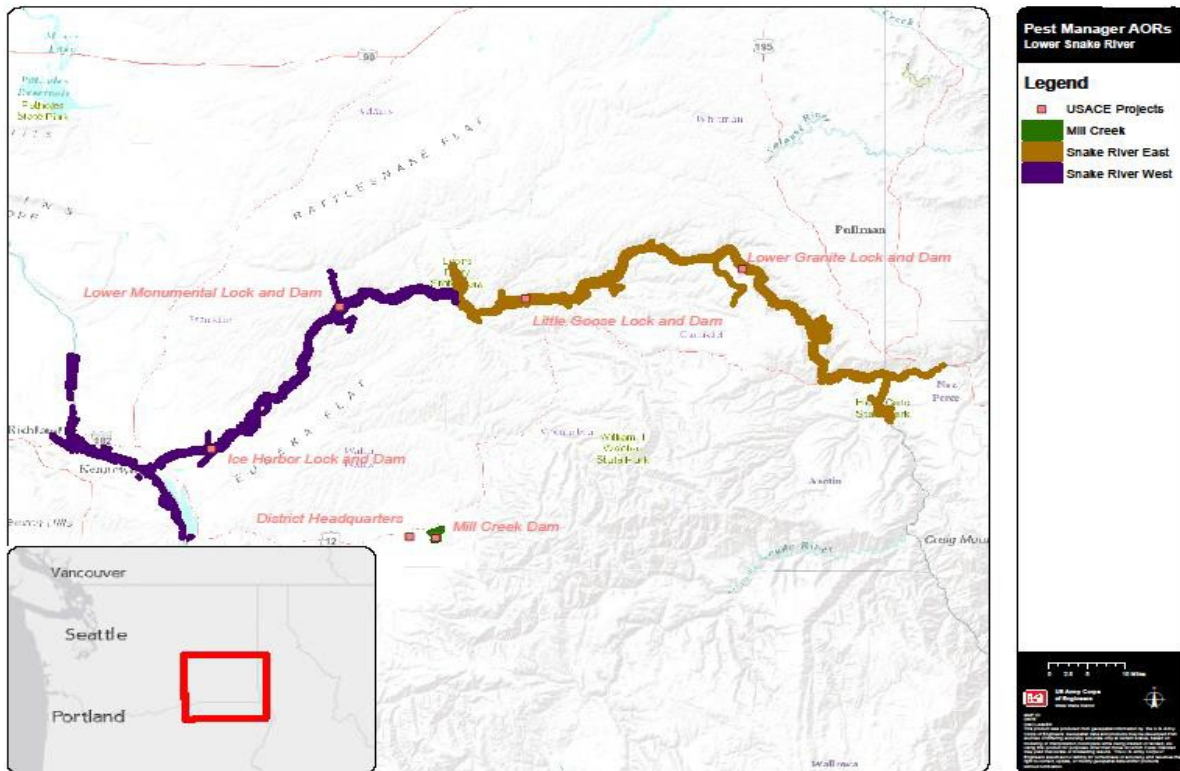


Figure 1. Overview of COE lands covered by the APMP.

The goal of the District APMP is to accomplish routine daily operation and maintenance actions by continuing to use Integrated Pest Management (IPM) concepts. The IPM is a holistic, multifaceted approach that seeks to achieve effective management and eradication where practical and possible. This will be accomplished through the use of diversified control methods while minimizing herbicide usage and herbicide resistance of invasive pests. These methods also encompass the use of natural pest predators and competitors through establishment of native plant species and a positive native seed bank. The overall long-term goal is to reduce riparian and aquatic pest management treatments once control and/or eradication is achieved. The proposed APMP is a riparian and aquatic component of the larger IPM approach that the COE is using to manage invasive and nuisance plants within the District.

The proposed action includes more treatment options (e.g., six additional herbicides, biological controls) than previous APMP actions (WCR-2014-688, April 19, 2016 and WCR-2017-6467, March 21, 2017), along with several clarifications regarding treatment locations and methods,

and an integrated set of conservation measures. The proposed action is designed to replace previous APMP actions.

A shoreline management plan (SMP) provides further policy and guidance to protect vegetation. Under this SMP, owners of private facilities (e.g., small docks, beaches) may only make minor changes to vegetation, by individual permit, using only manual methods; chemical methods are prohibited (NMFS 2011e; COE 2012b). Throughout the District, the COE, their contractors, and a limited number of grantees (entities that have received outgrants from the COE to use government property by lease, easement, license, or permit; Appendix A) may treat invasive plants.

The proposed APMP action includes approximately 18,711 total acres of submerged COE lands and riparian areas along the middle Columbia, lower Snake, lower Clearwater Rivers, and Mill Creek which are managed by the District. These lands can be separated into approximately 15,076 acres of submerged (aquatic) lands and 3,635 acres of riparian areas along shorelines, tributaries, wetlands, and other low-lying floodplains that are perennially or ephemerally wetted. The COE proposes in the APMP action to treat up to 400 acres per year for a cumulative total not to exceed 4,000 acres over 10 years. District lands included in this action extend from the upper reaches of Lower Granite Reservoir on the Snake and Clearwater Rivers and from the lower Yakima River downstream to McNary Dam on the Columbia River. Mill Creek is a tributary of the Walla Walla River, which flows westerly into the Columbia River within the McNary Pool. Also included in the action is the COE's Mill Creek resource area, which includes a dam and several concrete weir-baffles across Mill Creek, along with a water diversion, canals, and a storage reservoir that controls flooding and drainage through the town of Walla Walla, Washington. Mill Creek treatable areas under the APMP include 77 acres submerged and 71 acres of seasonally submerged riparian habitat.

1.3.1 Target Plants, Control Methods, and Limits

The proposed action includes riparian lands and waters managed by the COE within Washington, Oregon, and Idaho. These states provide current lists of noxious and invasive weeds ranked by threat level. The APMP proposes varying levels of control for 19 identified plant pests and for new invasive plant species, should they occur in the project area (Table 1).

The APMP has two invasive plant management components: (1) routine control and maintenance, and (2) early detection rapid response/eradication (EDRR). Control and maintenance is the operation of controlling already established invasive plants from either spreading from their current location or managing them within their location to meet mission goals. Rapid response and eradication primarily focus on newly detected invasive plants. The EDRR is projected to primarily consist of active management for 2 to 3 years and then monitoring to detect any newly established plants of that species. If EDRR is unsuccessful, then assessment of the invasive plant would occur following adaptive IPM concepts and actions may be moved toward control and maintenance of that plant based on mission goals.

Table 1. Target noxious weed species. Native species will not be targeted outside of a nuisance occurrence. The EDRR methods focus on eradicating specific weed species.

Target Common Name	Target Scientific Name	Target Intensity
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>	Nuisance only*
Parrotfeather	<i>M. aquaticum</i>	Routine O&M
Curly-leaf Pondweed	<i>Potamogeton crispus</i>	Routine O&M
False Indigo	<i>Amorpha fruticose</i>	Routine O&M
Flowering Rush	<i>Butomus umbellatus</i>	Routine O&M /EDRR
Hairy Willow-Herb	<i>Epilobium hirsutum</i>	Routine O&M
Japanese Knotweed	<i>Polygonum cuspidatum</i>	Routine O&M
Narrowleaf Cattail	<i>Typha angustifolia</i>	Routine O&M
Cattail hybrid	<i>T. glauca</i>	Routine O&M
Perennial Pepperweed	<i>Lepidium latifolium</i>	Routine O&M
Phragmites (common reed)	<i>Phragmites australis</i>	Routine O&M
Poison Hemlock	<i>Conium maculatum</i>	Routine O&M
Purple Loosestrife	<i>Lythrum salicaria</i>	Routine O&M /EDRR
Reed Canarygrass	<i>Phalaris arundinacea</i>	Routine O&M
Russian Olive	<i>Elaeagnus angustifolia</i>	Routine O&M
Saltcedar	<i>Tamarix ramosissima</i>	Routine O&M
Tree-of-Heaven	<i>Ailanthus altissima</i>	Routine O&M
Yellow-flag Iris (Pale Yellow Iris)	<i>Iris pseudacorus</i>	Routine O&M
Algae	<i>Various species</i>	Routine O&M
New Invasive Species	varies	Routine O&M /EDRR

*Milfoil will only be treated on a nuisance occurrence (e.g., around marinas, boat ramps, and swim beaches).

Control Methods, Area and Retreatment Limits

Treatments will include manual, mechanical, biological, and chemical control methods to manage nuisance and noxious plants on COE managed lands and waters in the District. Control of vegetation on levees is not included in the proposed action. Treatment limits are generally organized by method, location and type of target plants. Submerged plants are those that typically grow underwater and may form mats upon reaching the surface, emergent plants typically grow in shallow water with much of plant extending above the surface, and riparian plants are those growing in wetted habitats along shorelines, streambanks, and floodplain wetlands. The proposed action will treat up to 5 contiguous acres of submerged plants or 2 contiguous acres of emergent and riparian plants within an AOR each day, for a total of 400 acres annually, across the AORs detailed within this document (Appendix A). Mill Creek would only receive 5 acres chemical, and 5 acres manual or mechanical treatment annually; this totals 10 acres annually and 50 acres cumulatively over 10 years.

Treatment methods will primarily limit clearing of vegetation to small areas. Replacement or regrowth of proximate native or non-target vegetation is expected. Treatments removing vegetation from a one-acre or larger area will be monitored for natural regrowth and, if regrowth is not adequate, the area will be replanted with appropriate native vegetation. Control (treatment) methods include the following.

Manual controls include hand-pulling, cutting, raking, chopping, and digging methods. Substrate screens may be used to control invasive submerged plants in areas up to 1-contiguous acre and in several smaller areas within each AOR. Biodegradable substrate screens will be prioritized for use over synthetic materials and will be deployed in the smallest and narrowest forms required to control target invasive plants. Substrate screens will not be installed in non-submerged areas, will not cross the water's edge into riparian habitats, and will be maintained.

Mechanical controls generally include motorized cutters (specialized, portable boat-mounted, underwater) and harvesting (chopping or cutting of near-surface growth for boat navigation; only private marinas on McNary Pool) for submerged nuisance plants. Mechanical controls for target plants in riparian habitats include discing, tilling, and mowing. Prescribed burning may be used in riparian areas during specific seasons.

Biological controls include the release and establishment of nonnative invertebrate specialists that consume or otherwise weaken target plants in areas where at least portions of the target plants are emergent. The milfoil weevil, *Euhrychiopsis lecontei*, may be used as a tool for treatment of Eurasian watermilfoil. The two leaf-beetles *Galerucella californiensis* and *G. pusilla* may be used as tools for treatment of purple loosestrife in the action area.

Chemical controls include hand/select, spot spray, and broadcast applications to target plants among submerged, emergent, and riparian vegetation zones. Hand/select applications may be used to treat individual trees (e.g., Russian olive). Spot spray and broadcast applications may be used on emergent, floating, and submerged riparian plants, typically using hand-held, low pressure applicators, from tanks transported by boat, vehicle, or backpack. Applications begin with a single spray on an individual plant or small patch of targets and then move without spraying for a few feet or more to the next individual or small patch of targets. Broadcast applications include multiple spray nozzles on booms that may be used to treat monocultures of target plants. Submerged applications may use boats supporting one or more weighted hoses tipped with 1–3 nozzles at one or more depths.

Chemical retreatments may occur after a period of 3 weeks, if needed to meet performance requirements in COE contracts pertaining to vegetation management. The District currently uses performance-based contracts; which dictate an Acceptable Quality Level (AQL) for the contract action. Retreatment will be required of the contractor when an AQL is not met; thereby necessitating the treating of weeds that were missed or not effectively treated the first time. This will be done to increase the performance level to the contract AQL. The contractors typically treat the minimum necessary to bring the below standard AQL up to the required AQL so retreatment may occur frequently. The AQL varies in contracts based on the action being performed. The cumulative area of these treatments, retreatments, and their patterns of application will be included in daily and annual acreage limits.

Chemicals to be applied in the proposed action include eight herbicides, an algaecide, adjuvants, and dyes listed in Table 2. Different active ingredients or formulations will not be combined. Formulations will be approved for aquatic use and will be in liquid form. A commonly used formulation of glyphosate will be tested using a standard RCRA-8 metal panel and results reported to NMFS. The use of EPA-approved aquatic labeled glyphosate formulations will be

prioritized to those that do not contain heavy metals or petroleum per the product label. Adjuvants will be aquatic registered, will not contain petroleum products or metals, will target lower toxicity formulations, and will not be used for submerged applications (Table 2). Maximum application rates proposed for use are shown in Table 2, but reduced rates will be used whenever practicable.

Table 2. Proposed active ingredients for use in the APMP. Herbicides and adjuvants will be aquatic-registered, and no copper, ester, or monopotassium formulations will be used. Pints/acre = pt/ac; pounds/acre foot = lb/ac ft.

Active Ingredient	Emergent Application Rate (pt/ac)	Submerged Application Rate (pt/ac ft of water)
2,4-D (amine only)	4 to 8	11.3 to 22.7
Ammonium salt of imazamox	0.156 to 8	1.0625 to 10.8125
Diquat dibromide	4 to 16	2 to 4
Endothall (dipotassium only)	3.6 to 25.6	3.6 to 25.6
Fluridone	0.4 to 3.84	0.4 to 3.84
Glyphosate	1.5 to 7	Not for submerged
Imazapyr	2 to 6	Not for submerged
Triclopyr (TEA only)	4 to 16	5.6 to 18.4
Sodium carbonate peroxyhydrate	10 to 100 lb/ac ft or 10 to 100 pt/ac	10 to 100 lb/ac or 10 to 100 pt/ac
Colorants (dyes)	Varies	Varies
Adjuvants (no petroleum, non-metallic, aquatic registered, targeting lower toxicity)	May vary	Not for submerged application

Already mixed concentrations of active ingredients are proposed for spray application directly to plant surfaces that are above water (emergent vegetation) or near water (riparian vegetation). Depending on the situation, low or high target rate concentrations may be used (Table 3). Submerged applications use boats with booms that support weighted hoses tipped with 1-3 nozzles at one or more depths. The boat is steered over plant targets and herbicide is injected into the water from the pressurized nozzle(s). Before-mixing concentrations are those from the end-of-nozzle(s) that are not yet diluted with receiving water (Table 3). Low and high before-mixing application rates are designed to achieve the low and high target rate concentrations after mixing with receiving water. Imazapyr and glyphosate herbicides are proposed for use on emergent and riparian vegetation but will not be used to control submerged vegetation (Table 3).

Table 3. Concentrations (milligrams per Liter [mg/L]) of active ingredients proposed for use in the APMP.

Herbicide	Emergent and Submerged Target Concentration		Submerged Applications Before Mixing					
	Low	High	Low			High		
			1 nozzle depth range (1-6 feet)	2 nozzle depth range (5-8 feet)	3 nozzle depth range (9-12 feet)	1 nozzle depth range (1-6 feet)	2 nozzle depth range (5-8 feet)	3 nozzle depth range (9-12 feet)
2,4 D amine	2	4	38.08-228.51	95.21-152.33	114.25-152.33	76.2-457	190-304	228-304
Diquat dibromide	0.343	0.685	6.58-39.45	16.44-26.3	19.73-26.3	13.15-78.9	32.89-52.61	39.46-52.61
Endothall dipotassium	0.75	5	13.4-80.54	33.56-53.7	40.27-53.7	95.14-572.8	238.6-381.9	286.4-381.9
Fluridone	0.01	0.09	0.18-0.71	0.44-0.71	0.52-0.71	1.69-10.16	4.23-6.77	5.1-6.77
glyphosate	0.444	2.95	na	na	na	na	na	na
Imazapyr	0.184	0.552	na	na	na	na	na	na
Imazamox	0.05	0.5	0.93-5.6	2.34-3.75	2.81-3.75	9.53-57.16	23.8-38.13	28.6-38.13
SCP	3.68	36.8	352.6-2115.8	881.6-1410.5	1057.9-1410.5	705.3-4231.6	1763.2-2820.1	2115.8-2820.1
Triclopyr TEA	0.75	2.5	14.81-88.86	37.02-59.24	44.43-59.24	48.66-291.98	121.66-194.65	145.99-194.65

Timing Limits

Timing is summarized in Table 4. Manual control methods, excluding controlled burning, may be used year-round. Burning would occur January 1–April 15 and September 15–December 31. No burning would occur from April 15–September 15. Biological control would occur year-round, depending on the target plant (Eurasian watermilfoil or purple loosestrife) and control species.

Mechanical control timing is different for riparian and submerged plants. Riparian plant control may extend year-round (mowing, disking). Mechanical control of submerged plants may only occur from July 1–September 15 (Table 3; Appendix A; WDFW 2015).

Chemical applications within the Mill Creek AOR may occur July 1–August 15, contingent upon water temperature exceeding 18°C. Additionally, if a significant rain event (>0.5 inches) is anticipated within 2 days before treatment, treatment will be delayed up to 2 days after rainfall until increased flows have subsided. The APMP activities in Mill Creek may occur August 15–September 15 without the above contingencies (Table 4).

Outside Mill Creek, chemical control timing is different for emergent and submerged plants. Submerged vegetation treatment may occur between July 1 and September 15 (Table 4; WDFW 2015). Emergent plant treatment with spot spray and other hand methods may begin April 15th.

The use of diquat for spot spray and other hand application methods may begin May 5 to target flowering rush. Diquat broadcast application with a prior use check-in with the Services may occur May 5-June 1. All broadcast chemical applications may begin June 1 and continue to October 15 (Table 4). Broadcast applications may be used on monocultures of target plants to reduce disturbance and spread of plant targets and effectively reduce the amount of chemical reaching the water relative to spot spray.

Table 4. The APMP timing windows (shaded area).

Activity		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chemical	Riparian, Emergent												
	-Diquat (Begins May 5)												
	-Diquat Broadcast with check-in (May 5-June 1)												
	Broadcast												
	Submerged												
Mechanical	Riparian												
	Submerged												
Burning	Riparian												
Manual	Riparian, Emergent, Submerged												
Biological	Emergent												
Mill Creek													

1.3.2 Protective Measures and Best Management Practices

1. Contiguous chemical block treatments of 2 acres emergent and 5 acres submerged within off-channel habitats (e.g. backwaters and sloughs) would occur with 2 days between treatments, allowing for chemical dissipation and dissolved oxygen (DO) rebound.
2. Care will be taken to protect native plants, fish, and wildlife from biocides. Operators and technicians will be trained in pesticide use, and the identification and protection of native plants and wildlife. Disturbance of wetlands and native vegetation will be minimized.
3. Dyes shall be used to reduce the potential for over-application.
4. Control strategies, treatment locations and statistics, and field monitoring information among years will be summarized in annual reports and work plans (Section 1.3.3).

5. Treatments will generally be limited to a single pesticide application per year during open work windows; however, if needed, retreatment may occur after 3 weeks.
6. Chemical treatment may occur at habitat management units and recreation areas within the District, including the Mill Creek project area and along the lower Yakima River. Areas within other tributaries upstream of their mouths along the Columbia, Snake, and Clearwater Rivers will not be chemically treated.
7. Areas in or adjacent to potential salmonid spawning areas or immediately proximate to fish passage facilities at dams will not be chemically or mechanically treated.
8. Tree/shrub control will be limited to small areas to maintain canopy/shade and bank stability of riparian areas. Invasive trees listed in Table 1 may be trimmed, physically removed, or cut individually and sprayed or wicked (painted) with herbicide onto the cut stump.
9. Private docks and swimming areas within the District that were not listed in Appendix A are not included in the proposed action.

1.3.3 Integrated Monitoring, Reporting, Licensing, and General Best Management Practices

Annual pest management activities are determined by the previous year's activities in combination with reconnaissance during annual implementation of pest management activities. They must remain within the overall scope and impact of the current action.

Data collected will be used to help direct effective treatments in future years. Treatment areas will be inventoried in a Geographic Information System (GIS) database. The following is the typical sequence for pest management activities in the District:

- a. Continually collect weed inventory information across the District.
- b. Input treatment data into GIS through reporting during the treatment season.
- c. Include inventoried data in contract or work plans for the following year.
- d. Issue maps and descriptions of predetermined application areas to contractors.
- e. Perform treatments.
- f. Gather current data, add to previous year's data, and use combined data in subsequent inventories.

Treatments include reconnaissance of District lands to evaluate treated locations and document new outbreaks of weeds. During reconnaissance, the contractor, COE operators, or lessee also identifies invasive plants. The EDRR may be employed at this stage.

The District currently collects data regarding anticipated and actual use of invasive plant control for annual reporting purposes, in accordance with the section 7 consultations for the terrestrial portion of the District's pest management. Annual reporting for pest control activities in riparian and aquatic habitats under the APMP will be provided to the Services, along with those for the terrestrial portion, no later than May 1 of each year.

The COE also collects data and reports to EPA regarding licensing, general safety and spill prevention, and other general or basic aquatic pesticide use under EPA's PGP (EPA 2016; NMFS 2011a). The PGP provides substantial requirements and limits that may help reduce potential adverse effects to listed species related to implementation of riparian and aquatic pest control efforts. Key conservation measures from the PGP are listed below and others are included in the BA.

1. General Practices:

- a. Licensing/Certification: All applicators shall be state licensed or certified, or under the direct visual supervision of a state licensed or certified applicator.
- b. All applicators shall comply with all applicable federal, state (Oregon, Idaho, and Washington), and herbicide manufacturer's directions and requirements for handling pesticides, including storage, transportation, application, container disposal, and spill cleanup.
- c. Herbicide application shall be according to the chemical manufacturer's label recommendations. Applicators shall use caution to minimize the application of herbicides to non-target species and structures within the application areas.

2. Calibration/Maintenance:

- a. All application equipment shall be properly calibrated according to the chemical manufacturer's suggested application rates printed on the chemical label prior to use. Equipment and settings shall be properly maintained for the duration of the contract performance period.
- b. Appropriately sized nozzles shall be used to minimize the potential for drift.
- c. Winds and certain very still conditions (inversions) can increase overspray and drift of spray herbicide into water. Operators shall not apply chemicals when winds are over 10 miles per hour, during inversions (within 1-hour of sunrise or sunset), or immediately preceding storms, or during other unsettled weather and precipitation.
- d. Application equipment will be maintained to ensure proper application rates, minimize leakage, reduce drift, and ensure applicator safety. Equipment will be maintained, and visually inspected prior to each application.

3. Record Keeping:

- a. Grantees, contractors, and COE employees shall perform work planning by submitting their anticipated use on the “District Pest Control Application Record” forms, as provided by the District.
- b. All actual pesticide applications shall be recorded and submitted on the “District Pest Control Application Record” forms, as provided by the District.
- c. The District shall provide annual reporting to the Services on anticipated use and actual use.
- d. An annual report will be produced for the Services by May 1 of the following year. This report will summarize the area of treatment by species, chemical, and amount used. This summary report will be forwarded to the Services by the District’s Environmental Compliance Section.

4. Spill Management:

- a. All applicators shall carry a District-approved APMP Spill Prevention and Control Plan. The Plan shall provide detailed descriptions on how to prevent a spill or ensure effective and timely containment of any chemical spill. The Spill Prevention and Control Plan shall include spill control, containment, clean up, and reporting procedures.
- b. A spill kit will be available to all applicators and shall be within 150 feet of the application site.
- c. Equipment refueling will not occur within 100 feet of open water. This includes all-terrain vehicles (ATVs), trucks, tractors, aircraft, etc.
- d. All concentrated or mixed solution pesticides shall be placed in locked storage in closed containers with watertight lids and placed in secondary containment vessels, with 2.4 gallons of freeboard space.
- e. All mixing for spray bottles and backpack sprayers shall be done within a container capable of containing 110 percent capacity of the liquid.

5. Disposal:

- a. Disposal of waste materials shall be in accordance with label restrictions and instructions and all applicable federal, state, and county laws and regulations.

6. Water Quality:

- a. Only aquatic formulations of authorized chemicals will be used within 15 feet of water or areas with shallow water tables.

7. Timing:

- a. The COE will adhere to the proposed treatment windows.
- b. Narrower windows and additional protection measures established by states will also be followed, such as Washington Department of Ecology's Recommended Fish and Wildlife Treatment Windows for aquatic plant control.

“Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02). There are no interdependent or interrelated actions associated with this proposed action.

1.4 Action Area

“Action area” means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02).

For purposes of this consultation, the action area is COE lands and waters within the District, which represent the entire river corridor from the backwaters of Lower Granite Reservoir on the Snake and Clearwater Rivers downstream to the Columbia River; from Yakima River Mile (RM) 6.5 downstream to the Columbia River; and in the Columbia River from RM 356.5 to just below McNary Dam near Umatilla, Oregon at RM 292. Both banks of these river sections, their channels, and associated riparian lands are included in the action area, as are smaller tributary mouths and their lower reaches affected by reservoir backwaters that flow into this reach. Lands and waters managed by the COE surrounding the Mill Creek Flood Control Project in the Mill and Yellowhawk Creek drainages near Walla Walla, Washington are also included in the action area. The action area includes waters downstream of lowest treatment sites for 200 yards in the Columbia River and 500 yards in Mill Creek, and to other off-site project components such as mixing and staging areas, source and waste sites, and refueling areas, where effects of program activities occur.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with

NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an Opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This Opinion includes both a jeopardy analysis and/or an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR § 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This Opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" ((81 FR 7214, 7216) (February 11, 2016) (codified at 50 CFR § 402.02)).

The original designations of critical habitat for Chinook salmon (58 FR 68543) (December 28, 1993) and steelhead (70 FR 52630) (Sept. 2, 2005) use the terms "primary constituent element" (PCE) or "essential feature." The new critical habitat regulations (81 FR 7414) (February 11, 2016) (codified at 50 CFR § 402.02) replace these terms with the term "physical or biological feature" (PBF). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this Opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.

- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a Reasonable and Prudent Alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR § 402.02. The Opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

The status of each ESA-listed species and designated critical habitats that may be affected by the proposed action are described in Sections 2.2.1 and 2.2.2. More detailed information on the status and trends of the ESA-listed species, and their biology and ecology, can be found in the listed regulations and critical habitat designations published in the Federal Register (Table 4). Other sources of information include the most recent status reviews (NWFSC 2015; NMFS 2016a, 2016b, 2016c) and recovery planning documents (UCSRB 2007; NMFS 2009, 2015, 2016d, 2017b).

The species of listed anadromous fish in the action area are SR spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon, SRB steelhead, UCR spring Chinook salmon, MCR steelhead, and UCR steelhead (Table 4). Juvenile life stages of these species use the action area for migration and rearing, and adults use the action area for migration and holding/staging. Adult SR fall Chinook spawn in the action area and MCR steelhead could spawn in areas just upstream from the Mill Creek Flood Control Project in Mill and Yellowhawk Creeks. The action area is designated critical habitat for all seven species and is also designated as EFH for Chinook salmon and coho salmon Pacific Fisheries Management Council (PFMC; PFMC 1999).

Table 5. Federal Register notices for final rules that list threatened and endangered species, designated critical habitats, or apply protective regulations to listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (<i>Oncorhynchus tshawytscha</i>)			
Snake River spring/summer	T 6/28/05; 70 FR 37160 Originally 4/22/92; 57FR14653	12/28/93; 58 FR 68543 revised 10/25/99; 64 FR 57399	6/28/05; 70 FR37160
Snake River fall	T 6/28/05; 70 FR 37160 Originally 4/22/92 57FR14653	12/28/93; 58 FR 68543	6/28/05; 70 FR37160
Upper Columbia spring	E 6/28/05; 70 FR 37160	9/02/05; 70 FR 52360	ESA Section 9 applies
Sockeye salmon (<i>O. nerka</i>)			
Snake River sockeye	E 6/28/05; 70 FR 37160 Orig. 11/20/91 56 FR 58619	12/28/93; 58 FR 68543	ESA section 9 applies
Steelhead (<i>O. mykiss</i>)			
Snake River Basin	T 1/05/06 71 FR 834; 8/18/97 62 FR 4397	9/02/05; 70 FR 52630	6/28/05; 70 FR37160
Middle Columbia River	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR37160
Upper Columbia River	T 8/24/09; 74 FR 42605	9/02/05; 70 FR 52630	2/01/06; 71 FR5178

Listing status: “T” means listed as threatened, “E” means listed as endangered under the ESA.

2.2.1 Status of the Species

Table 6 provides a summary of listing and recovery plan information, status summaries and limiting factors for the species addressed in this Opinion. More information can be found in recovery plans and status reviews for these species. These documents are available on the [NMFS WCR website](http://www.westcoast.fisheries.noaa.gov/) (<http://www.westcoast.fisheries.noaa.gov/>).

Table 6. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for species considered in this Opinion.

Species	Listing Classification and Date	Status Summary and Limiting Factors
Upper Columbia River Spring-Run Chinook Salmon	Listing Classification and Date: Endangered 6/28/2005 Recovery Plan Reference: (UCSRB 2007) Status Review: (NMFS 2016b)	Status Summary: This ESU comprises three independent populations. All three are at high risk. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations. Limiting Factors: <ul style="list-style-type: none"> • Effects related to hydropower system in the mainstem Columbia River • Degraded freshwater habitat • Degraded estuarine and nearshore marine habitat

Species	Listing Classification and Date	Status Summary and Limiting Factors
		<ul style="list-style-type: none"> • Hatchery-related effects • Persistence of non-native (exotic) fish species • Harvest in Columbia River fisheries
Snake River Spring/Summer-run Chinook Salmon	Listing Classification and Date: Threatened 6/28/2005 Recovery Plan Reference: (NMFS 2017b) Status Review: (NMFS 2016a)	Status Summary: This ESU comprises 28 extant and four extirpated populations. All except one extant population (Chamberlin Creek) are at high risk. Natural origin abundance has increased over the levels reported in the prior review for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in the years leading up to the last status review were a major factor in recent abundance patterns. While there have been improvements in abundance and productivity in several populations relative to prior reviews, those changes have not been sufficient to warrant a change in ESU status. Limiting Factors: <ul style="list-style-type: none"> • Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River • Altered flows and degraded water quality • Harvest-related effects • Predation
Snake River Fall-Run Chinook Salmon	Listing Classification and Date: Threatened 6/28/2005 Recovery Plan Reference: (NMFS 2017a) Status Review: (NMFS 2016a)	Status Summary: This ESU has one extant population. Historically, large populations of fall Chinook salmon spawned in the Snake River upstream of the Hells Canyon Dam complex. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is ‘viable.’ Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of ‘viable’ developed by the Interior Columbia Basin Technical Recovery Team, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be “highly viable with high certainty” and/or will require reintroduction of a viable population above the Hells Canyon Dam complex. Limiting Factors: <ul style="list-style-type: none"> • Degraded floodplain connectivity and function • Harvest-related effects • Loss of access to historical habitat above Hells Canyon and other Snake River dams • Impacts from mainstem Columbia River and Snake River hydropower systems • Hatchery-related effects • Degraded estuarine and nearshore habitat
Snake River Sockeye Salmon	Listing Classification and Date: Endangered 6/28/2005 Recovery Plan Reference: (NMFS 2015)	Status Summary: This single population ESU is at very high risk due to small population size. There is high risk across all four basic risk measures. Although the captive brood program has been successful in providing substantial numbers of hatchery produced fish for use in supplementation efforts, substantial increases in survival rates across all life history stages must occur to reestablish sustainable natural production. In terms of natural production, the Snake River sockeye ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery-based program to amplify and conserve the stock to facilitate reintroductions.

Species	Listing Classification and Date	Status Summary and Limiting Factors
	Status Review: (NMFS 2016b)	Limiting Factors: <ul style="list-style-type: none"> • Effects related to the hydropower system in the mainstem Columbia River • Reduced water quality and elevated temperatures in the Salmon River • Water quantity • Predation
Upper Columbia River Steelhead	Listing Classification and Date: Threatened 1/5/2006 Recovery Plan Reference: (UCSRB 2007) Status Review: (NMFS 2016b)	Status Summary: This Distinct Population Segment (DPS) comprises four independent populations. Three populations are at high risk of extinction while one is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve from previous years. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5 percent extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns. Limiting Factors: <ul style="list-style-type: none"> • Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris (LWD) recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects
Middle Columbia River Steelhead	Listing Classification and Date: Threatened 1/5/2006 Recovery Plan Reference: (NMFS 2009) Status Review: (NMFS 2016c)	Status Summary: This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS. Limiting Factors: <ul style="list-style-type: none"> • Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Harvest-related effects • Effects of predation, competition, and disease
Snake River Basin Steelhead	Listing Classification and Date: Threatened 1/5/2006	Status Summary: This DPS comprises 24 populations. Two populations are at high risk, 15 are rated as maintained, three are rated between high risk and maintained, two are at moderate risk, one is viable, and one is highly viable. Four out of the five major population groups (MPGs) are not meeting the specific objectives in the draft

Species	Listing Classification and Date	Status Summary and Limiting Factors
	Recovery Plan Reference: (NMFS 2017b) Status Review: (NMFS 2016a)	recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain. A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations. Limiting Factors: <ul style="list-style-type: none"> • Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded freshwater habitat • Increased water temperature • Harvest-related effects, particularly for B-run steelhead • Predation Genetic diversity effects from out-of-population hatchery releases

2.2.2 Status of the Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential PBF of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species’ life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

A summary of the status of critical habitats for the remainder of the ESU/DPS considered in this Opinion, is provided in Table 7, below.

Table 7. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this Opinion.

ESU/DPS	Designation	Geographical Extent	Status of Critical Habitat
Upper Columbia River Spring-run Chinook Salmon	9/02/2005 70 FR 52630	<p>Critical habitat is designated in the following states and counties:</p> <p>(i) <i>OR</i>—Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, and Wasco;</p> <p>(ii) <i>WA</i>—Benton, Chelan, Clark, Cowlitz, Douglas, Franklin, Grant, Kittitas, Klickitat, Okanogan, Pacific, Skamania, Wahkiakum, Walla Walla, and Yakima.</p> <p>Detailed, textual descriptions of critical habitat for this ESU has been described in paragraphs (i) through (t) of the listing document: (https://www.westcoast.fisheries.noaa.gov/publications/frn/2005/70fr52731.pdf).</p>	<p>Activities within the ESU have affected habitat diversity and quantity, connectivity, and riparian function. Habitat in many upper reaches of most subbasins is relatively pristine. Elsewhere water quality and quantity have been degraded, LWD recruitment has been lost, and floodplain connectivity has reduced salmonid overwintering habitat in the larger rivers. Fish management, including introductions and persistence of non-native species continues to affect habitat in some locations (e.g., walleye and smallmouth bass) (UCSRB 2007).</p> <p>The most widespread ecological concerns continue to be degraded riparian condition, sedimentation, low levels of LWD, reduced habitat complexity, lack of side-channels, degraded water quality, and passage barriers (NMFS 2016b).</p>
Snake River Spring/Summer-Run Chinook Salmon	10/25/1999 64 FR 57399	All Snake River reaches upstream to Hells Canyon Dam; all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Salmon River basin; and all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Hells Canyon, Imnaha, Lower Grande Ronde, Upper Grande Ronde, Lower Snake-Asotin, Lower Snake-Tucannon, and Wallowa subbasins.	Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Both hydropower and land use activities have had impacts on habitat in the mainstem Snake River above Lower Granite Dam. A total of 12 dams have blocked and inundated habitat, impaired fish passage, altered flow and thermal regimes, and disrupted geomorphological processes in the mainstem Snake River. These impacts have affected juvenile and adult salmon through loss of historical habitat, altered migration timing, elevated dissolved gas levels, caused juvenile fish stranding and entrapment, and increased susceptibility to predation. In addition, land use activities have affected tributary habitats, affecting water quality and diminishing habitat quality. The most widespread ecological concerns pertain to a lack of habitat quality/diversity, degraded riparian conditions, low summer flows, and poor water quality (i.e., increased water temperatures in late summer/fall) (NMFS 2016a).
Snake River Fall-Run	10/25/1999 64 FR 57399	Snake River to Hells Canyon Dam; Palouse River from its confluence with the Snake River upstream to Palouse Falls; Clearwater River from its confluence with the	Hydropower and land use activities have had impacts on habitat in the mainstem Snake River above Lower Granite Dam. Twelve dams have blocked and inundated habitat, impaired fish passage, altered

ESU/DPS	Designation	Geographical Extent	Status of Critical Habitat
Chinook Salmon		Snake River upstream to Lolo Creek; North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam; and all other river reaches presently or historically accessible within the Lower Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower Salmon, Lower Snake, Lower Snake–Asotin, Lower North Fork Clearwater, Palouse, and Lower Snake–Tucannon subbasins.	flow and thermal regimes, and disrupted geomorphological processes in the mainstem Snake River. These impacts have affected juvenile and adult salmon through loss of historical habitat, altered migration timing, elevated dissolved gas levels, juvenile fish stranding and entrapment, and increased susceptibility to predation. While habitat loss is the primary limiting factor, a second major factor in the mainstem Snake River above Hells Canyon is highly degraded water quality. Agriculture, grazing, mining, timber harvest, and development activities have led to excessive nutrients, sedimentation, toxic pollutants, low DO, and altered flows. Habitat in this area currently likely too degraded to support anadromous fish (NMFS 2016a).
Snake River Sockeye Salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas Lakes (including their inlet and outlet creeks).	<p>Water quality in all five lakes generally is adequate for juvenile sockeye, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015). Construction and operation of water storage and hydropower projects in the Columbia River basin have altered biological and physical attributes of the mainstem migration corridor. These alterations have affected juvenile migrants to a much larger extent than adult migrants.</p> <p>Both hydropower and land use activities have had impacts on habitat in the mainstem Snake River above Lower Granite Dam. A total of 12 dams have blocked and inundated habitat, impaired fish passage, altered flow and thermal regimes, and disrupted geomorphological processes in the mainstem Snake River. These impacts have affected juvenile and adult salmon through loss of historical habitat, altered migration timing, elevated dissolved gas levels, juvenile fish stranding and entrapment, and increased susceptibility to predation. In addition, land use activities, including agriculture, grazing, resource extraction, and development have adversely affected water quality and diminished habitat quality throughout this designation. Sockeye salmon are particularly vulnerable to increased water temperatures in late summer and fall, when adults of this species are migrating (NMFS 2016b). Species is supported by an aggressive hatchery program which includes the removal of, and gamete</p>

ESU/DPS	Designation	Geographical Extent	Status of Critical Habitat
			collection from most returning adults prior to them entering Redfish Lake.
Upper Columbia River Steelhead	9/02/2005 70 FR 52630	<p>Critical habitat is designated in the following states and counties:</p> <p>(i) OR—Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Umatilla, and Wasco.</p> <p>(ii) WA—Adams, Benton, Chelan, Clark, Cowlitz, Douglas, Franklin, Grant, Kittitas, Klickitat, Okanogan, Pacific, Skamania, Wahkiakum, Walla Walla, and Yakima.</p> <p>Detailed, textual descriptions of critical habitat for this ESU has been described in paragraphs (i) through (t) of the listing document: (https://www.westcoast.fisheries.noaa.gov/publications/frn/2005/70fr52731.pdf).</p>	<p>Diversions and dams, agriculture, stream channelization and diking, road and railway construction, timber harvest, and urban/rural development have led to loss of habitat complexity, off-channel habitat, and large, deep pools due to sedimentation and loss of pool-forming structure (UCSRB 2007).</p> <p>The most widespread ecological concerns continue to be degraded riparian condition, sedimentation, low levels of LWD, instream structural complexity, side channel and wetland conditions, degraded water quality, and anthropogenic barriers (NMFS 2016b).</p>
Middle Columbia River Steelhead	9/02/2005 70 FR 52630	<p>Critical habitat is designated in the following states and counties:</p> <p>(i) OR—Clatsop, Columbia, Crook, Gilliam, Grant, Hood River, Jefferson, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, Wasco, and Wheeler.</p> <p>(ii) WA—Benton, Clark, Cowlitz, Columbia, Franklin, King, Kittitas, Klickitat, Lewis, Pacific, Pierce, Skamania, Wahkiakum, Walla Walla, and Yakima.</p> <p>Detailed, textual descriptions of critical habitat for this ESU has been described in paragraphs (i) through (t) of the listing document: (https://www.westcoast.fisheries.noaa.gov/publications/frn/2005/70fr52731.pdf).</p>	<p>Habitat quality and quantity has been impacted through removal of LWD from streams; removal of riparian vegetation; timber harvest, road construction, agricultural development, livestock grazing, urbanization, wetland draining, and gravel mining; alteration of channel structure through stream relocation, channel confinement and straightening; beaver removal; dams; and water withdrawal. While some streams and stream reaches retain highly functional habitat conditions, activities have degraded stream reaches across the DPS, leaving insufficient LWD in channels, insufficient instream complexity, and inadequate floodplain connectivity. Many streams lack sinuosity and suffer from excessive streambank erosion and sedimentation, as well as altered flow regimes and high summer water temperatures (NMFS 2009).</p> <p>Passage, low streamflows, warm water temperatures, remain habitat concerns. Efforts have been made to improve flow patterns below Pelton-Round Butte Selective Water Withdrawal and Fish Collection Facility; and fish passage has been opened up on approximately 170 miles of habitat in streams such as Whychus Creek, White Salmon River, and Deschutes River (NMFS 2016c).</p>

ESU/DPS	Designation	Geographical Extent	Status of Critical Habitat
Snake River Basin Steelhead	9/02/2005 70 FR 52630	<p>Critical habitat is designated in the following states and counties:</p> <p>(i) ID—Adams, Blaine, Clearwater, Custer, Idaho, Latah, Lemhi, Lewis, Nez Perce, and Valley.</p> <p>(ii) OR—Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, and Wasco.</p> <p>(iii) WA—Asotin, Benton, Clark, Columbia, Cowlitz, Franklin, Garfield, Klickitat, Pacific, Skamania, Walla Walla, Wahkiakum, and Whitman.</p> <p>Detailed, textual descriptions of critical habitat for this ESU has been described in paragraphs (i) through (t) of the listing document: (https://www.westcoast.fisheries.noaa.gov/publications/frrn/2005/70fr52731.pdf).</p>	<p>Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems.</p> <p>Both hydropower and land use activities have had impacts on habitat in the mainstem Snake River above Lower Granite Dam. A total of 12 dams have blocked and inundated habitat, impaired fish passage, altered flow and thermal regimes, and disrupted geomorphological processes in the mainstem Snake River. These impacts have affected juvenile and adult salmon through loss of historical habitat, altered migration timing, elevated dissolved gas levels, juvenile fish stranding and entrapment, and increased susceptibility to predation. In addition, agriculture, grazing, resource extraction, and development have adversely affected water quality and diminished habitat quality throughout this designation. The most widespread ecological concerns continue to be the lack of habitat quality and diversity, degraded riparian conditions, low summer flows, and poor water quality (i.e., increased water temperatures in late summer/fall) (NMFS 2016a).</p>

2.2.3 Climate Change

One factor affecting the rangewide status of ESA-listed salmon and steelhead, and aquatic habitat at large is climate change. Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the Pacific Northwest (Battin et al. 2007; ISAB 2007; Isaak et al. 2012). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs. Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected. Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2009). Those changes will shrink the extent of the snowmelt-dominated habitat available to salmon and may restrict our ability to conserve diverse salmon life histories.

In the Pacific Northwest, most models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Average temperatures in the Pacific Northwest are predicted to increase from 0.1 to 0.6°C per decade (Mote and Salathé 2009). Warmer air temperatures will lead to more precipitation falling as rain rather than snow. As the snow pack diminishes, seasonal hydrology will shift to more frequent and severe early large storms, changing stream flow timing and increasing peak river flows while lowering summer and fall base flows, which may limit salmon survival (Mantua et al. 2010). Also, as length of growing seasons increase, consumptive use of water will likely increase on currently irrigated land, reducing flow in anadromous salmonid spawning, rearing, and migration habitat (Walters et al. 2013).

Higher water temperatures and lower rearing and migration flows are all likely to increase salmon and steelhead mortality. The Independent Scientific Advisory Board (2007) noted that higher ambient air temperatures will likely cause water temperatures to rise. Salmon and steelhead require cold water for spawning, incubation, rearing, and migration. As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in rivers with intact flows or in the confluence of colder tributaries or other areas of cold water refugia (Mantua et al. 2010).

Climate change is expected to make recovery targets for salmon populations more difficult to achieve (Zabel et al. 2006). Climate change is expected to alter critical habitat by generally increasing temperature and peak flows and decreasing base flows. Although changes will not be spatially homogenous, effects of climate change are expected to decrease the capacity of critical habitat to support successful spawning, rearing, and migration (Zabel et al. 2006). Habitat action can address the adverse impacts of climate change on salmon. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia

and areas to naturally store excess floodwaters, protecting and restoring riparian vegetation and base flows to ameliorate stream temperature increases, and purchasing or applying easements to water and lands that provide important cold water or refuge habitat (Battin et al. 2007; ISAB 2007).

2.3 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The construction and operation of federal hydropower, navigation, flood control, and water storage systems adversely affects the action area. Hydroelectric dams and their reservoirs have inundated mainstem spawning habitat and altered rearing and migration corridor habitat and the seasonal flow regime of the Snake and Columbia Rivers, decreasing spring and summer flows, increasing fall and winter flow, and altering seasonal thermal patterns (Coutant 1999; COE 1999; NMFS 2008b, 2019). Storage dams and depleted flows from agricultural areas in the upper Columbia, Yakima, and upper Snake Rivers and other locations continue to reduce spring and summer flows through Columbia River System (CRS) dams and reservoirs. Hydrographs from gages below Hells Canyon Dam and from the upper Snake River show recent declines in SR flows are at steeper rates than those of the Salmon and Clearwater Rivers, and are further reducing spring and summer flows through CRS reservoirs. Slower flowing and warmer water spread across wide flats and shallow coves in some reservoirs provides prime conditions for the active invasion and establishment of nonnative riparian and aquatic vegetation. Regulated flows and power operations from upriver dams (including Hells Canyon dams on the upper Snake River) and local CRS dams cause daily and seasonally fluctuating flow and stage levels, which can disturb reservoir shorelines. Waves from wind across reservoirs and wakes from barge traffic also contribute to reduced native riparian vegetation, increased bank erosion and instability, and sedimentation, which promote continued invasions of nonnative weeds.

Survival of juvenile salmon and steelhead migrating through the mainstem CRS dams and reservoirs is affected by these alterations (NMFS 2008b, 2019). Operational modifications, structural improvements (especially surface passage routes and improvements to juvenile bypass systems), mitigation programs (tributary habitat, estuary habitat, and predator management), inseason river management, and research have been implemented throughout the Columbia Basin to improve survival and function of habitat. Operational and structural improvements at the mainstem CRS dams have improved juvenile survival in recent years (NMFS 2019). It has been hypothesized that increasing flow and spill above present levels could substantially increase smolt-to-adult return rates and overall abundance of interior populations (McCann et al. 2016). Mitigating the reduced survival and abundance of wild salmon and steelhead with hatchery fish improved the abundance of some populations, but can increase competition for limited prey, and increased predation (Muir and Coley 1996; Sanderson et al. 2009). The altered habitats among serial reservoirs slow smolt migration rates and create more favorable habitat conditions for invasive, nonnative species like American shad and sunfishes (which may compete with juvenile

salmonids or provide alternative prey for their predators) and predators species, including channel catfish, walleye, largemouth and smallmouth bass (NRC 1996; ISG 1998; Zimmerman 1999; Sanderson et al. 2009), which may particularly limit survival of smaller and later migrating wild salmon and steelhead (Kuehne et al. 2012).

Navigation, flood control, transportation, agriculture, urban, recreation and other developments have armored many miles of mainstem banks and shorelines with riprap. The COE's Mill Creek flood control project was found to jeopardize listed steelhead and adversely modify their critical habitat (NMFS 2011d) from activities including the diversion of water for irrigation and removal of riparian vegetation. Preventing vegetative shade along streambanks, canals, and drains contributes to critically warm water temperatures; however, the reasonable and prudent alternative addressing these activities has not been implemented. A study of the available salmonid rearing habitat in Lower Granite Reservoir by Tiffan and Hatten (2012) estimated that 44 percent of the shoreline of the reservoir has been armored with riprap. Large woody debris from upstream areas is removed to protect dams and other developments, sediment deposits are dredged for navigation, riparian zones are narrow and dominated by nonnative species like Russian olive, and shallow water habitats are now simplified in function and limited (COE 1999). Some shorelines are leveed to reduce flooding of urban and industrial development. Levees are cleared of native and nonnative trees and woody shrubs that would otherwise shade water and provide habitat for salmonids and their prey. Canals and drains fragment floodplain habitats throughout the District. Aquatic and riparian vegetation is typically killed along their entire length with broadcast herbicides. These annual activities prevent vegetative shading of water which elevates temperatures and contaminates miles of confined habitats that drain into rivers and streams. Hesser et al. (1973) estimated that there were 21 miles of drainage ditches for the Tri-City Levees that were routinely treated with broadcast herbicides and discharged directly into the Columbia River within Lake Wallula (McNary Pool). In the Casey Pond reports (Easterbrook 1995, 1997, 1998), juvenile subyearling and yearling salmon were found rearing during spring (March to late June) in floodplain habitats, including drains, canals, and ponds along Lake Wallula. Nonnative fish predation on juvenile salmon is intense within the Lake Wallula canals and sloughs (Easterbrook 1995, 1997, 1998). Nearly two-thirds of juvenile fall Chinook salmon released from the Hanford Reach fail to survive to McNary Dam (Harnish et al. 2014; McMichael and James 2017). The Lewiston Levees along the Clearwater and Snake Rivers near the head of Lower Granite Reservoir include several miles of shoreline without trees or vegetation, contributing to warm water temperatures, invasive fish predators, and the critically low survival of juvenile Snake River fall Chinook salmon (Erhardt et al. 2018). Bennett et al. 1983 recommended increasing salmonid production throughout the lower Snake River reservoirs by increasing vegetation and shallow water habitats. Throughout the District terrestrial, riparian, and aquatic vegetation is managed to simplify and increase drainage. Reduced shading of water, shorelines, riverbanks, floodplains, and riparian areas increases water temperatures, promotes invasive plants (Hesser and Gangstad 1978) and warmwater piscivores, and reduces salmonid food production and survival.

Formerly complex habitats in the mainstem and lower tributaries of the Snake and Columbia Rivers have been simplified, for the most part, to single channels with disconnected floodplains. Consequently, the potential for normal riparian processes (e.g., litter fall, bank and channel complexity, large wood recruitment, and forage production) to occur is diminished (Ward and

Stanford 1995). Altered ecosystems have formed in some reservoir areas around the production and cover of extensive beds of aquatic plants. New and poorly understood food webs that have developed in run-of-the-river reservoirs in recent decades may not support the energetic needs of rearing and migrating salmon and steelhead or other native organisms (Naiman et al. 2012). Future changes in food webs associated with serial reservoirs can be expected as altered habitats age and non-native species competitors and predators that can affect several trophic levels (Stein and Magnuson 1976; Strayer 2009) become further established. These changes may have unanticipated effects on the nutritional condition and fitness of rearing and migrating juvenile salmon (Kareiva et al. 2000).

Terrestrial and riparian habitats, water and sediment quality are also impaired by a number of contaminants in the action area. Extensive agriculture along the Columbia and Snake Rivers contaminates runoff and groundwater seepage. Urban and industrial runoff occurs along the McNary pool of the Columbia River and in Lower Granite pool near the Snake and Clearwater River confluence. Numerous contaminants mostly from agricultural, urban, and industrial uses impair water and sediment quality of the Snake and Columbia Rivers (EPA 2002a; Gilliom et al. 2006; WDOE 2010; Naiman et al. 2012). A number of studies found that organochlorine pesticides that were discontinued 15 to 30 years ago still exceeded benchmarks for human health, aquatic life, and fish-eating wildlife in bed-sediment or fish tissue samples from the lower Columbia River (Johnson and Norton 2005; Hinck et al. 2006; Alvarez et al. 2014). Significant contaminants in Columbia and Snake River water and sediments include mercury, chlorinated pesticides (DDT, DDE), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers, polychlorinated dibenzo-p-dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), and many others (Hinck et al. 2006; Seiders et al. 2007; Alvarez et al. 2014; Counihan et al. 2014). These contaminants were found in wild and hatchery salmon juveniles, in flesh, stomachs, and prey from the Columbia River estuary, likely from dietary uptake during freshwater rearing and migration (Johnson et al. 2006; Yanagida et al. 2012). Arkoosh et al. (2011) tracked ESA-listed salmon from upriver areas to the Columbia River estuary and found high proportions (42 percent to 94 percent) of fish were exposed in the lower Snake and middle Columbia Rivers to PAH levels that could potentially cause adverse effects. Nilsen et al. (2015) sampled lamprey at locations in the lower and middle Columbia River and found potentially harmful levels of PAHs in most samples. There is high-incidence of genetic markers for sex reversal in wild Chinook salmon from the middle Columbia River (Nagler et al. 2001). Flesh of resident fish in the District is contaminated with 4,4'-DDE, 4,4'-DDD, hexachlorobenzene, dieldrin, toxaphene, T-PCB, dioxin/furans, mercury, and others (Seiders et al. 2011; Nilsen et al. 2014).

Herbicides contribute to degraded water and sediment quality in the baseline and are additional stressors to fish and their prey. Herbicides are the most frequently detected group among pesticides found at monitoring sites throughout Washington in the [Washington Department of Ecology Environmental Information Management database](http://www.ecy.wa.gov/eim/) {http://www.ecy.wa.gov/eim/}. One of the most frequently detected herbicides is 2,4-D (Burke et al. 2006), which is included in the proposed action, is toxic to native plants, and has a dozen or more environmental metabolites that are often not monitored. Maximum and median concentrations of 2,4-D are typically lower than 6 micrograms per liter ($\mu\text{g/L}$) and 0.1 $\mu\text{g/L}$, respectively (Sargeant et al. 2010, 2011, 2013a, 2013b; Tuttle 2014). Dozens of other herbicides are also commonly detected in water samples, including diuron, dicamba, bromacil, terbacil, dichlobenil, metolachlor, and triclopyr acid.

Maximum and median pesticide concentrations are typically lower than 5 µg/L and 0.3 µg/L, respectively. The Washington State Department of Agriculture (WSDA) has not monitored for imazapyr or sodium carbonate peroxyhydrate in its program, but will add imazapyr to the analysis in 2014 (Tuttle 2014).

The Walla Walla District maintains a sediment quality GIS database that contains information for the Snake River from Ice Harbor Dam upstream to Clarkston, Washington. The database was used to determine levels of various contaminants in sediments in the Snake River. Herbicides included in the testing were 2,4-D, dicamba, glyphosate, and picloram, but not their metabolites. Glyphosate was the only one detected at several sites with concentrations up to 68.9 µg/kg (at Snake RM 78). In the terrestrial vegetation control program on their lands, the COE (2012a) estimated herbicides were applied each season to approximately 750 acres in the Columbia River area, 16,500 acres in the Snake River area, and 1,700 acres in the Mill Creek area. Glyphosate (Roundup) and several other terrestrial herbicides were used 15 feet from water and aquatic formulations of glyphosate and 2,4-D were used within 15 feet of water (COE 2012a). Several herbicides include metabolites that are more persistent than parent compounds, however, these compounds were not investigated or reported in older surveys.

Presence of Species and Critical Habitat. Although much is known about the timing and survival of smolt migrations through the action area, less is known about feeding, movement patterns, and the relative importance of habitat components to rearing salmonids in the lower Snake and Columbia Rivers (Naiman et al. 2012; Barrows et al. 2015).

The ecological interactions between salmonids and aquatic, riparian, and terrestrial vegetation are often overlooked. Differences between native and nonnative vegetation and salmonid growth and survival are less well known. Invasive nonnative plants are most commonly proliferated in altered habitats, including: warmer soils/waters, lower elevation, lower gradient, ponded with lower current velocity, not shaded by trees, and exposed bare soil (Hesser and Gangstad 1978). The removal of vegetation increases erosion, bare soil, and algae.

Yearling salmonids are present throughout peripheral and floodplain habitats from late winter to late spring in cold water. Yearling and older migrating and rearing fish typically frequent deeper nearshore and pelagic habitat. Most older juveniles do not rear for extended periods in the District during summer, but rather migrate through using main channels and their peripheries during spring. Smolts must continue feeding and growth throughout migrations that may require 14 to 120 days in the action area. Migrations extend into summer for younger and smaller juveniles. Some life history types use the action area for year-round rearing.

Subyearling salmonids slowly move and feed downstream, growing up to 1 millimeter per day gaining energy reserves, size/length to reduce predation and increase swimming efficiency and speed. Parr growth is a major influential factor for predicting subyearling survival in the action area (Rondorf et al 1990; Connor and Burge 2003; Tiffan et al. 2010; Tiffan et al. 2014; Connor et al. 2015). Small reductions or delays in growth of body-length can reduce survival during remaining life in freshwater and early ocean-rearing. By late spring, older subyearlings migrate and rear with more of a pelagic pattern with access to deep water, aquatic vegetation food sources, and near-surface feeding currents being important.

Slower velocities (<35 centimeters per second), low lateral slopes, and medium-sized cobble substrates were associated with subyearling fall Chinook presence in the Columbia River (Tiffan et al. 2006). In the lower Snake River, Curet (1993) found subyearling Chinook salmon in relatively shallow, gently sloping shores, side channels, and gravel bars with smaller cobble and sand substrates that were relatively clean or sparsely vegetated. Tiffan et al. 2006 found that subyearlings frequented shorelines without cover or where submerged terrestrial grasses and annual forbs were commonly the only cover available due to water level fluctuations in the middle Columbia River. Subyearling salmon are well-documented to use shallow water habitat, overhanging riparian vegetation, and sparse or scattered emergent plants or flooded terrestrial plants throughout the spring season (Bennett et al. 1983, 1995 in Gottfried et al 2011; Arthaud 1992; Tiffan et al. 2006). Studies beach-seined thousands of subyearling fall Chinook salmon from shorelines in less than 3 feet of water throughout river and reservoir shorelines from late March to early July (Tiffan et al. 2014; Erhardt et al. 2018).

Throughout the action area, riparian habitats are narrow, simplified, and poorly functioning. Most floodplain habitats are inundated by reservoirs, blocked, or drained and developed for agriculture, leaving steep and poorly vegetated shorelines. Developed shorelines, docks, and large boulder or riprapped habitats have reduced value for rearing juvenile salmonids (Li et al. 1984; Curet 1993; Garland et al. 2002; Kemp et al. 2005; Tiffan et al. 2006; Jorgensen et al. 2013; Erhardt et al. 2018) and their preferred forage. Steeper banks, riprap, and other developments are also likely to disproportionately support invasive predatory fishes (Munther 1970; Tabor et al. 1993; Erhardt et al. 2018). Riprap without vegetation supports invasive predatory fish but very few salmonids; however, vegetated riprap includes increased use by juvenile salmonids (Garland et al. 2002), although densities remain lower than those of undeveloped shorelines of lesser slope (Tiffan et al. 2016; Erhardt et al. 2018). Submerged vegetation produces large quantities of invertebrates that disperse into open pelagic areas and are fed upon by rearing and migrating salmonids (Rondorf et al. 1990; Bennett et al. 1995). Bennett et al. (1983) found subyearling Chinook salmon were positively correlated with macrophyte abundance, as were smallmouth bass and northern pikeminnow.

By mid-late May in warm years and by early July in cool years, water temperatures increase in nearshore areas and most juvenile salmonids may move away from shallowest shorelines and begin dispersing offshore (Curet 1993; Fresh 2000; Connor et al. 2015). In large rivers and reservoirs during summer, rearing juveniles may be difficult to observe because they are spread out over large areas in deeper water habitats (Tabor et al. 2006). However, throughout summer and fall, subyearlings often remain surface-oriented in their feeding (Tiffan et al. 2010). Migrating smolts (including many subyearlings) in the lower Snake River mostly use deeper, faster-flowing, mid-channel or peripheries (Chapman 2007; Rondorf et al. 2010; Connor et al. 2015) but commonly swim near the surface, particularly steelhead, and probably feed and rest near the surface during morning and evening each day (Li et al. 2018).

Juvenile salmonids appear to be opportunistic, feeding extensively on prey such as chironomid pupae and adults, oligochaetes, other localized hatches and stream drift, amphipods and cladocerans throughout larger rivers and lakes, and may also eat fish (Muir and Coley 1996; Koehler et al. 2006; Tabor et al. 2006). Muir and Coley (1996) found that smolts continue to

feed and grow during migration through the action area. Feeding and growth rates were lower in the relatively simple channel and narrow canyon of the lower Snake River and higher in the wider, shallower, and more heavily vegetated Columbia River. Subyearling Chinook salmon diets in the Columbia River included predominantly caddisflies in riverine nursery habitats and mostly *Daphnia* and terrestrial insects in reservoir habitats (Rondorf et al. 1990; Muir and Coley 1996; Tiffan et al. 2014). Terrestrial insects comprised about 40–60 percent of subyearling fall Chinook diets in riverine habitats and about 10–30 percent in reservoir habitats (Tiffan et al. 2014). Muir and Coley (1996) found that large terrestrial insects (Hymenoptera; bees, wasps, ants) comprised a major portion of yearling Chinook smolts in the lower Snake River during spring and summer. Zooplankton and larger invertebrates which depend on aquatic vegetation in offshore reservoir habitats may be particularly important forage for juvenile sockeye salmon.

Tributary mouths and lake shores near natal tributaries are important nursery areas for salmonids. The action area includes a number of natal tributaries, such as the Clearwater, Yakima, Tucannon, Walla Walla, and other smaller streams. Throughout the year, pulses of fry, parr, and migrating smolts feed, rest, and move through lower sections of tributaries, their mouths, and nearby lake shores. Steelhead juveniles rear and migrate and adults migrate to and from headwater spawning areas through the Mill Creek project area and its relatively small streams. In the Mill Creek portion of the action area juvenile steelhead may be present throughout small stream habitats and depend on riparian and instream vegetation for cover and prey production year-round.

Adult salmon and steelhead migrate upstream through main channels in relatively deep water, typically along slower velocity peripheries that may include aquatic and riparian vegetation. Adults may use aquatic vegetation for cover or current breaks and for thermal and water quality benefits when migrating or holding in refugia. Reduced numbers of native trees in riparian habitats and reservoir shorelines increase solar radiation to surface waters, contributing to warmer temperatures, which can be particularly adverse for adult migrations of SR sockeye, summer-season runs of fall-spawning sockeye, spring/summer Chinook, and fall Chinook salmon. Adults migrate in and out of tributaries for spawning, often staging near tributary mouths for extended periods, and may seek thermal refugia and hold in these locations during summer and fall. Fall Chinook salmon may spawn in parts of the action area, including below dams, along certain main channel shorelines, and flowing side channels (Dauble et al. 1999; Dauble and Geist 2000). Salmonid redds are often placed in locations that relate to geomorphic features and hyporheic flow (Witzel and MacCrimmon 1983; Geist and Dauble 1998) that can be affected by aquatic and riparian vegetation.

2.4 Effects of the Action

Under the ESA, “effects of the action” means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.4.1 Effects on Listed Species

This section describes and evaluates the effects of proposed manual, mechanical, and chemical vegetation control activities in and along the lower Snake and middle Columbia Rivers and Mill Creek on the survival and fitness of individual fish. We evaluate consequences of these individual effects on the viability of affected populations and then to potential effects and risks at the ESU/DPS scale. Analysis includes three primary components: exposure, response, and risk characterization, each with its own variability and relationship to other stressors. The seven ESUs/DPSs analyzed in this Opinion are all closely related migratory anadromous salmonids that occupy many of the same geographic areas and share similar life history characteristics and PBFs (Tables 6 and 7). They also exhibit similar physiological and behavioral responses to disturbance, contaminants, and other stressors.

2.4.1.1 Manual, Mechanical, and Biological Control Methods

Effects to salmonids caused by manual or mechanical riparian and aquatic weed control could occur in two main ways: direct death or injury; or indirect effects such as temporary reductions in DO from dying plants, displacement from cover by disturbance, turbidity, or loss of vegetation that temporarily increases predation.

Direct effects. Chopping machines are for aquatic use, such as maintaining access to boat ramps and marinas by cutting near-surface growth of submerged aquatic weeds and clearing boat lanes. The season of use is restricted to mid-summer (July 1 to September 15) when near-surface water temperatures may be too warm for salmonids to remain for extended periods. Fewer smolts are migrating than during spring season, most subyearlings will be several months old, and are not likely to be rearing extensively in dense weeds or the shallowest water. The maximum area that may be chopped in any treatment area per day is limited to 5 acres, and will mostly occur in McNary pool. Only the top few feet of aquatic plants will be cut to enable boat and motor clearance, yet not disturb or contact substrates. Situations where chopping may be used typically include relatively dense beds of Eurasian watermilfoil, parrotfeather, and curly-leaf pondweed in deeper water locations that are already developed or frequented by boat traffic. Although exposure of fish will likely be very limited in the locations and during the times of this activity, over the 10-year program a small number of juvenile fish are likely to be injured or killed by the mechanical choppers. Chopping may injure or kill fish that are present in the vegetation by cutting, crushing, or entangling them. However, the number of fish actually injured or killed will likely be small because few salmon and steelhead will be present in and along the weed beds during the time of the activity, and because salmonids are visually-oriented and fast swimmers, and by summer most individuals are large enough to readily detect disturbances and move away from potential danger.

Substrate screens or fabrics may be anchored on areas of substrate to block sunlight and reduce root growth of submerged invasive plants. Fish present during deployment will readily detect disturbances and move away from the area being covered temporarily. Salmonid prey and plants will be reduced by substrate screens, potentially for several months. Juvenile fish will have less cover and prey in the treatment area, but prey will be available in surrounding habitats. The

limited habitat area (up to 1-acre) to be covered is not likely to adversely alter fish movements or reduce growth.

Mowing and burning will only occur in riparian areas, such as along streambanks and shorelines (including reservoir drawdown zones), but may include marshy areas, wetlands, and small streams and drainages. There will be only limited potential to contact fish in water with moving blades or heat because activities will occur on banks above water, on lands exposed by lower water levels, or in marshy areas of very shallow water unlikely to be inhabited by salmonids.

Disturbances from manual and mechanical control methods will be temporary and of limited area so that fish will only be displaced temporarily to immediately adjacent undisturbed habitat. However, fish displaced from their habitat will be more vulnerable to predation (Mesa 1994; Sanderson et al. 2009; Kuehne et al. 2012) and this will likely result in the death of some juvenile anadromous fish over the 10-year program.

Indirect effects. Discing monocultures of invasive plants in some riparian areas could cause erosion and sediment runoff into streams or floodplain habitats. Raking, cutting, hand pulling, digging, or hoeing of aquatic vegetation with hand tools and non-mechanized implements will re-suspend some sediment, as will the installation and removal of substrate screens. Chopping will suspend epiphytic particles and organic matter which, in turn, may increase turbidity. These perturbations will be temporary and small in scale, and areas larger than 1-acre are expected to be replanted with native plants if vegetation is not naturally reestablished.

Salmonid survival depends on many factors, including food availability, predator avoidance, and immune system health and reproduction. Stressful conditions are known to reduce the adaptive responses of salmonids to natural environmental fluctuations and increase their susceptibility to disease (Birtwell 1999). Information in the scientific literature regarding effects of turbidity and suspended fine sediments on fish shows a variety of results ranging from benefits of reduced predation (Gregory and Levings 1998) to reduced visual ability to feed or avoid predation (Hansen et al. 2013), temporary displacement, various sublethal physiological effects, or even death depending on the amount or concentration of sediment (Bisson and Bilby 1982; Berg and Northcote 1985; Servizi and Martens 1992; Newcombe and Jensen 1996). Suspended sediments could cause harm to ESA-listed species resulting in a range of effects described in Rowe et al. (2003) and Muck (2010).

Increased turbidity levels associated with proposed activities could result in temporary displacement of fish from preferred habitat. Salmonids are sensitive to low-middle range turbidity increases, which will likely occur, and will readily move into non-affected areas (Bisson and Bilby 1982). Turbidity caused by the proposed action is not expected to reach levels that would result in physical injury or mortality to ESA-listed fish. The areas affected will be small and only low concentrations of suspended sediment are expected to be produced. These events will be of short duration.

Substrate screens are an effective non-chemical method for reducing aquatic plant growth (Hofstra and Clayton 2012; Laitala et al. 2012). These are expected to be used only in submerged aquatic habitat, such as in boat lanes and around docks and facilities. Substrate

screens physically cover small areas of substrate, blocking sunlight, and preventing plant growth. All plants (even non-target species) beneath the screens will likely be killed and regrowth curtailed until the screens degrade or are covered by sediment.

Substrate screens remove plants that shade water and substrates and may expose dark fabric surfaces to sunlight, but treatment area limits should prevent any significant increase in local or larger-scale warming. Screens could physically interfere with fish spawning, invertebrate production, or substrate use by rearing salmonids; however, sites where dense weedbeds flourish and where substrate screens would be used include fine-sediment, muck, and detritus substrates and would not be used for spawning. Side channels and areas near current that help maintain relatively clean substrates of gravel, mixed sand, and small cobbles with sparse weeds that could be used for spawning and will be used by rearing juveniles would not be covered with substrate screens.

The proposed biological control methods include insect species proposed for use on Eurasian watermilfoil and spotted knapweed. Biological controls include the release and establishment of nonnative invertebrate specialists that consume or otherwise weaken target plants in areas where at least portions of the target plants are emergent. The milfoil weevil, *E. lecontei*, may be used as a tool for treatment of Eurasian watermilfoil. The two leaf-beetles *G. californiensis* and *G. pusilla* may be used as tools for treatment of purple loosestrife in the action area. General concerns include switching hosts to native plants by adapting to feed on similar plants, hybridizing with or competing with other insects, and spreading from treatment areas (Simberloff and Stiling 1996). The proposed control species are highly-selective for target plants and are rarely found to switch to closely related hosts (Blossey et al. 1994; Solarz and Newman 1996; Solarz and Newman 2001). Adults may also transiently feed on nontarget plants under no-choice conditions (Kaufman and Landis (2000)). The presence of the species applied for biological control and their effects are not expected to appreciably alter cover and forage for juvenile salmonids. The biological controls thus are not expected to reduce growth of, or otherwise decrease survival of juvenile salmonids.

Manual, mechanical, and biological control treatments are not expected to reduce prey in large enough expanses or for long enough periods of time to reduce growth of juvenile salmonids. Mechanical disturbances will occur in localized (maximum 5 acres) nuisance situations during summer when few fish are present, but over the 10-year program only a small number of juvenile fish would likely be injured or killed by the mechanical choppers. Disturbances will be temporary, occur in dispersed locations of limited area, and cause limited turbidity. Some fish will be displaced from treatment areas to surrounding habitat and be more vulnerable to predation, which will indirectly result in the death of some juvenile fish over the 10-year program.

2.4.1.2 Chemical Control Methods

Effects to salmonids caused by chemical control of riparian and aquatic invasive plants could occur in four main ways: (1) Direct death or injury from toxicity; (2) reduced growth from toxicity to prey; (3) altered behavior or reduced fitness from sublethal toxicity; or (4) indirectly

by temporary reductions in dissolved oxygen from contaminated dying plants, or by displacement from cover from the loss of vegetation that temporarily increases predation.

In the proposed action, herbicides will be used to control 15 species of invasive plants (Table 1) mostly among well-distributed sites (i.e., parks, facilities, marinas) within large areas of aquatic and riparian habitat (Table 3, Appendix A). Proposed control methods for three of the invasive plant species include EDRR management objectives (Table 1) and will be targeted throughout COE lands and waters. If EDRR (or other) treatments are successful, invasive plants would decline and be outcompeted with resilient and higher-functioning native vegetation (Zimmerman et al. 2018). Herbicide use in local areas and overall is expected to decrease within 1–3 years and remain at low levels in fewer and smaller areas. If EDRR treatments are not effective, other herbicides in this proposed action will likely be tried, until within 2–3 years the IPM framework would lead to altering management objectives to maintenance and control. This proposed/anticipated shift in approach to the EDRR species such as flowering rush after the initial 2–3 years of the program is expected to reduce control intensity and thus reduce herbicide use for former EDRR species throughout the remainder of the 10-year-long action.

The proposed action includes limits on the amount, size, and intensity of treatments that will reduce adverse effects to rearing salmonids and their prey. Chemical methods will not be used to control submerged aquatic vegetation outside the July 1 to September 15 season. Most applications will be in nuisance situations, in AORs, or for the few EDRR targets (Table 1). Within a single AOR, daily treatments will not exceed 5 acres for submerged applications and will not exceed 2 acres for emergent and riparian habitat applications. Replacement or regrowth of proximate non-target vegetation is expected, and emergent and riparian habitat areas larger than 1-acre that do not regrow would be replanted with appropriate native plants.

The proposed action includes BMPs designed to further reduce exposure and accumulation of residue. Only one chemical application per year is allowed at any site, unless monitoring finds target plants were missed, then retreatment is allowed for specifically missed plants 3 weeks after initial herbicide application. In off-channel habitats, herbicide applications to contiguous areas will be rested 2 days after large applications. These BMPs will reduce transfer of herbicide between adjacent areas, reduce herbicide buildup in local areas, and typically allow active ingredients nearly a year to degrade before subsequent application in the same location.

2.4.1.2.1 Exposure and Fish Presence: In the proposed action, herbicide may contact water by direct application or by inadvertent overspray, runoff from plant and soil surfaces, spill, and aerial drift. Herbicide that binds to plants, detritus, and other organic material is released into water when contaminated plants fall into water, membranes of fermenting cells leak, and detritus degrades, breaking chemical bonds. Water currents may erode substrates and transport contaminated sediments for miles downstream, even to estuaries and the ocean. Likewise, local river currents may continually aggrade contaminated material into specific habitats and locations through sedimentation (tributary deltas, reservoir backwaters, shorelines, and floodplains). In soil, sediments, and water, various metals and changes in oxygen, pH, and temperature can alter herbicide binding properties, volatility, and degradation patterns and persistence. Metals especially serve as catalysts to chelate and bind herbicides or to elute them from their bound state. Herbicide bound to soil or organic particles is carried into other habitats by water and

wind erosion. Degradation products of glyphosate include one primary metabolite (aminomethyl phosphonic acid [AMPA]) while 2,4-D may include a dozen potential metabolites.

Fish may be exposed to herbicide in water by dermal contact, ingestion, and respiration. Salmonid prey may temporarily accumulate herbicide by direct contact, respiration in water, or ingestion of contaminated plants, plankton, and detritus, and may then be ingested by fish. Herbicide residues or degradants may persist at low concentrations for days and months in water and sediments, and for weeks on treated plants and dying vegetation (Table 8).

Table 8. Chemical and physical properties of chemicals proposed for use. Values are from Honeycutt (1994), except some soil and water half-lives are from the literature.

Common Name	Acid Dissociation Constant	Soil Adsorption Coefficient	Soil half-life (days)	Water half-life (days)
Diquat	11	10 ⁶	500	2–4 ^d
Fluridone	1.7	1000	21	7–30+
2,4-D	3	20	60 ^a	10–14 ^{ac}
Endothall	3.6	10	7	2–12
Imazapyr	1.8	10	90	3–5
Imazamox	nd	5–143 ^{ab}	nd	5–15
Triclopyr TEA	2.7	20	46	1–2
Glyphosate	2.3	10 ^d	40	3–14 ^c
Sodium carbonate peroxyhydrate	nd	nd	nd	0.4

(a) EPA 2005, 2013; (b) WDOE 2012; (c) Wang et al. 1994; (d) Parsons 2007; Robb et al. 2014.

Exposure of listed salmonids to submerged applications of herbicide in the proposed action area will only occur between July 1 and September 15. This timing of application avoids eggs, larval fish, and spawning adults, and therefore effects to these life stages from submerged applications is expected to be minimal. By early summer, most subyearlings and older juveniles tend to move away from warming shallows to rear in relatively deep and flowing water. For this reason, they will have limited risk of exposure, and potential toxicity effects to these fish will be reduced due to increased dilution effects in the deeper water.

During summer months, migrating older juveniles and adults likely use main channels and adjacent peripheral habitats and are expected to mostly remain in deeper water. Some older juvenile salmonids and adults may hold under overhanging riparian vegetation, undercut banks, and shoreline cover in close proximity to potential treatment areas, but are usually in water deeper than a foot or two, and will be exposed to low concentrations of herbicide. Some fish will likely detect presence of application disturbance and traces of herbicide in water (Folmer 1976) and move away from the surface and general vicinity of treatments, resulting in reduced exposure to lower concentrations of herbicide. Some subyearling fish may remain in very shallow water or hide in weeds being treated.

Other situations that prevent complete mixing of chemical concentrations during otherwise normal operations or in unique or sensitive habitats where use by fish may be more frequent were also considered. Lower reaches of tributaries and confluences may be too shallow and warm during summer for most fish to use extensively. Potential spawning areas and fish passageways at dams are excluded from treatments. Winds or currents could push surface waters

into shallow wetlands, backs of coves, and shorelines. Strong or gusty winds tend to increase overspray and aerial drift, very still or rising air conditions can increase aerial drift, and wet surfaces or saturated soils can increase herbicide runoff. During these conditions, increased amounts of herbicide could inadvertently enter water in confined areas, temporarily resist mixing, and therefore increase the duration of higher concentrations.

Submerged treatments will occur during hottest days of summer when low flows and warm water temperatures may already stress juvenile and adult salmonids. Exposure to an additional chemical stressor, even at low concentration for short durations, could have increased effects, including increased oxidative stress, reduced predator avoidance, feeding, and disease resistance (Mesa 1994; Congleton et al. 2000; Tort 2011; Schreck and Tort 2016; Picard et al. 2018). Predation pressure from invasive fish is likely intense in habitats that are proposed to be treated (Harnish et al. 2014; Erhardt et al. 2018). However, during summer months, surface water temperatures will be warm and after reaching 20°C, most fish will likely be pelagically oriented or along deeper shoreline contours (Tiffan and Connor 2012) where exposure is less likely and dissipation rates will be higher.

Throughout this effects analysis, increased risk or worst-case situations were considered. High risk situations include herbicide use in shallow and confined habitats with low water exchange. Examples typically include other stressors, such as when fish occupy thermal refugia in small springs and pools during summer low flows in small streams or side-channels. During spring rearing and migration, subyearling and yearling fish utilize peripheral shoreline along the Columbia, Snake, and Yakima Rivers and throughout floodplain habitats in accessible side-channels, sloughs, drains, canals, irrigation pump inlets, levee ditches, ponds, and the lower reaches and mouths of tributaries (Figure 2). Larger herbicide treatments in backwaters or sloughs may produce low DO levels from dying plants. During emergent treatments there is increased risk to fish from chemical applications in very shallow water during spring when very young and small fish are present and expected to hide in treated vegetation or remain in the application area. Risk of extended exposures from herbicide applications to riparian, emergent, and submerged vegetation could also occur in shallow, confined, peripheral habitats with limited water movement.

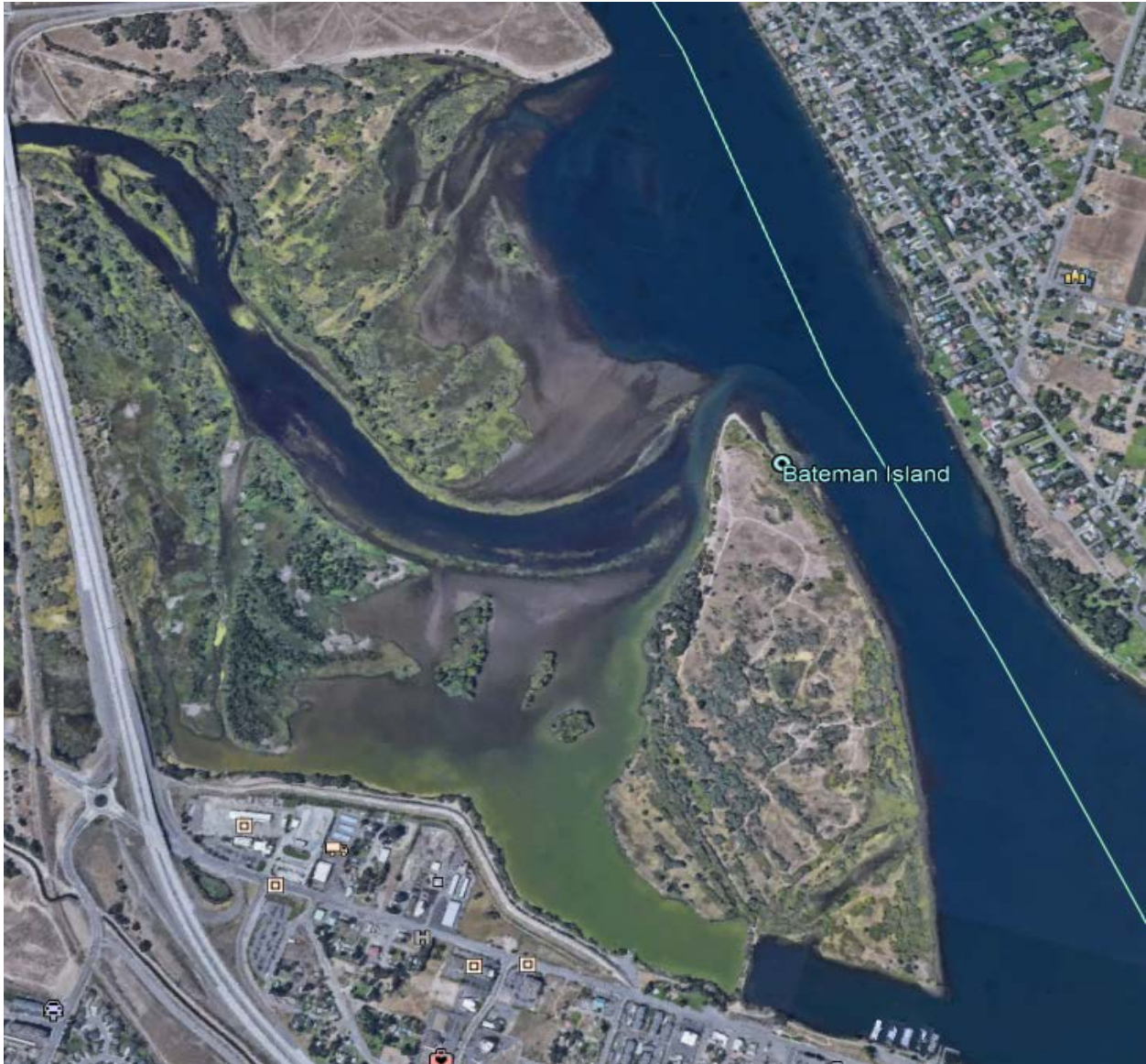


Figure 2. Google Earth photograph of the Yakima River confluence with the Columbia River. Several areas of reduced water exchange, complex currents, and confined habitats are visible. Note the ponded green algae and the narrow plume of its drainage around the northwest shoreline of Bateman Island, and back-eddies in the north delta and southeastern channel of Bateman Island.

Submerged applications of herbicide will extend along shoreline contours and will be limited to 5 acres treated per day within an AOR. There are several acres of flowering rush almost entirely within the McNary pool. Shallower habitats directly downstream of submerged treatment areas could have extended exposures of several hours to diluted concentration of herbicide. The total acreage of flowering rush is not known but most appears to be along 2 to 12 feet deep contours and extends along one or both banks through roughly 20 miles of shoreline in and downstream of the Yakima River delta and downstream to the mouth of the Walla Walla River (Figure 3). Treatment of this section could include applications to dozens of acres throughout weeks of summer. Areas that will be treated include canals, coves, side channels, ponds, and tributary

mouths that have slow or back-eddied water current. Deeper habitats along shoreline contours will mostly include strong current, wind, and waves that promote rapid dilution and dissipation.

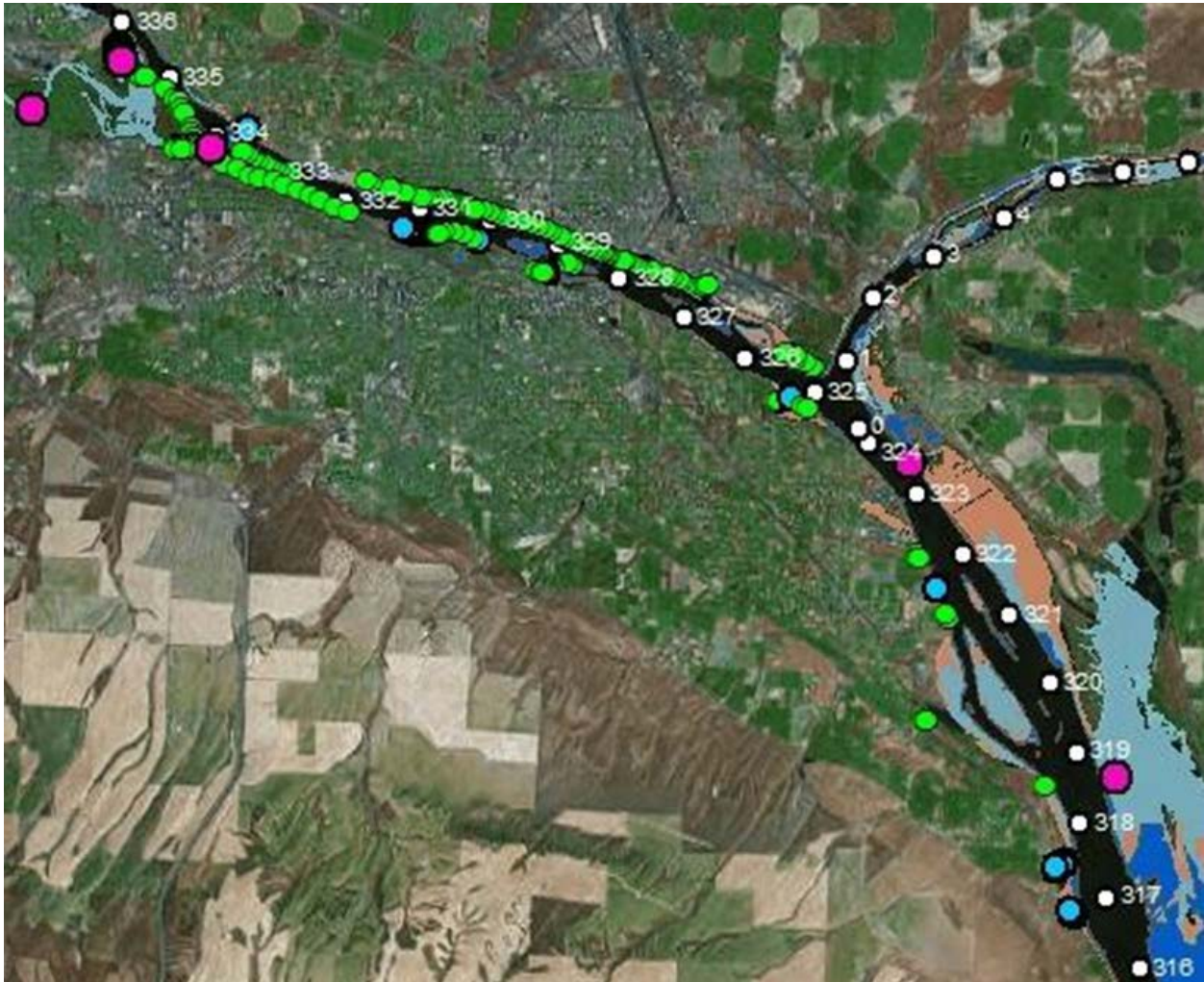


Figure 3. Google Earth photograph of the McNary pool, with the Yakima River confluence in the upper-left portion near RM 335. Flowering rush stands, represented by colored circles, are present in many peripheral, floodplain, side-channel, low-velocity, and confined habitat areas. Note flowering rush stands along the south and north shores of Bateman Island and around the northern back eddy in the Yakima Delta.

During the July 1 to September 15 window for submerged applications, there will be substantially fewer yearling and older migrating smolts present than during the primary migration period (April–June). Rearing and slowly migrating subyearling fish, mostly fall Chinook salmon, and some older juveniles will be present. Most rearing fish will be in deeper water than that being treated, however, each day some of these fish may feed at the surface, in relatively shallow water, and in areas close to emergent or submerged aquatic vegetation.

During spring seasons when floodplain and shoreline habitats contain cold water, both very young salmonids (fry and subyearling migrants) and older smolts (ages 1–3 years) frequent low-

velocity areas of near-shore shallow water, near riparian and aquatic vegetation in the lower Snake River (Bennett et al. 1983, 1995 in Gottfried et al. 2011; Arthaud 1992; Curet 1993; Tiffan and Connor 2012; Tiffan et al. 2014; Erhardt et al. 2018) and middle Columbia River (Dauble et al. 1989; Easterbrooks 1995, 1997, 1998; Tiffan et al. 2006). During April and May most 0-age fish captured along shorelines were wild-reared and less than 46 mm fork length (FL), and during June less than 70 mm FL (Dauble et al. 1989). Spring Chinook smolts actively migrated a few hours then rested and fed in near-shore and shallow areas of 1-foot or less depth each day. Easterbrooks (1995, 1997, 1998) found fall Chinook and steelhead subyearlings and spring Chinook yearlings in Casey and Burbank Sloughs and pump intake canals during March to June. In the lower Snake River, yearling Chinook and steelhead smolts frequented near-surface water in reservoirs and when approaching dams (Li et al. 2018). Subyearling Chinook salmon also frequented near-surface waters around sunrise and sunset, suggesting that fish may feed at the surface or in shallow water once or twice each day (Li et al. 2018).

During these spring periods and conditions, the risk of exposure is high if herbicide enters the water during applications to emergent or riparian vegetation. The proposed action would begin spot-spraying of riparian and emergent target plants on April 15 with chemicals other than diquat. Spot-spraying riparian and aquatic plants with diquat would begin on May 5 and could include broadcast applications of diquat from May 5 to June 1 requiring a check-in with and approval by NMFS and USFWS. Broadcast applications of all proposed herbicides for riparian and emergent plants can begin June 1. During June, fewer juvenile fish will be in the shallow water than in April and May; however, some fish, particularly subyearling fall Chinook salmon, will still be present in the areas where broadcast treatments of emergent plants are implemented. Up to 2 acres of these shallow habitats may be treated each day within each AOR.

2.4.1.2.2 Ecological Risk Assessments: The risk of adverse effects to listed salmonids and their habitat from the proposed herbicide applications were screened using established ecological risk assessment methodologies (ERA; EPA 1986, 2001, 2004; NMFS 2008a, 2011c). Risk hypotheses were tested by relating expected environmental concentrations with experimental findings on effects of the chemicals to fish and their invertebrate prey. Impacts to critical habitat were also considered, in part by investigating the toxicity thresholds of vascular and nonvascular plants.

This effects analysis relied heavily upon published LC_{50} s (i.e., concentrations that killed 50 percent of the organisms tested) and EC_{50} s (i.e., concentrations that affected 50 percent of the organisms tested) values of various durations. In general, toxicity studies are limited for many herbicides in aquatic environments. Other commonly reported toxicity endpoints such as LOECs (lowest observed effect concentrations) do not necessarily reflect hazardous concentrations and can have low statistical power. Even though LC_{50} s are useful measures of adverse effects, they must be interpreted carefully. LC_{50} s reflect effects at a single concentration, and do not relay information about the dose-response relationship over a range of exposure concentrations. LC_{50} values are species-specific and should be extrapolated to other species and other taxa with caution. Additionally, adverse biological effects that cause fitness-level consequences can certainly occur at exposure concentrations below reported LC_{50} values. For example, studies in ECOTOX reported EC_{50} concentrations for the herbicide diquat an order of magnitude lower than reported LC_{50} concentrations. These particular studies measured intoxication and

immobility as endpoints; fish and prey rendered immobile are not likely to survive in the environment.

Reported LC₅₀s and other estimated minimum thresholds, above which adverse toxicity effects were likely to occur, were based on reviews of published literature, NMFS biological opinions (NMFS 2011b, 2011c), and databases and studies collected by EPA's Office of Pesticide Programs, various state agencies, and others (i.e., ECOTOX, TOXNET, and National Pesticide Information Center). When few or no toxicity data exist for sublethal endpoints, the 1/20th of LOECs were considered. Standard safety factors of half the LC₅₀s for older juvenile ESA-listed salmonids (Sappington et al. 2001; Dwyer et al. 2005) and 1/10th of the LC₅₀s for young and developing life stages were considered in analyses. The importance of considering such lower values below measured LC₅₀s is well-demonstrated and expected to be reasonably conservative (EPA 1986, 2001, 2004). Further analyses include results of sublethal toxicity testing and additional information, when available, that add to information from standard acute lethality endpoints. Ecological effects consider environmental conditions, reduced growth and productivity of sensitive prey and primary producers. This process for reviewing several types of effects to several types of organisms (mammals, birds, fish, prey, and primary producers) from various types, durations, and conditions of exposure is required to understand the overall impacts of toxicants in the environment.

Sublethal effects from acute or repeated exposures may cause delayed or latent mortality and other adverse impacts in natural environments over longer terms. Young life stages that have undeveloped or developing immune systems, limited metabolic energy, high predation risk, and low mobility are much more sensitive in the environment than would appear from standardized mixed age and species LC₅₀s. Additional stressors, such as warm temperatures, poor water quality (including other pesticides and contaminants, reduced DO, changing pH, increased salinity), intense predation, lack of food, overexertion, and disease will effectively reduce lethal concentrations (Sloman and McNeil 2012; Gandar et al. 2017; Macneale et al. 2010; Baldwin et al. 2009). Multiple stressors weaken or prevent adaptive response by reducing and delaying endocrine response, antioxidant defense, and metabolic compensation (Congleton et al. 2000; Schreck and Tort 2016; Gandar et al. 2017).

Some uncertainties remain regarding chronic or latent effects on fish from herbicides. There are few published chronic toxicity data for herbicides and fish that can be used to assess ecological risk of herbicides in aquatic environments (Fairchild et al. 2009). Sublethal toxicological effects can harm fish or their forage in ways that are not readily apparent or well researched (Baldwin et al. 2009). Small changes in the health or performance of individual fish or their forage in laboratory studies are difficult to translate exactly to essential behaviors or fitness of fish in the wild. Where tests which result in sublethal effects have been conducted, they are typically reported for individual test animals under laboratory conditions. Test conditions often lack predators, competitors (Jones et al. 2011), certain pathogens, and numerous other hazards found in natural environments. This may create effects that differently affect the survival and reproductive potential of individual fish or their prey in natural conditions.

Herbicide end-use products (i.e., formulated products) have other inert ingredients besides the active ingredients. Different formulations may have different toxicities to aquatic organisms,

and specific toxicity information on formulated products may be limited (Trumbo and Waligora 2009). Often only limited information is available for specific formulations and their degradants (Abdelghani et al. 1997; Trumbo and Waligora 2009). However, with recent technological improvements, specific components and toxicities are being tested among more formulations (Defarge et al. 2018; Cuhra et al. 2013), field situations and conditions (Melendez et al. 1993), and metabolites (Matozzo et al. 2018).

Herbicide concentrations in water and sediment immediately after treatment are rarely measured in the field and are widely assumed and modeled to follow first-order decay rates. In the few instances when environmental concentrations have been measured, most herbicides were found to dissipate and degrade as expected (Figures 4 and 5; Xie et al. 2005; Patten 2003; ENTRIX 2003; USDA 2012). However, some dissipated more rapidly than expected (esters in NMFS 2011b) and others degraded slower than expected (Melendez et al. 1993; Parsons et al. 2007). Another common assumption is that after initial mixing, herbicide concentrations in water bodies will be below meaningful toxicity levels. Along shorelines, in small streams, and other confined or ponded waters, complete mixing does not readily occur and still-toxic herbicides may be transported past single narrow points (Figure 2), out of treatment areas (Parsons et al. 2007), or far downstream (Bowmer et al. 1986; Melendez et al. 1993). In some situations, herbicides that are expected to strongly bind to soil or organic particles remain dissolved in water or can be eluted and produce toxicity at later times (Birmingham and Colman 1983; Bowmer et al. 1986). Two common assumptions are that if no sublethal effects are found/reported then none exist, and that degradation products have similar toxicity/persistence to that of the active ingredient. The literature includes conflicting toxicity information (Emmett 2002; Cuhra et al. 2013), often because sublethal effects or metabolites were discovered and described when none were previously assumed. Often metabolites have different properties, toxicity, and longer persistence in the environment than parent ingredients (Battaglin et al. 2012; Silva 2018).

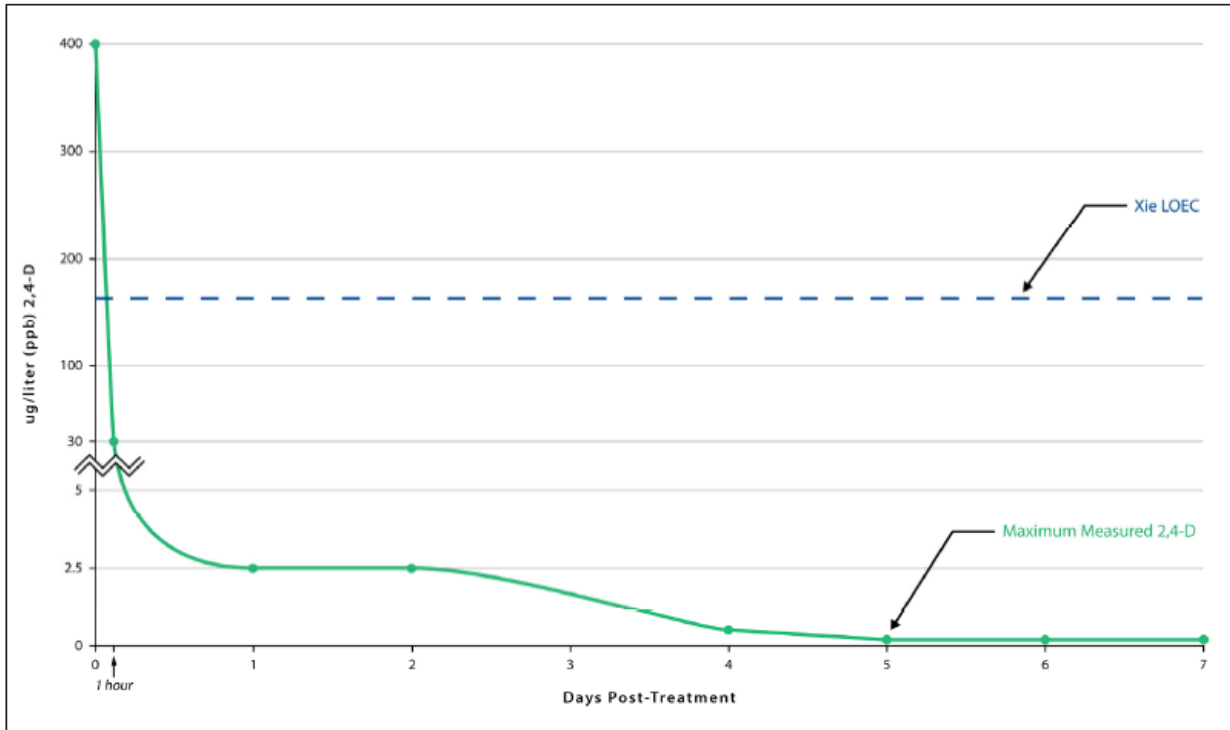


Figure 4. Comparison of measured 2,4-D levels post-treatment with LOEC for estrogenic activity from Xie et al. (2005) in USDA (2012).

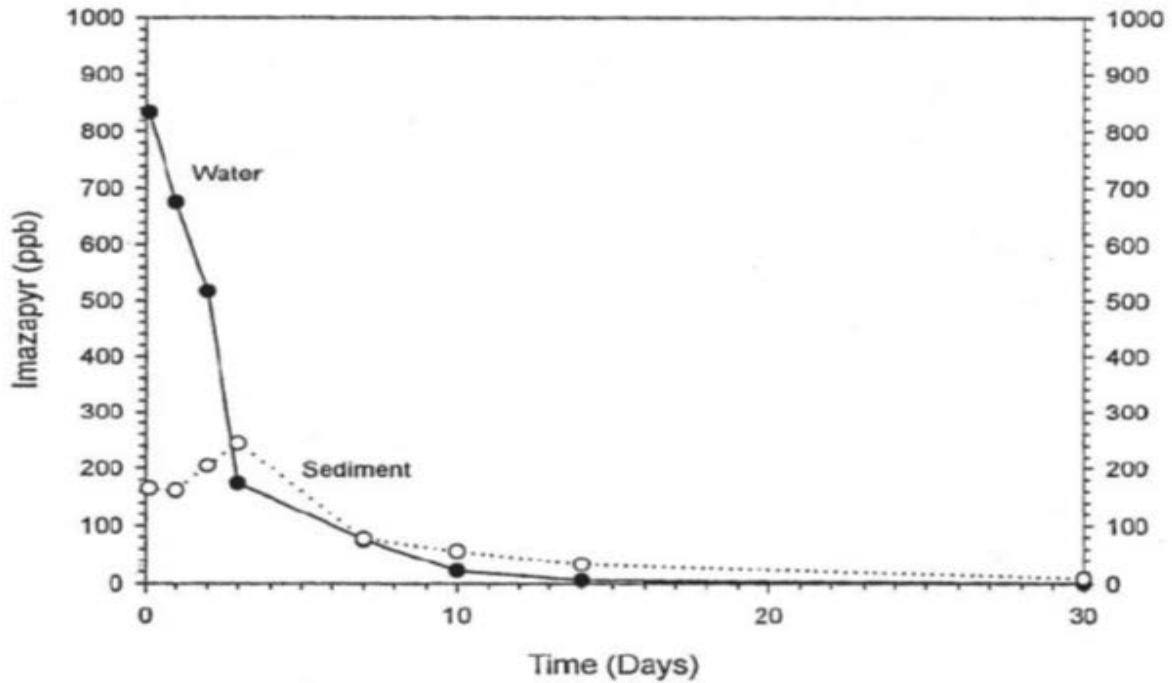


Figure 5. Residues of imazapyr measured in water and sediment from a Louisiana pond treated with 1.5 lb/acre (from Mangels and Ritter 2000, in ENTRIX 2003).

Other challenges are associated with mixtures of legacy and current-use pesticides present in water and sediments of the Snake and Columbia Rivers (Arkoosh et al. 2011; Nilsen et al. 2015). The Columbia River estuary, nearshore marine waters, and sediments also contain legacy and current-use pesticides (Johnson et al. 2006). The scientific literature includes data gaps for many individual chemicals, experimental design difficulties for large numbers of complex chemicals, poorly understood pathways for chemical interaction, potential differences in response among species, and the need for more sophisticated statistical tools for analyzing complex data and monitoring latent effects (Laetz et al. 2009). Although EPA, state agencies, and other organizations maintain substantial pesticide databases, studies for the subject species at every life stage and those of their preferred forage are yet lacking, and additional sublethal and chronic effects are being discovered for some herbicides (e.g., diquat and glyphosate).

Properties of herbicides proposed for use, detailed methods for application and expected concentrations, along with fish and forage exposure and response effects, are summarized in the following section.

2.4.1.2.3 Herbicides, Inert Ingredients, Adjuvants, and Spills: The proposed action includes the use of several herbicides with different active ingredients, different formulations, and different adjuvants that may be added to formulations just prior to application. Many of the following toxicity data are from studies of the active ingredient alone, however, most applications in the action area will be of commercial formulations along with adjuvants (e.g., surfactants, oils) combined just prior to use on target plants. There are several terrestrial and aquatic formulations available for each active ingredient and not all studies report specific formulations or every ingredient within a commercially purchased formulation. The most precise estimates of effects would be for specific formulations that will be used rather than only the active ingredient. However, the proposed action includes the potential use of several formulations of each active ingredient grouped only by the “approved for aquatic use” registration. Throughout the analysis we narrowed searches to aquatic data for active ingredients, with appropriate types of formulations included, depending on what is proposed for use in the APMP.

The following analysis of effects, Figures 7 to 15) compare herbicide-specific acute LC₅₀s and/or EC₅₀s values of aquatic organisms for various exposure durations with expected environmental concentrations resulting from the proposed application methods. Applications of each herbicide are analyzed for acute lethal, growth of fish from prey reduction, sublethal, and indirect effects.

During herbicide applications to submerged plants, herbicide solution is released from nozzles at much higher concentrations (unmixed) than target levels (mixed), because herbicide solutions will be diluted by receiving water as they spread over larger areas and are carried with water currents. Boat-booms supporting weighted hoses tipped with pressurized nozzles enable application of herbicide at appropriate depths to target plants. Initial dilution is expected to occur within seconds from pressurized nozzles. Target concentrations are expected within 45 minutes, and will further dissipate within a few hours (e.g., Figures 4 and 5), aided by water movements and increasing depth (e.g., Figure 6). Further degradation to very low levels is expected to occur within hours to days, often generally following a first-order degradation rate (Figures 4 and 5). Persistence differs among water, decaying plant material, and sediments. The

chemicals proposed for use on submerged vegetation are imazamox, fluridone, triclopyr TEA, endothall (dipotassium), diquat dibromide, 2,4-D (amine), and SCP. Maximum daily size of submerged applications will be 5 acres.

During herbicide applications to emergent and riparian plants, herbicide solutions are tank-mixed to achieve the target concentration when sprayed directly onto plant surfaces that are above or near water. Thus, out-of-nozzle, low and high target concentration for emergent plant applications are the same as the “after mixing” concentrations for submerged applications (red and black dots in the following figures). For emergent plant and riparian applications (both spot and broadcast) those red and black dots/vertical lines in the figures below represent the maximum applied concentration at water and soil surfaces, if spray is not intercepted by plants, or it runs off or drifts. Initial dilution at the water surface will reduce concentrations below respective high/low target rates within minutes to hours to much lower concentrations, aided by water movements and increasing depth. Further degradation to very low levels is expected to occur within hours and days, as contaminated plants fall into the water and decay. The chemicals proposed for use on emergent and riparian vegetation are imazamox, fluridone, triclopyr TEA, endothall (dipotassium), diquat dibromide, 2,4-D (amine), imazapyr, and glyphosate. Broadcast spraying will only be used on monocultures of target plants and maximum daily size of applications to emergent and riparian vegetation will be 2 acres.

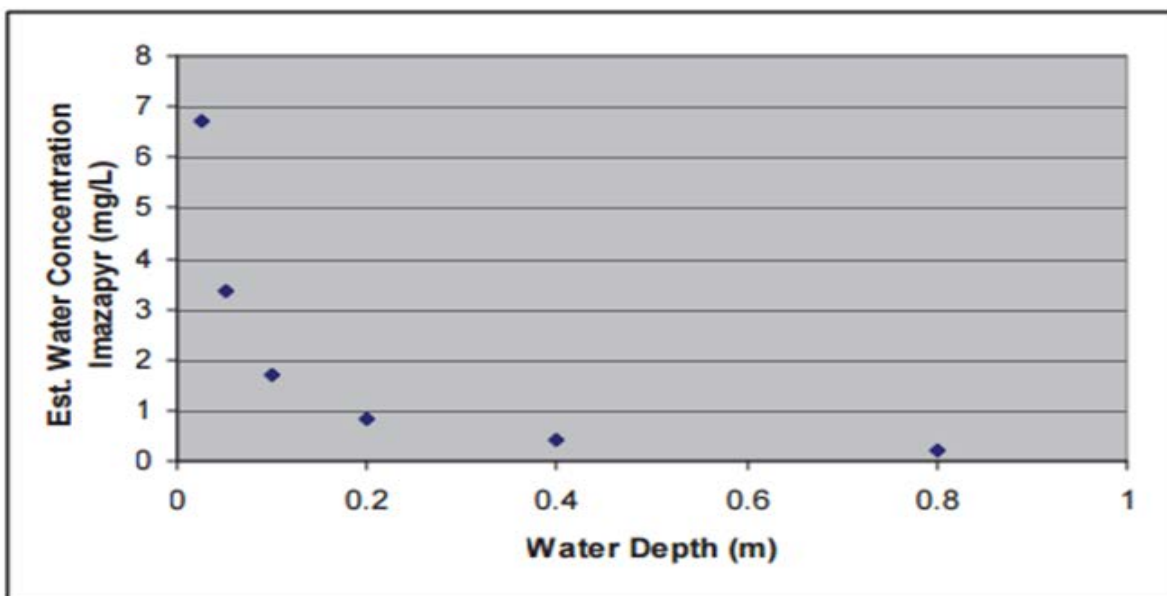


Figure 6. Estimated water concentrations of imazapyr with increasing depth after treatment with no canopy interception and an application rate of 1.5 lbs/acre (from ENTRIX 2003).

2,4-D

2,4-D is a systemic herbicide that can be used to selectively control submerged and emergent weeds and broadleaf plants (EPA 2005; SERA 2006; Gervais et al. 2008; WSDA 2010). Systemic herbicides travel within the plant to kill it completely. It is one of the oldest and most widely used herbicides in the world and is the third most commonly used herbicide in North

America. Its mode of action is to stimulate uncontrolled growth in the meristematic tissue (i.e., rapidly growing/dividing), which ultimately causes plant death. In a previous Biological Opinion NMFS (2011b) determined that ester formulations of 2,4-D may jeopardize listed salmonids or adversely modify their critical habitat, whereas other common formulations of 2,4-D (amines, salts, acids) had lower risks to Pacific salmonids and critical habitat. Only aquatic-approved amine formulations of 2,4-D will be used on submerged and emergent plants in this proposed action.

For emergent vegetation control, maximum concentrations of active ingredient at plant surfaces or at the water surface, will be 4 mg/L for high application rates and 2 mg/L for low application rates (Table 3, Figure 7). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations, before mixing with receiving water occurs, range from 76–457 mg/L for the high rate and from 38–229 mg/L for the low rate.

Environmental fate data show that 2,4-D is relatively short-lived in water (14 days, Wang et al. 1994) and soil (Table 8). 2,4-D has low potential for bioaccumulation or bioconcentration (EPA 2005, 2013). Animal metabolism studies demonstrate that the herbicide is rapidly eliminated through the kidneys with few known sublethal effects. Salmonids readily smell and avoid 2,4-D at trace concentrations (Tierney et al. 2010). Reduced olfaction was not observed in chronic exposure tests at concentrations below those causing other permanent damage or lethality (100 mg/L; Tierney et al. 2006). Folmar (1976), in Tierney et al. (2006), found that rainbow trout avoided 2,4-D concentrations of 1 and 10 mg/L but not 0.1 mg/L, suggesting that salmonids may also avoid 2,4-D in their natural aquatic habitats.

In most aquatic and terrestrial environments 2,4-D (amine) dissociates to form 2,4-D acid instantaneously. The dissipation of 2,4-D appears to be dependent on oxidative microbial-mediated mineralization, photodegradation in water, and leaching. The general half-life of 2,4-D in aerobic water and sediment is 4 to 21+ days. It typically persists about 2 days in surface water and about 2 months in the sediments (EPA 2005, 2013). Breakdown is slower in acidic or anaerobic environments (half-life of 41 to 333 days). Although these conditions are uncommon in alkaline waters of the action area, 2,4-D has been detected in streams and shallow groundwater at low concentrations in both rural and urban areas throughout the Columbia River basin.

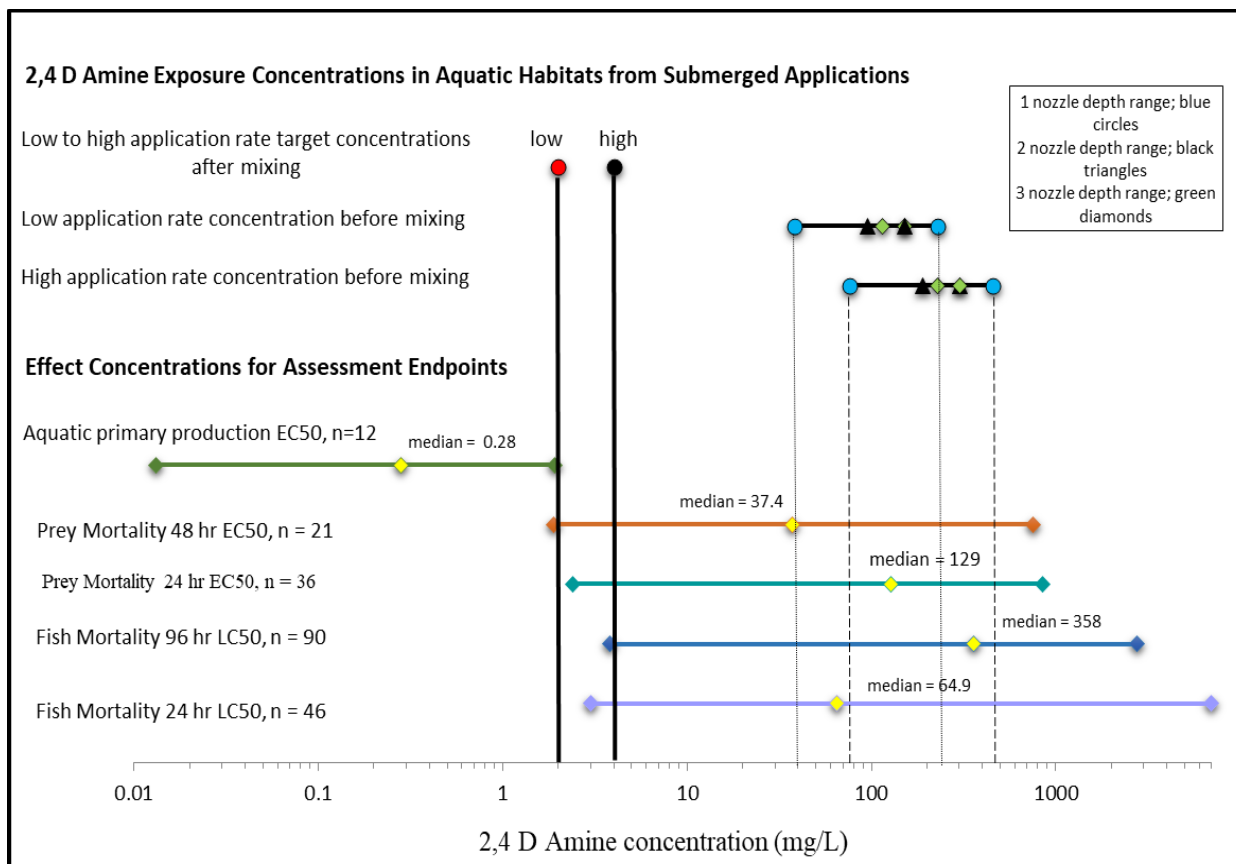


Figure 7. Exposure concentrations for 2,4-D (amine) in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum 2,4-D concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Submerged applications of 2,4-D at low and high application rate concentrations before mixing are well above fish mortality thresholds (Figure 7). At high application rates, unmixed concentrations are higher than the median 24-hour fish mortality concentration and include the median 96-hour LC₅₀. Submerged low application rates before mixing include the median 24-hour fish mortality concentration but are below the median 96-hour LC₅₀. Juvenile salmonids in the application area exposed within the first 45 minutes following application may die due to the unmixed concentrations of 2,4-D at low and high application rates.

After mixing, high target concentrations exceed 24-hour and 96-hour mortality thresholds, but the low target concentrations do not (Figure 7). Mixed high-rate concentrations may be lethal to sensitive fish; however, those concentrations fall below the tenth-percentile lowest concentration for 24-hour fish mortality (9.1 mg/L) and the fifth-percentile lowest concentration for 96-hour fish mortality (17.4 mg/L). If juvenile salmonids in the application area are exposed to the low or high rate applications prior to mixing, some fish are expected to die from the exposure. Such

exposure would be of shorter duration (assumed 45 minutes) than is typically applied in the toxicology studies. However, as noted in the earlier discussion of herbicide testing generally, the initial exposure concentration can be lethal to exposed fish.

Although most fish may avoid 2,4-D if possible, it is likely that some juvenile salmonids within application areas will die from unmixed submerged applications of 2,4-D. Some sensitive juveniles could die from the mixed high rate concentrations but there is low likelihood that fish will die from the low-rate mixed concentrations of 2,4-D during or after applications.

Fish Growth from Prey Reductions. Many individuals of most prey species in the application area will likely die if exposed to the submerged unmixed concentrations as these concentrations exceed most reported mortality thresholds. The more sensitive prey will die from exposures to the mixed high-rate concentrations yet more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. A few studies reported chronic or sublethal effects of 2,4-D to fish. Fairchild et al. (2009) found rainbow trout swim-up larvae exposed for 30 days to 108 mg/L of 2,4-D decreased in weight by 18 percent compared to the control treatment. No statistically significant effects were observed in growth of juvenile rainbow trout exposed to 2,4-D at the highest concentration tested (108 mg/L). Xie et al. (2005) found that 2,4-D increased estrogenic activity in rainbow trout when exposed to 1.64 mg/L for 7 days (Figure 4). A 2,4-D metabolite, 2,4-dichlorophenol, includes estrogenic properties (Jobling et al. 1995). Tests by EPA (2013) found fathead minnow (*Pimephales promelas*) larval length was affected with 2,4-D dimethylamine salt with a no observed effect concentration of 17.1 milligrams per liter of active ingredient (mg a.i./L); survival was also reduced at higher concentrations. In 21-day reproduction assays, fecundity was decreased (34 percent) at a 2,4-D concentration of 96.5 mg a.i./L. An increase in the number of female ovaries at stage 2 (compared to stage 3 or 4) was observed for the 2,4-D treatment groups compared to the negative control, but the incident rates were not dose-responsive and there were no other effects observed in this study. The EPA (2013) found no convincing evidence of interaction of 2,4-D with the androgen pathway.

We find it unlikely that the proposed concentrations of 2,4-D and durations of exposure (likely less than 4 days) will result in alterations to fish growth or endocrine or reproductive functions. Single applications to submerged and emergent plants will result in short exposure durations. In off-channel habitats a 2-day rest between large applications to contiguous areas is expected to minimize risk of build-up concentrations within an area induced by applications in adjacent areas. We find it unlikely that juvenile salmonids would experience direct reductions in growth, or chronically reduced survival or fecundity from exposure to 2,4-D at the proposed application rates.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. 2,4-D is acutely toxic to sensitive plants

and primary producers well below application concentrations (Figure 7). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary 2,4-D Effects. Exposure to unmixed concentrations of 2,4-D applied to kill submerged vegetation is sufficient to reduce abundance of juvenile salmonids via acute lethality. Some sensitive juveniles could die from the mixed high rate concentrations but there is low likelihood that fish will die from the low-rate mixed concentrations of 2,4-D during or after applications. Displacement of fish from application areas to surrounding habitats may temporarily increase risk of predation. Although some sensitive prey will likely die from exposure to unmixed and high rate mixed concentrations, it is unlikely that juvenile salmonids will suffer growth related adverse effects. Based on the information available on sublethal effects, we find it unlikely that juvenile salmonids would experience direct reductions in growth, or chronically reduced survival or fecundity from exposure to 2,4-D at the proposed application rates and expected durations.

Diquat Dibromide

Diquat is an older organic bipyridylium herbicide commonly used for aquatic weed control and in fish culture for treatment of diseases such as bacterial gill disease (Lorz et al. 1979). Bipyridyls are nonselective herbicides that upon contact with plants are strongly absorbed, causing rapid wilting of foliage and destruction of plant cell membranes, especially in sunlight (Nesheim et al. 2005). Toxicity is caused when diquat interferes with the photosynthetic process by accepting electrons from photosystem I, producing highly destructive superoxide radicals that disrupt and inactivate cells and cellular functions (Mees 1960; Emmett 2002). Transport is limited, because cellular damage is rapid, and any uncontacted or underwater remainder of the plant may survive.

For emergent vegetation control, maximum concentrations of diquat at plant surfaces or at the water surface will be 0.69 mg/L for the proposed high application rates and 0.34 mg/L for low application rates (Figure 8). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations, before mixing with receiving water occurs, range from 13–79 mg/L for the high rate and from 6.6–39 mg/L for the low rate. Longest degradation rates for diquat are those in ponds and lakes with limited access to sediments, thermoclines that limit or prevent sinking, low levels of organic material in water columns, low hardness or conductivity, and low or confined water movement (Table 8; Melendez et al. 1993; Parsons et al. 2007; Ducrot et al. 2010; Robb et al. 2014).

There is substantial variation in lethal diquat concentrations among aquatic organisms, particularly among invertebrates and fish, depending on species, age or developmental stage, dose, exposure method, sediment composition, and water quality (Williams et al. 1984; Siemering et al. 2008). Water quality parameters documented to affect diquat toxicity include temperature, turbidity, DO, pH, and hardness. Diquat toxicity to plants and poikilotherms increases with temperature and associated increased metabolic rates (Netherland et al. 2000; McCuaig 2008). Diquat may not sink well with some polymers and adjuvants and may remain

isolated in warmer near-surface habitats above thermoclines. Molecular oxygen is limiting for diquat toxicity in plants and bacteria (Mees 1960). Diquat toxicity varies considerably depending upon water hardness and pH; Surber and Pickering (1962) found 96-hour LC₅₀s in hard water were two to ten times lower than levels observed in soft water tests with fathead minnows (*Pimephales promelas*) and bluegill sunfish (*Lepomis macrochirus*).

Diquat is highly soluble in water and its cationic residues in the environment are quickly absorbed by organic matter and soil surfaces, where about 70 percent may remain persistently bound with a potential half-life of 160 days (Birmingham and Colman 1983; Siemering et al. 2008). Although diquat is relatively persistent, it has low bioaccumulation properties in food webs. Acute and chronic toxicity test results may vary widely depending on laboratory or field conditions. Wilson and Bond (1969) found that adding pond mud to test aquaria increased the 96-hour LC₅₀ of diquat for the amphipod (*Hyaella azteca*) from 0.046 to 6.8 mg/L. Sediments contaminated with diquat may cause subsequent phytotoxicity (Birmingham and Colman 1983; Peterson et al. 1994) and toxicity to benthic crustacea (Williams et al. 1984), but no studies were found for fish. Diquat can be carried by water in canals and small channels for relatively long distances (Ducrot et al. 2010). Parsons et al. (2007) found maximum diquat concentrations were a fourth of target concentrations within 4 hours after treatment in a clear, low-conductivity, lake in western Washington. At some stations outside the treatment area, maximum concentrations of drifting diquat were a third of target concentrations 2 days after treatment. Sediments and organic material contaminated with diquat may be carried downstream to collect in aquatic substrates.

In mammals and birds diquat toxicity is caused primarily through the increased generation of free radicals that cause oxidative damage to lung tissue and kidneys (Magalhaes et al. 2018). Several studies in fish, amphibians, and invertebrates have described similar effects of diquat on oxidative processes, enzyme activity, and gross morphology (Di Giulio et al. 1983). Histological examination of yearling coho salmon by Lorz et al. (1979) found that 144-hour exposure to 10–20 mg/L of diquat caused degeneration in gill tissue and limited necrosis in the liver.

Upon entering fish through water or diet, diquat accumulates predominantly in the gastrointestinal tract until it is metabolized or excreted (Lorz et al. 1979). Diquat residues in fish track water concentrations until leveling off between 1.5 and 5 parts per million (ppm doses) (Dodson and Mayfield 1979), indicating reduced absorption or increased metabolism and elimination (Lorz et al. 1979). Rainbow trout exposed to 1 mg/L diquat for 16 days accumulated 0.5 to 0.6 mg/L whole body residues that were detected in the skin, gills, gut, liver, and kidneys; residues steadily declined after transfer to fresh water (Lorz et al. 1979). Schultz et al. (1995) demonstrated that in yearling channel catfish (*Ictalurus punctatus*), most diquat accumulated in the intestine after water exposure. They surmised that absorption in the intestine may be limited until microbial degradation occurs. The less-toxic metabolites are then absorbed and cycled (with requisite energy costs and cellular damage) through the liver and bile, with renal elimination.

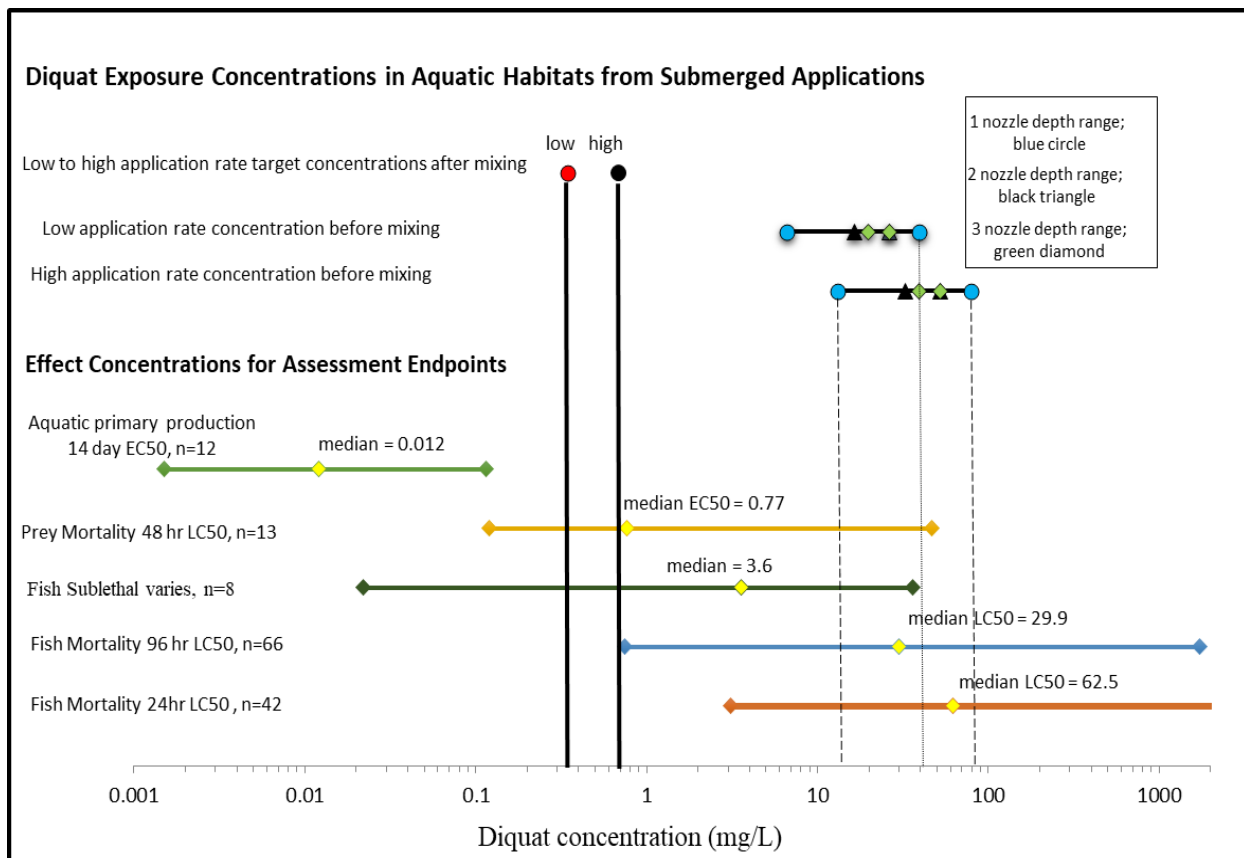


Figure 8. Diquat exposure concentrations in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum diquat concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Given that pesticides are applied directly to submerged aquatic habitats, including areas of designated critical habitat when the listed fish are present, a high likelihood of exposure is expected to fish within the area of application and a lesser likelihood of exposure downriver. Fish are shown not to detect or avoid diquat (Folmer 1976; McCuaig 2018). Diquat strongly binds to organic matter and may enter fish through gills, gut, and skin. Sensitive microbiota in these organs may also be exposed to and affected by diquat.

The COE calculated out-of-nozzle concentrations for waters that are 2 and 6 feet deep before herbicide is completely mixed. The high and low target concentrations are based on the assumption that 45 minutes following application, the concentration estimates would be uniformly mixed across the application area. For the first 45 minutes, unmixed concentrations would be up to one to two orders of magnitude higher than the uniformly mixed concentrations thereafter. Some juvenile salmonids of sensitive very young life stages, in submerged application areas exposed to unmixed concentrations within the first 45 minutes will likely die from low and high rate concentrations. The concentration of diquat released from the nozzle into

the water exceeds medians of all reported fish LC₅₀s shown in Figure 8. Juvenile salmonids in the application area that are exposed to the estimated concentrations that occur after mixing are not likely to die from the low or high target rates.

Fish Growth from Prey Reductions. Individuals of most prey species in the application area will likely die if exposed to the submerged unmixed concentrations as these concentrations exceed most reported mortality thresholds (Figure 8). The more sensitive prey will die from exposures to the mixed high-rate and low-rate concentrations yet more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. Exposure to unmixed concentrations of diquat during submerged applications will likely cause sublethal adverse effects to fish (Figure 8). High and low target rates of mixed concentrations of diquat may also cause sublethal effects to fish, particularly in shallow and/or slow circulation water, where the target concentrations may persist longer than in deeper water treatments. Sublethal effects of diquat vary among fish, with younger ages being most sensitive to behavioral, oxidative stress, immunity, and locomotor effects.

Using a Y-shaped maze, Folmar (1976) demonstrated that rainbow trout fry displayed no avoidance of diquat at concentrations of 0.1 to 10 mg/L. Bimber (1976) observed a significant level of respiratory stress (cough response) in age-2 yellow perch (*Perca flavescens*) exposed to 1 to 5 mg/L of diquat. Bimber's study was in the northeastern U.S. where water was likely less buffered than in other areas. Elevated coughing was not observed in rainbow trout by Dodson and Mayfield (1979).

The redox cycling characteristics of diquat toxicity are documented to cause sublethal effects through oxidative stress and immunity pathways. Berry (1984) showed that diquat (0.11 to 23 ppm) decreased lymphocytes and increased thrombocytes in the blood of bluegill sunfish and goldfish. Sublethal 144-hour exposure to concentrations greater than 1.0 mg/L of diquat in freshwater caused dose-dependent mortality of juvenile coho salmon in seawater entry tests, which indicates oxidative stress (Lorz et al. 1979). Wang et al. (2018) tested genetic transcripts related to oxidative stress and found zebrafish larvae exposed to 3.6 mg/L diquat showed higher levels of catalase compared to control fish, indicating forms of reactive oxygen were produced (oxidative stress).

Sturve et al. (2005) found that rainbow trout response from exposure to high concentrations of diquat involved hundreds of upregulated genes related to oxidative damage, immune defense, cellular death cascade signaling, and metabolic alterations, and that responses to diquat and Cr VI were the most similar among several toxicants. McCuaig (2018) found that cellular processes related to the immune system were significantly altered after rainbow trout pre-feeding and feeding fry were exposed to two 24-hour pulses of 0.37 mg/L diquat separated by 14 days of clean-water rearing. Among functional groupings, erythrocyte differentiation increased, while blood flow, platelet response, platelet shape change, platelet function, thrombocyte aggregation,

and neutrophil chemotaxis all decreased. Caspase activation occurred in both life stages, indicating apoptosis in the liver and possible hepatotoxicity after exposure to diquat. However, feeding fry exhibited immune-related response as significant increases in cell signaling and defenses for adapting to a foreign element. McCuaig (2018) concluded that the upregulation of these and other processes in feeding fry indicate an immune response to diquat, whereas the downregulation of multiple immunity processes for pre-feeding fry indicates they were less able to adequately respond to diquat as a stressor due to an immature immune system. Wang et al. (2018) surmised that fish embryos store diquat until the liver develops enough to metabolize it, which is when the requisite oxidative damage and blood toxicity occur. Similarly, Bimber and Mitchell (1978) exposed leopard frog eggs to diquat with no apparent effect until 14 days post-hatching when all tadpoles died.

Diquat exposure at concentrations of 0.5 to 3.0 mg/L for 96-hour did not affect smolting of yearling coho salmon; however, it was the only herbicide tested that significantly reduced seaward migration, possibly from increasing mortality rates from predation, stress, natural causes, or latent effects (Lorz et al. 1979). Dodson and Mayfield (1979), using an optomotor tank which simulates visual stimuli produced by displacement in a water current by moving the background, found that short-term field application doses (0.5 to 5 ppm) of diquat significantly increased the frequency of non-response and significantly decreased swimming speeds in yearling rainbow trout. The frequency of positive rheotaxis was also significantly reduced at 5 ppm. Wang et al. (2018) found zebrafish embryos exposed to diquat for 96-hour did not show any significant mortality or deformity compared to controls, and there was no difference in the timing of hatch. However, assessment of locomotor behavior in 7 days post-fertilization zebrafish treated with diquat (3.6 to 36.2 mg/L) showed hyper-activity in total distance traveled, velocity, movement cumulative duration, and overall activity compared to unexposed fish (Wang et al. 2018). McCuaig (2018) found rainbow trout fry exposed to <0.37 mg/L of diquat showed no behavioral abnormalities; however, at higher doses (3.3 to 22.5 mg/L) fish showed reduced feeding behavior, lethargy, increased operculum movement, and loss of equilibrium. McCuaig (2018) found 24 percent of rainbow trout alevins exposed to two 24-hour pulses of 9.25 mg/L of diquat were observed to be lethargic, did not swim, did not avoid capture, and could not be revived in fresh water.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Diquat is acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 8). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Diquat Effects. Some juvenile salmonids in submerged application areas that are exposed to unmixed concentrations within the first 45 minutes will likely die from low and high rate concentrations. Juvenile salmonids in application areas that are exposed to diquat after mixing are not likely to die from the low or high target rates. Many individuals of most prey species in the application area will likely die if exposed to the submerged unmixed concentrations as these concentrations exceed most reported mortality thresholds. The more sensitive prey will die from exposures to the mixed high-rate and low-rate concentrations, yet

more tolerant prey will likely remain available. Migrating and rearing juvenile salmonids are particularly sensitive to energy use and limited reserves. Diquat inducement of redox cycling, oxidative stress, and antioxidant defenses indicates increased energy is necessary to maintain homeostasis at concentrations within the range of those to be applied. Although the results of many of the studies testing for sublethal effects involve higher doses and longer exposures to concentrations of diquat that are expected under the proposed action, the sublethal effects to swimming and negative rheotaxis (willingness to move downstream) in highly-migratory fishes are particularly concerning. When small fish are exposed to diquat in very shallow water, where mixing will be slow and mixed concentrations will persist, adverse sublethal effects are reasonably certain to occur. Reductions in DO from dying plants will occur within 1 to 3 weeks after treatment. Juvenile salmonids feeding in treatment areas during this period will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Endothall.

Endothall is a selective contact herbicide. Only dipotassium formulations will be used in this proposed action. Endothall is highly mobile in soil and water with low persistence (Table 8).

For emergent vegetation control, maximum concentrations of endothall (dipotassium) at plant surfaces or at the water surface will be 5 mg/L for high application rates and 0.75 mg/L for low application rates (Table 3, Figure 9). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations, before mixing with receiving water occurs, range from 95–573 mg/L for the high rate and from 13–81 mg/L for the low rate.

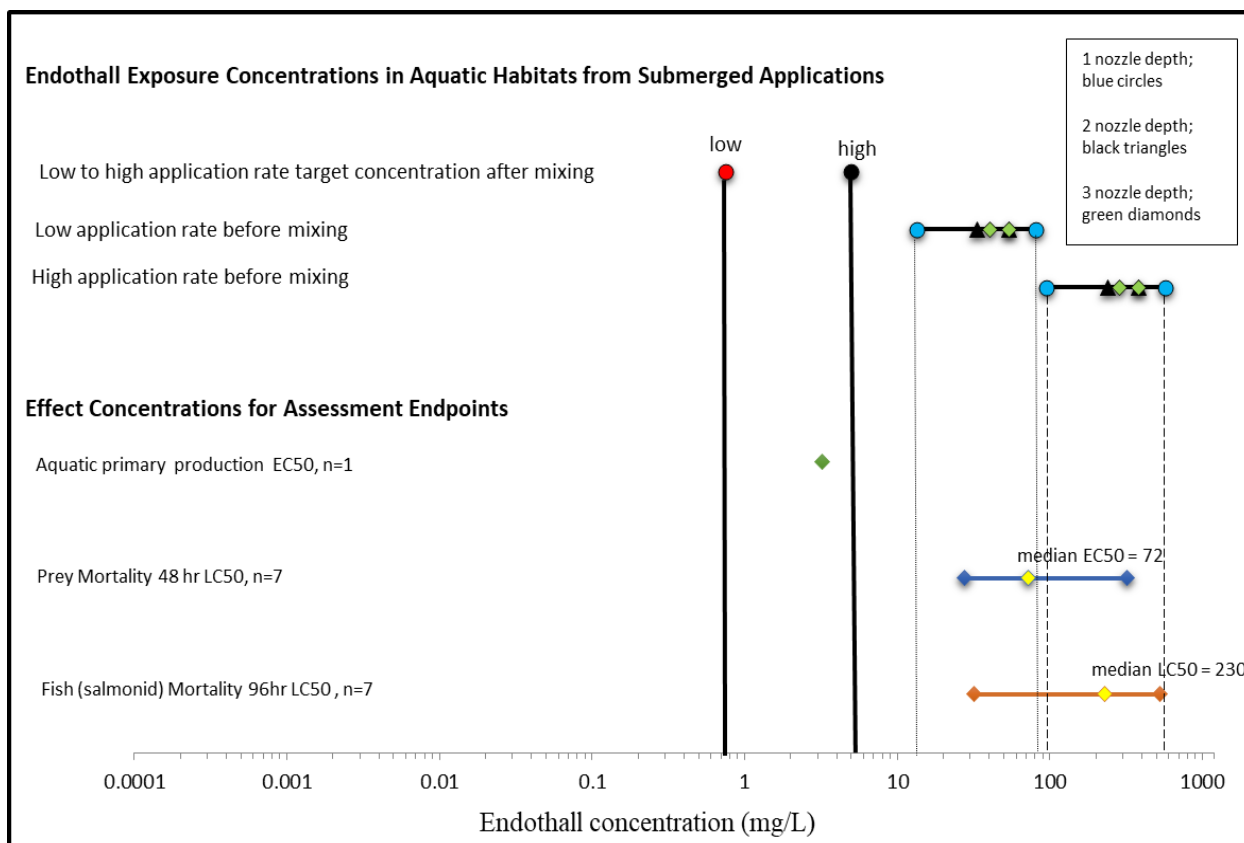


Figure 9. Exposure concentrations for endothall (dipotassium) in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum endothall concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Submerged vegetation applications of formulations containing endothall at low and high rates before mixing include concentrations that are higher than fish 96-hour mortality thresholds (Figure 9). After mixing, low and high application rates from submerged and emergent treatments fall below 96-hour fish mortality thresholds. Juvenile salmonids are not expected to die from the mixed low or high application rates for submerged or emergent vegetation. Juvenile salmonids in the application area exposed within the first 45 minutes of mixing following submerged applications of endothall may die from the low and high application rate levels.

Fish Growth from Prey Reductions. Before mixing exposure to formulations containing endothall at low and high application rates are above 48-hour prey mortality thresholds (Figure 9). After mixing, high and low application rates fall one to two orders of magnitude below 48-hour prey mortality thresholds. Prey are not expected to die from the mixed low or high rate of applications. Sensitive prey in the application area exposed within the first 45 minutes of mixing following submerged applications may die from the low and high application rate levels. The more sensitive prey will die from exposures to the unmixed

applications, however more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. There is very little information on sublethal effects of endothall on fish and what there is involves testing substantially higher concentrations and longer exposures than will occur with this program. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Although only one study was found, endothall (dipotassium) is expected to be acutely toxic to sensitive plants and primary producers well below unmixed submerged application concentrations and below target concentrations (Figure 9). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Endothall Effects. Exposure to formulations containing endothall applied to kill submerged aquatic vegetation is sufficient to reduce abundance of juvenile salmonids via acute lethality. However, it appears unlikely that death of juveniles will occur unless the juveniles are sensitive and exposed to endothall before mixing. Although more sensitive prey will die from exposure to unmixed concentrations, it is unlikely that juvenile salmonids will suffer growth related adverse effects. We find it unlikely that juvenile salmonids would experience direct reductions in growth from exposure to formulations containing endothall.

Fluridone.

Fluridone is a selective systemic herbicide, which inhibits formation of carotene and allows degradation of plant chlorophyll when exposed to sunlight (USDA 2014). Only aqueous solutions of fluridone will be used. Sunlight degrades fluridone and shaded water and substrate cause increased persistence (Table 8).

For emergent vegetation control, maximum concentrations of fluridone at plant surfaces or at the water surface will be 0.09 mg/L for high application rates and 0.01 mg/L for low application rates (Table 3, Figure 10). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations, before mixing with receiving water in submerged treatments, range from 1.7–10.2 mg/L for the high rate and from 0.18–0.71 mg/L for the low rate.

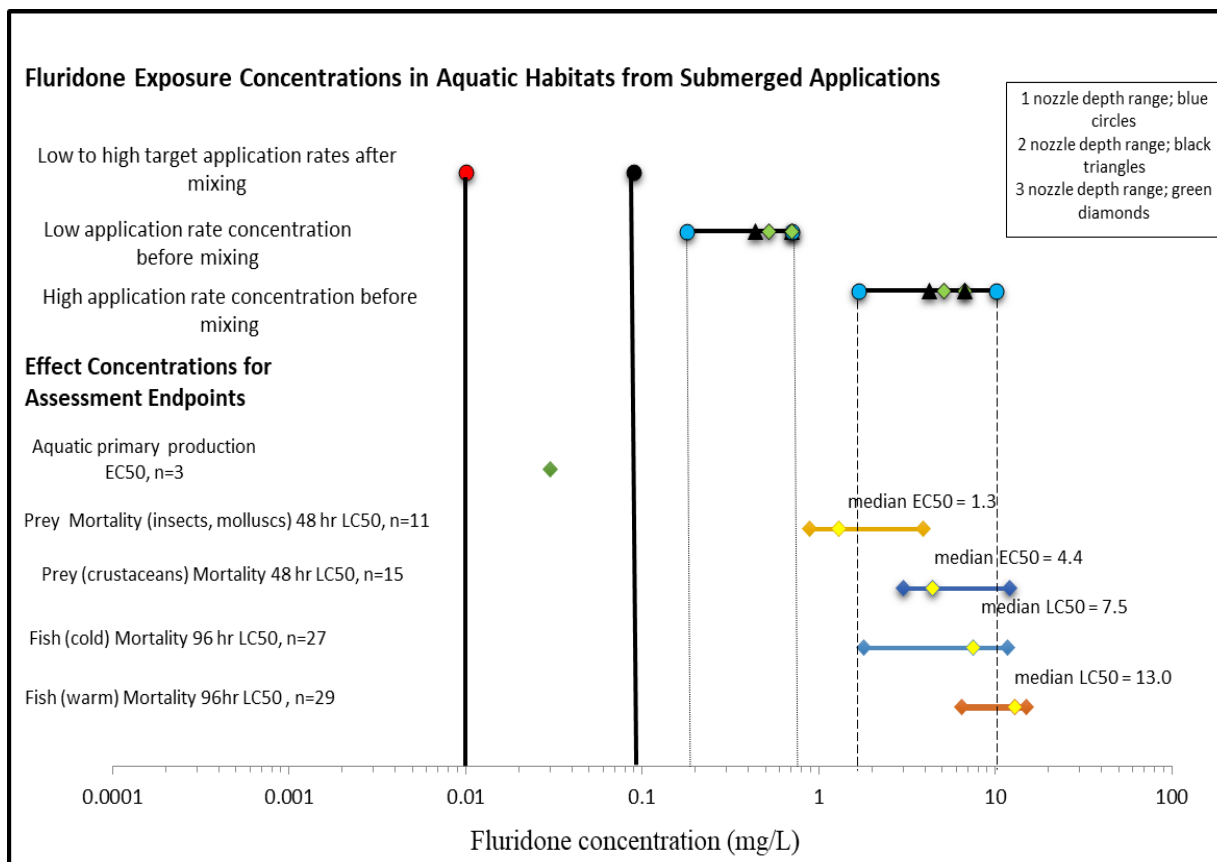


Figure 10. Exposure concentrations for fluridone in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum fluridone concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Submerged applications of formulations containing fluridone at low rate ranges include concentrations before mixing that fall well below fish mortality thresholds (Figure 10). However, high application rates at all nozzle depth concentrations before mixing exceed coldwater fish (including salmonids) 96-hour mortality thresholds. After mixing, low and high application rate concentrations fall well below 96-hour fish mortality thresholds. Concentrations of fluridone from submerged applications after mixing and emergent applications are one to two orders of magnitude lower than fish mortality thresholds. Juvenile salmonids are not expected to die from the unmixed low application rates for submerged vegetation or from the mixed low and high rates of applications. Sensitive juvenile salmonids in the application area exposed within the first 45 minutes of mixing following submerged applications may die from the high application rate concentrations.

Fish Growth from Prey Reductions. Before mixing exposure to formulations containing fluridone at low application rates are below 48-hour prey mortality thresholds (Figure 10). High application rates to submerged vegetation before mixing exceed 48-hour prey mortality

thresholds. After mixing, low and high application rates fall one to two orders of magnitude below 48-hour prey mortality thresholds. Prey are not expected to die from the unmixed low application rates or from the mixed low or high rate of applications. More sensitive prey exposed within the first 45 minutes of mixing following submerged applications may die from the high application rate levels, however more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. There is very little information on sublethal effects of endothall on fish and what there is involves testing substantially higher concentrations and longer exposures than will occur with this program. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Although very few studies were found, fluridone is expected to be acutely toxic to sensitive plants and primary producers below application concentrations (Figure 10). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Fluridone Effects. Initial exposure to formulations containing fluridone applied to kill submerged aquatic vegetation is sufficient to kill juvenile salmonids. However, it appears unlikely that death of juveniles will occur unless the juveniles are sensitive and exposed to the highest concentrations before mixing. Juvenile salmonids are not expected to die from the unmixed low application rates for submerged vegetation or from the mixed low and high rates of applications. Although more sensitive prey will die from exposure to the highest rates of unmixed concentrations, it is unlikely that juvenile salmonids will suffer growth related adverse effects. From the few studies available we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing fluridone.

Triclopyr TEA

Triclopyr is a selective systemic, pyridine herbicide used to control woody and broadleaf plants. Only triclopyr TEA formulations will be used in this proposed action. Triclopyr degrades rapidly in sunlit water but can be mobile in soil where persistence is longer (30- to 90-day half-life), particularly in cold or arid conditions (Table 8).

For emergent vegetation control, maximum concentrations of triclopyr TEA at plant surfaces or at the water surface will be 2.5 mg/L for high application rates and 0.75 mg/L for low application rates (Table 3, Figure 11). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations, before

mixing with receiving water occurs, range from 49–292 mg/L for the high rate and from 15–89 mg/L for the low rate.

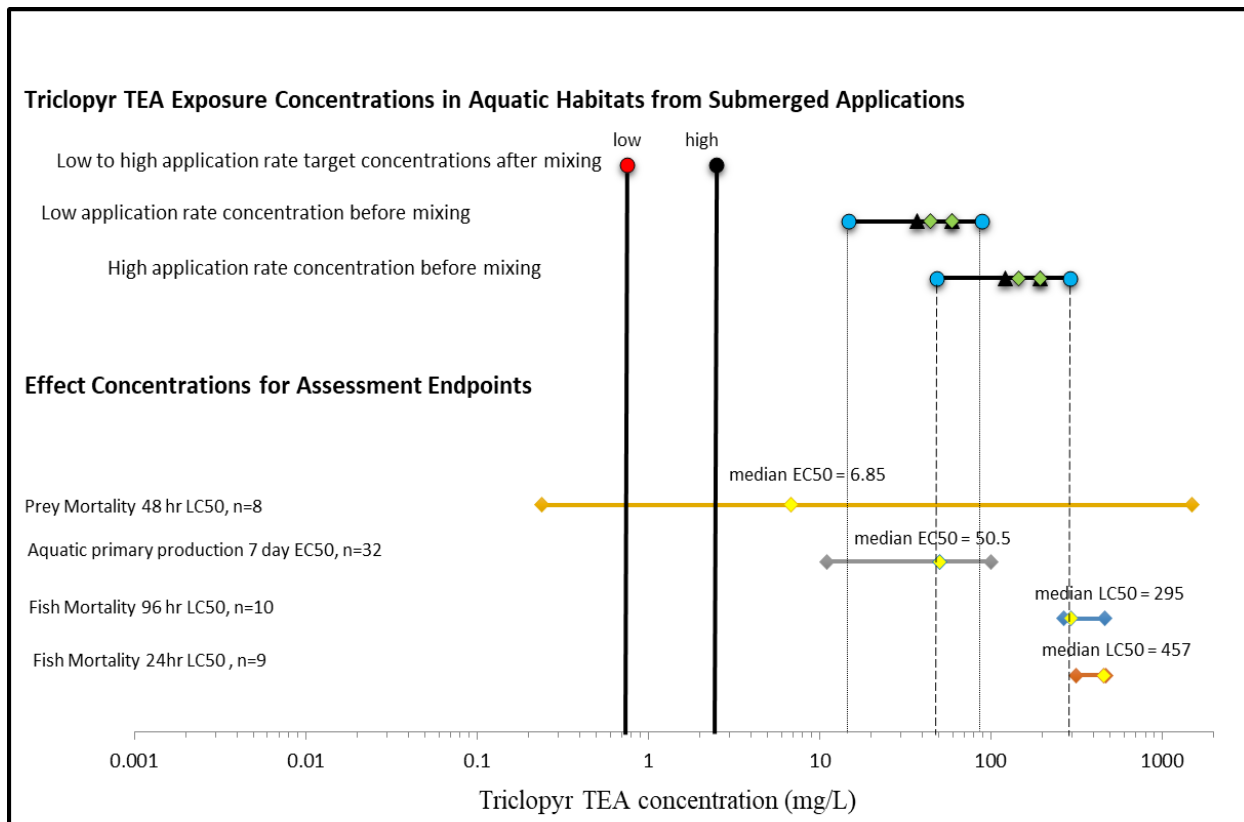


Figure 11. Exposure concentrations for triclopyr TEA in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum triclopyr TEA concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Submerged low application rates including Triclopyr TEA at all nozzle depth concentrations fall well below fish mortality thresholds (Figure 11). At high application rate ranges, two of three nozzle depth concentration ranges fall below both 24-hour and 96-hour fish mortality thresholds. The upper end of the high application rate exceeds the low end of the 96-hour fish mortality thresholds and is near the low end of the 24-hour threshold range. Sensitive juvenile salmonids in submerged application areas may die if exposed within the first 45 minutes to highest application rates.

Low application rate target concentrations are three orders of magnitude lower than the 24-hour and 96-hour fish mortality thresholds (Figure 11). High application rate target concentrations are two orders of magnitude lower than the 24-hour and 96-hour mortality thresholds. Juvenile salmonids are not expected to die from the low or high rates of mixed applications at target concentrations.

It is unlikely that death of juveniles will occur from submerged or emergent applications of formulations including Triclopyr TEA, unless the juveniles are sensitive and exposed to the highest concentrations before mixing in submerged treatments.

Fish Growth from Prey Reductions. Exposure to formulations containing triclopyr TEA applied to kill submerged and emergent aquatic vegetation fall above prey mortality thresholds (Figure 11). Expected application concentrations are substantially above many of the prey LC/EC₅₀s. Many individuals of most prey species in submerged application areas will likely die if exposed to the end-of-nozzle concentrations, as these concentrations exceed the median of reported mortality LC₅₀s. The more sensitive prey may die from exposures to the low and high rate target concentrations, however more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. There is very little information on sublethal effects of triclopyr TEA on fish and what there is involves testing substantially higher concentrations and longer exposures than will occur with this program. From the few studies available we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing Triclopyr TEA.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Although study toxicity thresholds were above target concentrations, Triclopyr TEA is expected to be acutely toxic to sensitive plants and primary producers below most unmixed submerged application concentrations and at least slightly below target concentrations (Figure 11). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Triclopyr TEA Effects. Exposure to formulations containing Triclopyr TEA applied to submerged aquatic vegetation is sufficient to reduce abundance of juvenile salmonids via acute lethality. However, it appears unlikely that death of juveniles will occur unless the juveniles are highly sensitive and exposed to the highest concentrations before mixing. Although more sensitive prey may die from exposure to target concentrations, it is unlikely that juvenile salmonids will suffer growth related adverse effects. Few studies were found to support sublethal effects. We find it unlikely that juvenile salmonids would experience growth reductions or other sublethal effects from exposure to formulations containing Triclopyr TEA.

Imazamox

Imazamox is a rapidly absorbing systemic herbicide that is highly soluble in water and is mobile in soil (Table 8). The imazamox mode of action in plants inhibits the acetolactate synthase enzyme, blocking the synthesis of three essential amino acids (WDOE 2012; USDA 2014).

For emergent vegetation control, maximum concentrations of imazamox at plant surfaces or at the water surface, will be 0.5 mg/L for high application rates and 0.05 mg/L for low application rates (Table 3, Figure 7). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle concentrations before mixing with receiving water occurs, range from 9.5–57 mg/L for the high rate and from 0.93–5.6 mg/L for the low rate.

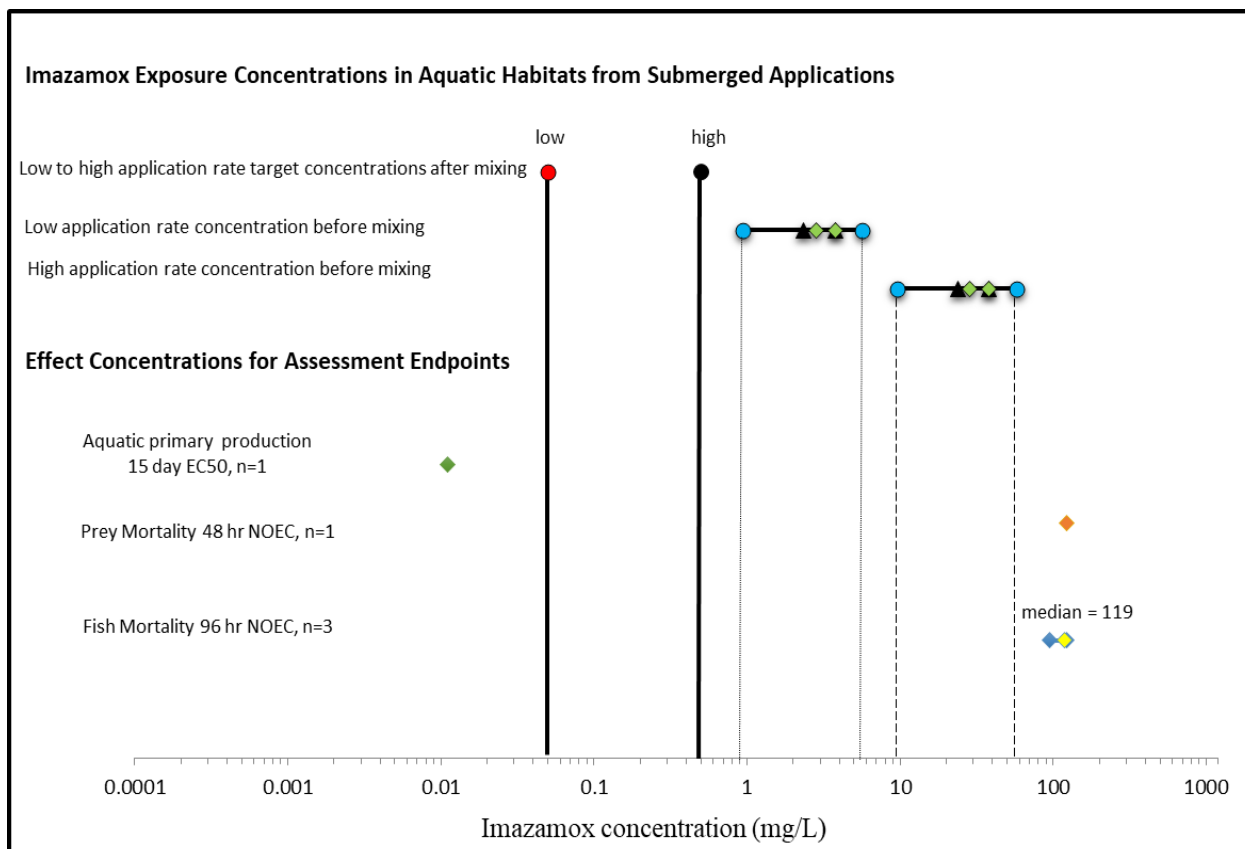


Figure 12. Exposure concentrations for imazamox in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum imazamox concentrations (x-axis) applied to emergent and riparian plants and are also target concentrations for submerged plants after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Before mixing, low application rate ranges of formulations including imazamox at all nozzle depth concentrations fall well below fish mortality thresholds. At low and high application rate ranges, all nozzle depth concentration ranges fall well below both 24-hour and 96-hour fish mortality thresholds from the limited set of available studies (Figure 12). Submerged applications after mixing and emergent applications from nozzles are two to three orders of magnitude lower than fish mortality thresholds. Juvenile salmonids are not expected to die from the unmixed or mixed, low or the high rate of applications.

Fish Growth from Prey Reductions. Exposure to formulations containing imazamox is not likely to reduce prey because acute effects thresholds from the few studies available are well above the highest expected concentrations (Figure 12). No reductions in abundance or growth of juveniles are expected. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. There is very little information on sublethal effects of imazamox on fish and what there is involves testing substantially higher concentrations and longer exposures than will occur with this program. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing imazamox.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Although only one study was found, imazamox is expected to be acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 12). Treatments of dense monocultures and large areas (maximum submerged 5 acres, emergent 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Imazamox Effects. Exposure to formulations containing imazamox applied to kill submerged or emergent aquatic vegetation are not sufficient to reduce abundance of juvenile salmonids via acute lethality. It is unlikely that prey will die from the highest expected concentrations and is unlikely that juvenile salmonids will suffer sublethal or growth-related adverse effects.

Sodium carbonate peroxyhydrate

Sodium carbonate peroxyhydrate (SCP) is composed of hydrogen peroxide and sodium carbonate. Pure SCP contains approximately 67.5 percent sodium carbonate and 32.5 percent hydrogen peroxide by weight (EPA 2002b; USDA 2014). Sodium carbonate peroxyhydrate is a contact algaecide that selectively controls blue-green algae at lower application rates and controls many types of algae at higher rates (USDA 2014). Upon contact with water, SCP rapidly dissociates into hydrogen peroxide and sodium carbonate. The hydrogen peroxide oxidizes critical cellular components of unicellular organisms and other simple multi-cellular organisms such as algae. Sodium carbonate peroxyhydrate and its breakdown product hydrogen peroxide are oxidizing agents, so there is a potential for toxicity to fish, aquatic invertebrates, insects, plants, and other primary producers.

In the proposed action, SCP may be used for floating and submerged algae, and will not be used in riparian zones. For floating or submerged algae control, maximum concentrations of SCP at the water surface or submerged area will be 36.8 mg/L for high application rates and 3.7 mg/L for low application rates (Table 3, Figure 13). Applications to submerged vegetation are designed to achieve these same high and low target rates when completely mixed. Out-of-nozzle

concentrations, before mixing with receiving water occurs, range from 705–4,232 mg/L for the high rate and from 353–2,116 mg/L for the low rate.

Sodium Carbonate Peroxyhydrate is extremely soluble in water (140 grams per liter) and has a pH of approximately 10.5 at 1-percent concentration (USDA 2014). Sodium carbonate dissociates into sodium and carbonate in water with a typical half-life of <8 hours (Table 8; EPA 2002b). There is little risk of absorption to sediments or volatilization. Sodium carbonate in water results in an increase in alkalinity and a subsequent increase in pH until the carbonate ions react with water, forming bicarbonate and hydroxide, and achieving equilibrium. The hydrogen peroxide is ultimately broken down into water and oxygen (EPA 2002b). Both sodium and inorganic carbon that result from the breakdown of sodium carbonate are ubiquitous in the environment (USDA 2014).

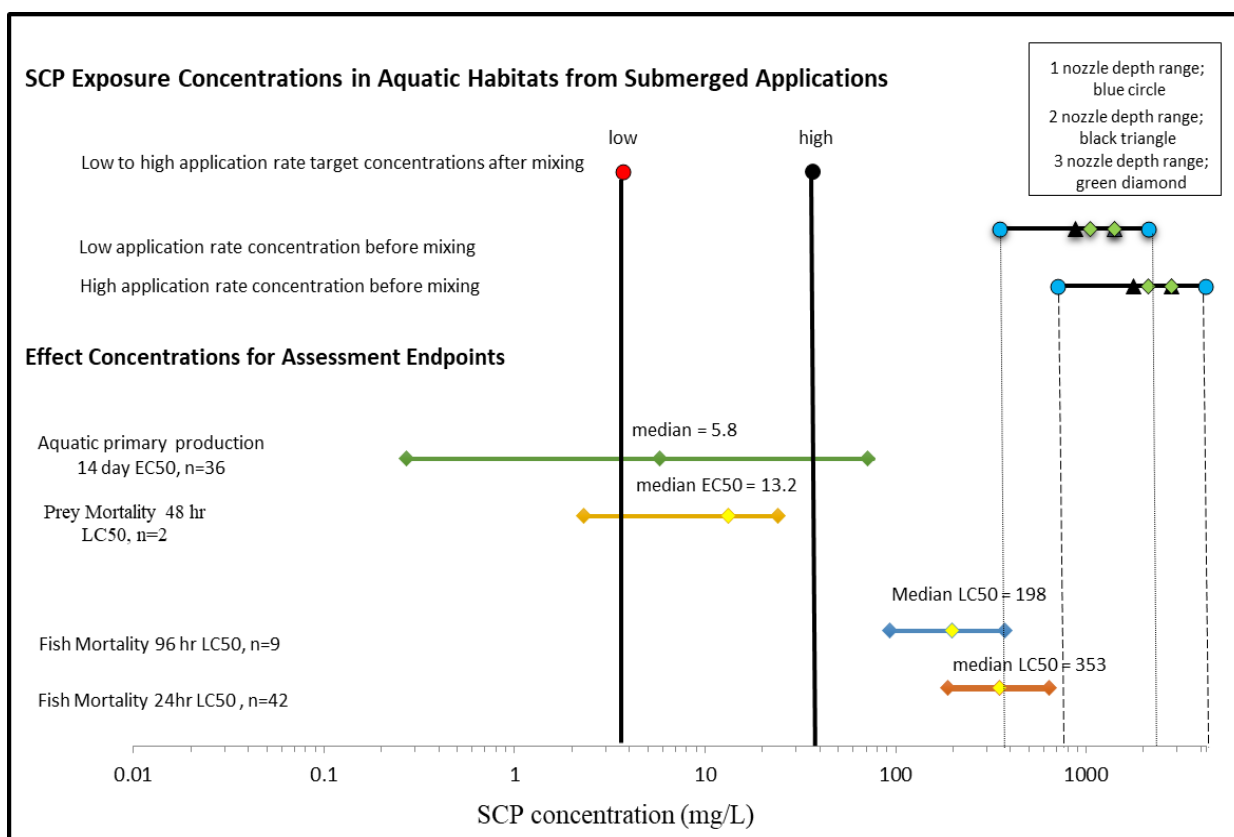


Figure 13. Exposure concentrations for SCP in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum SCP concentrations (x-axis) applied to floating algae and are also target concentrations for submerged algae after mixing. Blue circles frame the low and high rate out-of-nozzle concentrations (unmixed) for submerged plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Before mixing, low and high application rate ranges of formulations including SCP at all nozzle depth concentrations are well above fish mortality thresholds (Figure 13). At high application rate ranges, concentration ranges are higher than all reported 24-hour and 96-hour fish mortality thresholds. The unmixed low application rates

exceed the medians of all reported 24-hour and 96-hour fish mortality thresholds. Juvenile salmonids in the application area exposed within the first 45 minutes following application may die due to the unmixed concentrations of low and high application rates.

After mixing, targeted high and low application rates will have estimated concentrations that are one to two orders of magnitude lower than the 24-hour and 96-hour fish mortality thresholds. Juvenile salmonids are not expected to die from the low or high rates of mixed applications.

It appears likely that some juvenile salmonids, particularly sensitive life stages, within application areas will die from unmixed submerged applications of SCP. Juveniles are not likely to die from mixed concentrations of SCP during or after applications to submerged or emergent vegetation.

Fish Growth from Prey Reductions. Exposure to formulations containing SCP fall above prey mortality thresholds (Figure 13). Expected application concentrations are substantially above many of the prey LC/EC₅₀s. Most prey species in submerged application areas will likely die if exposed to the end-of-nozzle concentrations, as these concentrations exceed the median of reported mortality LC₅₀s. The more sensitive prey may die from exposures to the low and high rate target concentrations, however more tolerant prey will likely remain available. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

Sublethal Fish Effects. There is very little information on sublethal effects of SCP on fish and what there is involves testing substantially higher concentrations and longer exposures than will occur with this program. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing SCP.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. The SCP is acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 13). Treatments of dense monocultures and large areas (maximum submerged application of 5 acres) may reduce DO levels from dying plants and algae which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary SCP Effects. Exposure to unmixed concentrations of SCP is sufficient to kill juvenile salmonids via acute lethality. Death of juvenile fish is not likely to occur from low or high target mixed concentrations of SCP. Displacement of fish from application areas to surrounding habitats may temporarily increase risk of predation. Although most prey will likely die from exposure to unmixed and high rate mixed concentrations, it is unlikely that juvenile salmonids will suffer growth related adverse effects. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing SCP. Treatments of dense monocultures and

large areas (maximum submerged application of 5 acres) may reduce DO levels from dying plants and algae which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Imazapyr

Imazapyr is a foliar-applied, systemic, non-selective herbicide used for the control of a broad range of terrestrial and aquatic weeds and woody plants (EPA 2006, 2007, 2010; AMEC Geomatrix 2009; SERA 2011). Imazapyr works in the meristematic tissue (i.e., rapidly growing/dividing) by inhibiting the synthesis of certain amino acids in protein production. In the proposed action imazapyr may be used to treat emergent and riparian plants including flowering rush, hairy willow-herb, Japanese knotweed, narrowleaf cattail, perennial pepperweed, phragmites, and yellow-flag iris. For emergent and riparian vegetation control, maximum concentrations of imazapyr at plant surfaces or at the water surface will be 0.55 mg/L for high application rates and 0.18 mg/L for low application rates (Figure 14).

Imazapyr is a water soluble, weak acid (EPA 2006, 2007). Imazapyr is found in an ionic form at typical environmental pHs, as greater than 99 percent is ionized at pH 6 and higher. Aqueous photolysis was the primary route of degradation for imazapyr in water. The typical half-life of imazapyr in surface water is 7 to 14+ (Table 8) days or less (1 to 4 days; Leson and Associates 2005). Salmonids readily smell and avoid many pesticides at trace concentrations and extended exposure to higher concentrations could reduce olfaction (Folmar 1976; Tierney et al. 2006; Tierney et al. 2010). Imazapyr will further degrade to low levels within a few days in ponded water, sediments, and plants (Figure 5; Patten 2003; ENTRIX 2003). Imazapyr is unlikely to partition significantly to sediments because it is relatively hydrophilic (Table 8; EPA 2006, 2007). Therefore, interactions between the sediments and the water column, or subsequent effects on benthos are not expected with this active ingredient. The half-life in benthic sediments is < 2 to 7 days (Leson and Associates 2005).

Imazapyr is more persistent and mobile in soil, with a soil half-life of 25 to 141 days (Leson and Associates 2005). Volatilization is an unlikely route of dissipation from soil (EPA 2006, 2007, 2010). Available studies show that hydrolysis in moist soil and photodegradation on soil are unlikely to occur, and that the primary process is slow microbial degradation. Metabolites of imazapyr include pyridine hydroxyl-dicarboxylic acid and pyridine dicarboxylic acid (EPA 2010). In the absence of a complete suite of toxicity data on these metabolites, their toxicity is assumed to be equivalent to the parent compound, imazapyr.

Imazapyr does not partition to lipids and therefore is not expected to bioaccumulate in the tissues of prey organisms or biomagnify in birds and mammals (EPA 2006, 2007). Laboratory studies with bluegill sunfish, eastern oyster, and grass shrimp indicate imazapyr degrades did not bioaccumulate.

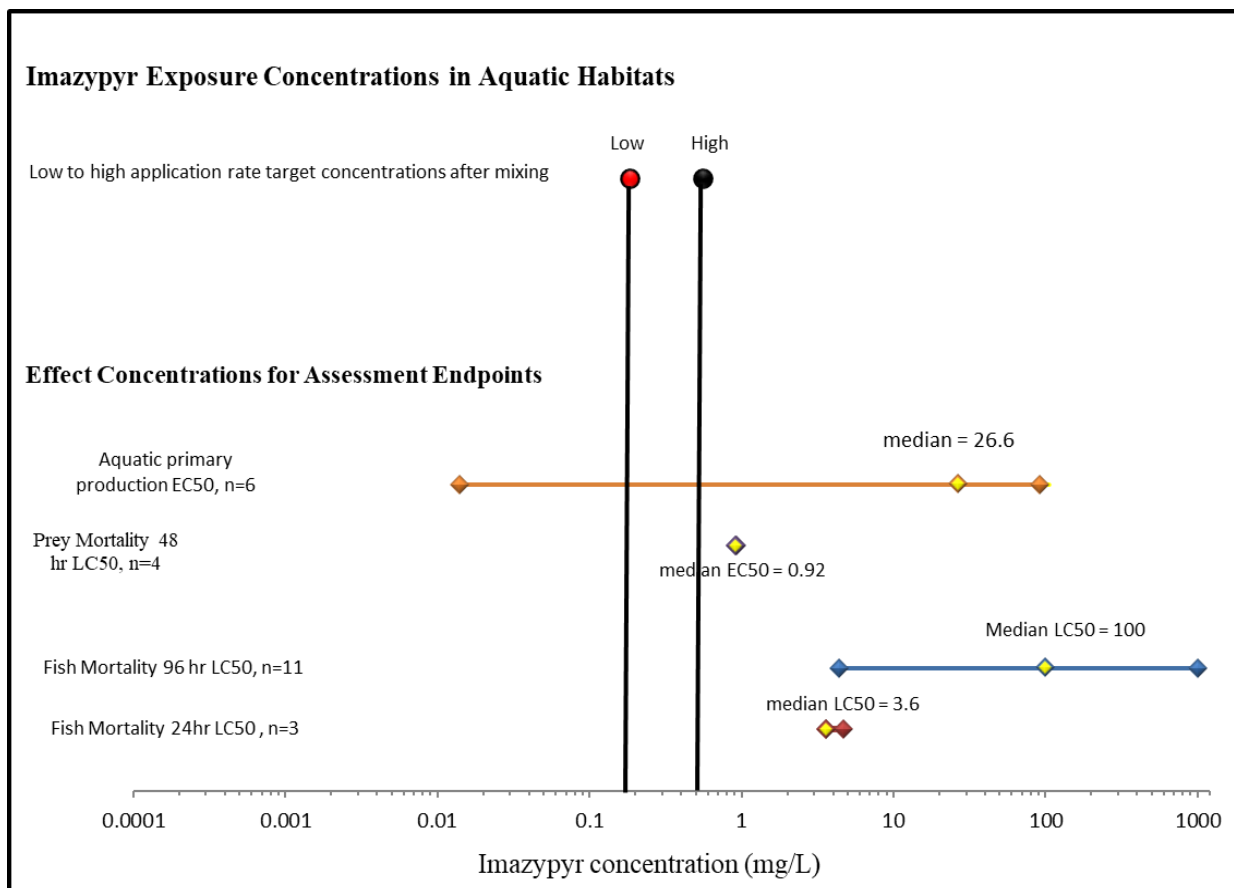


Figure 14. Exposure concentrations for imazapyr in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum imazapyr concentrations (x-axis) applied to emergent and riparian plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Applications of imazapyr for control of emergent and riparian vegetation are expected to produce concentrations that are an order of magnitude lower than the 24-hour and 96-hour fish mortality thresholds (Figure 14). Juvenile salmonids are not expected to die from the low or high rate of applications.

Fish Growth from Prey Reductions. Only a few study results were found that reported 48-hour acute toxicity thresholds of prey following exposure to imazapyr. Prey acute toxicity thresholds are nearly double the high rate concentration of imazapyr that is expected to enter receiving water at its surface (Figure 14). Exposure to formulations containing imazapyr are not likely to reduce prey because acute effects thresholds from the studies available are well above the highest expected concentrations. No reductions in abundance or growth of juveniles are expected. Studies on chronic effects to prey were not found and are also unlikely because applications will only occur once per year at any given location.

Sublethal Fish Effects. There is very little information on sublethal effects of imazapyr on fish and what there is involves testing substantially higher concentrations and longer exposures than

will occur with this program. From the few studies available, we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing imazapyr.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Imazapyr is acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 14). Treatments of dense monocultures and large areas (maximum 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Imazapyr Effects. Exposure to formulations containing imazapyr applied to kill emergent and riparian vegetation are not sufficient to reduce abundance of juvenile salmonids via acute lethality. It is unlikely that prey will die from the highest expected concentrations and from the few studies available we find it unlikely juvenile salmonids would experience direct reductions in growth or other sublethal effects from exposure to formulations containing imazapyr. Application of herbicide and dying plants is likely to displace fish to surrounding habitats. Large areas (maximum 2 acres) of dying contaminated plants are likely to reduce DO and may reduce survival of fish in confined or ponded water.

Glyphosate

In the proposed action, aquatic-approved glyphosate-based-herbicides (or GBH) may be used to treat emergent and riparian invasive plants including flowering rush, hairy willow-herb, Japanese knotweed, narrowleaf cattail, perennial pepperweed, phragmites, and yellow-flag iris. For emergent vegetation control, maximum concentrations of glyphosate at plant surfaces or at the water surface will be 2.95 mg/L for high application rates and 0.44 mg/L for low application rates (Table 3, Figure 15).

Glyphosate is a systemic non-selective herbicide. Some chemical properties of glyphosate are shown in Table 8. Several GBHs have recently been found to have “inert” ingredients that include petroleum and heavy metals. These ingredients may increase acute and chronic toxicity, neurotoxicity, and bioaccumulative properties (Defarge et al. 2018). Ford et al. (2017) used protein profiling to identify mechanisms of glyphosate toxicity in mice: initially glyphosate increases liver fat and as an oxidative stress response is metabolized to glyoxylate which inhibits fatty acid oxidation. Serini et al. (2014) found that ingestion (food and water) from multiple sources of GBH caused sublethal effects in rats which led to chronic endocrine disruption and increased mortality rates. Kubsad et al. (2019) found that GBH exposure had few apparent effects on parents and first-filial rats; however, second and third filials exhibited endocrine disruption and increased mortality rates from transgenerational chronic effects. Several studies comparing glyphosate and GBH effects on aquatic organisms show that glyphosate can cause similar or reduced adverse sublethal effects at similar concentrations.

Glyphosate is the most used herbicide on agriculture lands upstream of the action area (Thelin and Stone 2013). More than 6 billion kilograms of GBHs have been applied worldwide in the last decade (Benbrook 2016). In the U.S. there were two glyphosate resistant weeds identified in 2003, and by 2016 there were 17 identified (Heap and Duke 2017). Glyphosate and metabolites

from terrestrial applications and planting of genetically modified glyphosate-resistant (Roundup-ready) crops are now nearly ubiquitous in aquatic habitats (Battaglin et al. 2014). Glyphosate and its metabolites persist in food, water, and dust (Bento et al. 2017; Silva et al. 2018). It occurs in precipitation, plants, and animals, including fish (Wang et al. 1994; Alferness and Iwata 1994; Scribner et al. 2007; Silva et al. 2018).

Glyphosate is a hydrophilic weak acid that readily runs off plant and rock surfaces (riprap, concrete, railroad and highway right-of-ways) after application (Kjaer et al. 2011). Mobility is low in most soils after application because glyphosate strongly binds to mineral sites, particularly chelating metals (e.g., iron and aluminum; Kjaer et al. 2011). Thus, an organic material-metal-glyphosate binding group is formed, but if organic material is not present for the chelating process, the adsorption of glyphosate in soil can be reduced 50–75 percent (Yu and Zhou 2005). When dissolved in water, glyphosate does not bind well to organic matter (Bowmer et al. 1986; Kjaer et al. 2011) and may leach in high concentrations from contaminated plants, organic matter, and wet surfaces for several days and weeks later. Glyphosate that is first absorbed by plants and released later, does not bind well to minerals and delays degradation which can increase its environmental persistence two to six times (Doublet et al. 2009). Glyphosate can also alter soil by fully-loading minerals and metals within a thin surface layer, after which more glyphosate will run off (Yu and Zhou 2005).

Glyphosate has relatively fast degradation rates in sunlit water (3 days, Wang et al. 1994; Table 8), but when shaded in weedbeds or after absorption by plants persistence increased to 2 weeks (Wang et al. 1994; Doublet et al. 2009). The major metabolite of glyphosate is the much more persistent AMPA (Mamy et al. 2005; Annett et al. 2014; Gill et al. 2018). Both forms can enter riparian and aquatic habitats by several routes, including from soil erosion and windblown dust (Bento et al. 2017; Silva et al. 2018) and from runoff and leaching laterally through soil macropores and wetted habitats when dissolved in water (Kjaer et al. 2011). Bowmer et al. (1986) showed that in water only a minor proportion of glyphosate is absorbed onto suspended sediments, even in turbid irrigation water, and its phytotoxicity may not be significantly reduced after moving 17 km downstream. Adsorption by benthic sediments attenuated glyphosate loads at 13–27 percent per kilometer of downstream travel. When sprayed directly onto dry sediment and then flooded only 7 percent of glyphosate was eluted (Bowmer et al. (1986), similarly, vertical leaching rates of glyphosate bound to soil were approximately 15 percent which limits leaching to deeper soils and groundwater (Kjaer et al. 2011).

Battaglin et al. (2014) summarized glyphosate and AMPA occurrence in soil and waters of the U.S. Their results indicate that glyphosate and AMPA are usually detected together, mobile, and occur widely in the environment. Glyphosate and AMPA were frequently detected in soils and sediment, ditches and drains, precipitation, rivers, and streams. Detections were less frequent in lakes, ponds, wetlands, soil water, and groundwater. Concentrations were below levels of concern for humans or wildlife, but pesticides were often detected in mixtures, and ecosystem effects of sublethal and chronic low-level exposures are uncertain (Battaglin et al. 2014). Relatively few studies were found for AMPA toxicity in aquatic environments; generally, results indicate acute lethal and sublethal toxicities were similar or less than its parent compound (Antunes et al. 2017; Matozzo et al. 2018). Glyphosate-use on agriculture crops in the area include Roundup and several other formulations, which include additional ingredients and

surfactants that may be more toxic than those approved for aquatic use. Defarge et al. (2018) analyzed several glyphosate formulations using mass spectrometry and found that other ingredients were commonly metals, petroleum, and surfactants with higher toxicity than the active ingredient.

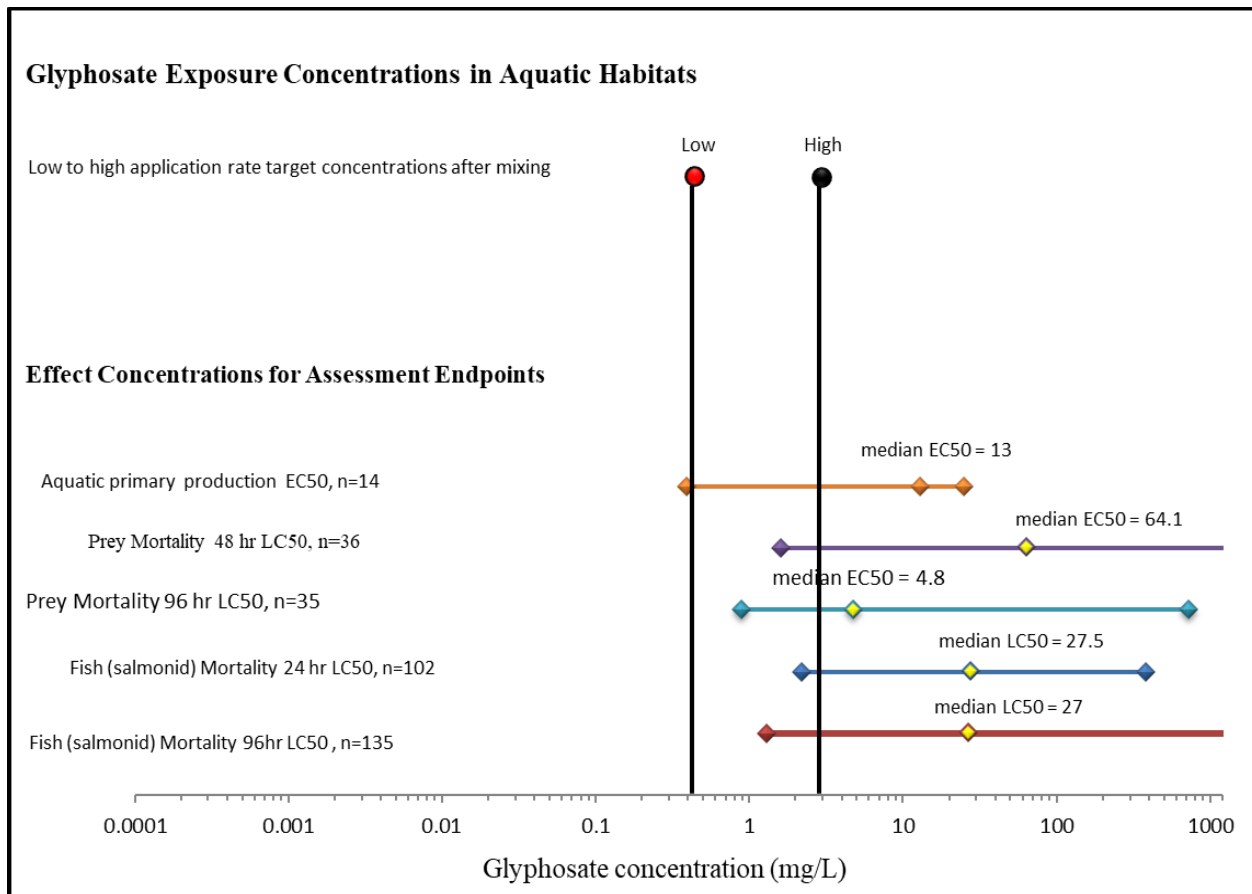


Figure 15. Exposure concentrations for glyphosate in aquatic habitats. Low and high rate target concentrations (red and black circles) are maximum glyphosate concentrations (x-axis) applied to emergent and riparian plants. Colored horizontal lines show ranges of effect concentrations at different exposure durations.

Acute Toxicity: Fish Lethality. Applications of formulations that include glyphosate for the control of emergent and riparian vegetation are expected to produce high-rate target concentrations that are above the 24-hour and 96-hour fish mortality thresholds (Figure 15). The low-rate target concentration is almost an order of magnitude lower than the 24-hour and 96-hour fish mortality thresholds. Sensitive fish may die from the expected short duration exposures to the high target concentration. The exposure to the high target/lethal range concentration would likely be brief (a few minutes), as some volume of the herbicide would enter water during emergent applications but would also be rapidly diluted in a larger volume of receiving water.

Fish Growth from Prey Reductions. Several study results were found for 48-hour and 96-hour acute toxicity thresholds of prey from concentrations of glyphosate (Figure GLY). Prey acute

toxicity thresholds exceed the high rate concentration of glyphosate that is expected to enter receiving water at its surface. The low-rate target concentration is almost an order of magnitude lower than the 48-hour prey mortality threshold. Exposure to formulations containing glyphosate are likely to reduce prey at the high-rate target concentrations, but not at the low-rate target concentrations. Although sensitive prey may die from high-rate target concentrations. Larger areas of dying vegetation will likely reduce abundance of prey in the short term, for approximately 1 to 3 weeks. Juvenile salmonids feeding in treatment areas will likely have less food available. Fish will likely avoid treated areas and feed in surrounding habitat. Because herbicide application will occur only once in the same place in any given year, we find it unlikely that juvenile salmonids will suffer growth related adverse effects.

During spring and summer, adult terrestrial insects are major food sources for Chinook salmon smolts in the lower Snake River (Muir and Coley 1996) and middle Columbia River (Tiffan et al. 2006). Wild Chinook juveniles were found to derive 24–31 percent of their diet from energy-dense terrestrially sourced prey, which only comprised 2–8 percent of hatchery fish diets (Davis et al. 2018). The concentrations of glyphosate sprayed on riparian vegetation in the proposed action is well within the range of concentrations and exposure durations that can have sublethal effects on terrestrial insects. Glyphosate can reduce gut microbiota colonization, reducing growth, and delaying molting of bees and other pollinators during and after exposure from pollen and plants (Vazquez et al. 2018). Honeybee growth may be reduced by low concentration and short duration exposures to glyphosate, along with increased susceptibility to pathogens and increased mortality within hives (Motta et al. 2018; Gill et al. 2018). Honeybee navigation is also impacted as worker bees have reduced ability to return to food sources (Balbuena et al. 2015). Butterflies, terrestrial and aquatic moths, caddisflies, some beetle larvae, and some microbes are sensitive to glyphosate. Rossi-Marshall et al. (2007) found that pollen and plant material from transgenic glyphosate-tolerant crops can accrue in headwater streams in amounts and concentrations that can reduce survival, growth, and production of aquatic caddisflies. Glyphosate can alter aquatic microbial community structure (Austin et al. 1991; Pizarro et al. 2016). Cuhra et al. (2013) found planktonic crustacean (*D. magna*) acute lethality 48-hour EC₅₀s of 1.4–7.2 mg a.i./L for glyphosate IPA. After a 55-day exposure to either formulation, significant reduction of juvenile size was observed even in the lowest test concentrations of 0.05 mg a.i./L. Juvenile salmonids feeding in larger treatment areas will likely have less food available and some individuals may incur reduced growth from feeding on smaller prey.

Sublethal Fish Effects. Several recent studies report significant and broad-spectrum sublethal effects from glyphosate exposure. Glyphosate degrades fish immune systems, which can increase oxidative stress during warm temperatures and increase the difficulty of metabolizing diquat, petroleum products, and metals, causing at least additive effects (Gandar et al. 2017). Glyphosate can cause teratogenic, neurotoxic, carcinogenic, endocrine disruptive, cognitive, and behavioral toxicity at very low concentrations (Roy et al. 2016). Bridi et al. (2017) found that locomotor activity and aversive behavior (cognitive escaping response) were significantly altered in larval zebrafish after 96-hour exposure to concentrations of 0.01 to 0.5 mg/L of glyphosate. Exposure to 0.5 mg/L of glyphosate altered larval development by decreasing ocular distance. Adult zebrafish significantly reduced distance traveled, mean swimming speed, aggression, and inhibitory avoidance memory after 96-hour exposure to concentrations of 0.01 to 0.5 mg/L of glyphosate. After 6-hour exposure to low levels of glyphosate, estradiol and glutathione levels in

the liver were disrupted in smelt fish (Jin et al. 2018). In tetra fish, sperm viability and motility were impaired at 0.3 mg/L and 0.05 mg/L concentrations of glyphosate-based herbicides (Goncalves et al. 2018).

During spring seasons GBH spot-spray applications to emergent and riparian vegetation beginning April 15 and broadcast applications during June will likely expose the most fish to glyphosate. Fish will likely avoid areas of contaminated dying plants for a short time. Relatively small quantities of glyphosate are expected to enter water and relatively fast dissipation and degradation times will reduce concentrations and exposure risk. Applications in shallow, confined, or ponded water may reach 2 acres in size per day. In off-channel habitats a 2-day rest between large applications to contiguous areas is expected to minimize risk of build-up concentrations within an area induced by applications in adjacent areas. However, large daily applications of glyphosate are reasonably certain to cause sublethal effects to fish, such as lethargy, reduced locomotor activity, reduced predator avoidance, and aggression. Those and other sublethal effects could lead to some instances of increased predation mortality, reduced growth, and reduced fitness from increased oxidative stress, immunity degradation, and endocrine disruption.

Indirect Effects. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Glyphosate is acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 15). Treatments of dense monocultures and large areas (maximum 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Summary Glyphosate Effects. Juvenile salmonids are not expected to die from the low-rate target applications, but sensitive fish are expected to die from exposure to high-rate concentrations of glyphosate. Exposure to formulations containing glyphosate are likely to reduce prey at the high-rate target concentrations, but not at the low-rate target concentrations. Although sensitive prey will likely die from high-rate target concentrations, no reductions in abundance or growth of juveniles are expected from these temporary and patchy reductions of prey. Juvenile salmonids feeding in larger treatment areas will likely have less food available and some individuals may incur reduced growth from feeding on smaller prey. Applications in shallow water may reach 2 acres in size per day and will cause sublethal effects to fish such as reduced locomotor activity, swimming speed, cognitive predator avoidance, and aggression. Displacement of fish from temporarily contaminated application areas to surrounding habitats may increase risk of predation. Glyphosate is acutely toxic to sensitive plants and primary producers well below application concentrations (Figure 15). Treatments of dense monocultures and large areas (maximum 2 acres) may reduce DO levels from dying plants which could reduce survival of fish in confined or ponded water or cause fish to avoid treated areas.

Inert ingredients

The proposed action would allow application of any aquatic-approved formulation of active ingredients listed in Table 2. Inert ingredients in herbicide formulations are considered proprietary information and are not necessarily required to be disclosed to the public or

regulatory agencies. There are typically few toxicity studies available for specific formulations. Technology and methods for identifying key ingredients in pesticide formulations have become increasingly available and relatively inexpensive (e.g., mass spectrometry, gas and liquid chromatography, and others). The inert ingredients of several terrestrial-use herbicides have been found to include petroleum and heavy metals with increased acute and chronic toxicity, and bioaccumulative properties (Defarge et al. 2018). These consisted primarily of petroleum-based oxidized molecules, arsenic, chromium, cobalt, lead, and nickel. It is not known if herbicide formulations proposed for use include these inert ingredients but there is risk that some may include these toxicants. The COE will test inert ingredients of a primary GBH formulation proposed for use to reduce this risk.

Polycyclic aromatic hydrocarbons (PAHs). These petroleum-based contaminants are usually in the form of two or more condensed aromatic carbon rings. The PAHs are lipophilic, persistent particularly when bound to sediment, and may disperse long-distances in water. Metabolites are commonly more toxic than the parent, some are carcinogenic, neurotoxic, and cause genetic damage. Although oxidative stress is caused with subsequent cellular damage, and increased energy is required, most organisms can eliminate PAHs from their bodies as part of metabolism and excretion. Some mussels have limited ability to metabolize or degrade PAHs and may accumulate PAHs for years.

The PAHs and metabolites are acutely toxic to salmonids at high levels of exposure, can in some cases bioaccumulate through food webs (water, groundwater, soil, and plants; Zhang et al. 2017), and can also cause chronic sublethal effects to aquatic organisms at very low levels (Neff 1985; Varanasi et al. 1985; Meador et al. 1995). The PAHs can affect DNA within the nucleus of cells, cause genetic damage, and are classified as a carcinogens.

Chromium. Chromium is a common pollutant in aquatic environments. While the pure metallic form is absent naturally, it is commonly found in three oxidation states: Cr II, Cr III, and Cr VI (Bakshi and Panigrahi (2018). Chromium is a redox-active metal, causing oxidative stress and oxidative-induced alterations of DNA in fish and other aquatic organisms (Eisler 1986; Sevcikova et al. 2011). Diquat is also redox active (Sturve et al. 2005) and the presence of chromium can contribute to increased redox strength and oxidative damage. Hook et al. (2006) found that Cr VI caused oxidative stress in rainbow trout, with gene expressions similar to those of diquat. Comprehensive reviews show that chromium is taken up by fish and aquatic organisms through the gastrointestinal tract, respiratory tract, and skin (Eisler 1986; Sevcikova et al. 2011; Bakshi and Panigrahi 2018).

Other metals. Cadmium, arsenic, nickel, and lead are redox inactive metals (Sevcikova et al. 2011). These metals accumulate in sediments, soil, groundwater, plants, and invertebrates from contaminated irrigation drains and herbicide runoff (Farag et al. 1999; Zhang et al. 2017). They can cause oxidative stress, immune defense depletion, hemotoxic, genotoxic, and other adverse effects in fish, invertebrates, and other exposed organisms (Eisler 1985, 1989; Stohs and Bagchi 1995; Sevcikova et al. 2011; Palermo et al. 2015). Lead also induces oxidative damage through direct effects on cell membranes and interactions with hemoglobin. Christensen (1975) found cadmium and lead caused decreases in weight of brook trout (*Salvelinus fontinalis*) alevins. Cadmium is a known teratogen, carcinogen, probable mutagen, and may cause severe deleterious

effects on fish and wildlife (Eisler 1985). Freshwater biota is the most sensitive group and low concentrations of 0.8 to 9.0 µg/L (parts per billion [ppb]) in water may be lethal to aquatic insects, crustaceans, and fish. Sublethal effects of decreased growth, inhibited reproduction, and population alterations are associated with concentrations of 0.7 to 570 ppb of cadmium in water (Eisler 1985). Waterborne exposures of 2–4 days to 10 µg/L cadmium caused oxidative stress and hyperglycemia in tilapia (*Oreochromis mossambicus*), but fish were able to adapt to low cadmium concentrations after 35 days (Pratap and Bonga 1990).

Adjuvants and dyes

Adjuvants, functioning mostly as surfactants and adhesion increasers, improve efficacy of herbicide application and adsorption by plant targets. Adjuvants are proposed to be added to some formulations before application. Adjuvants to be used in the proposed action are limited to those registered for aquatic use that do not contain petroleum or metals and have lower toxicity. There is a wide toxicity range among commonly used adjuvants, with several that are moderately or highly toxic to aquatic organisms (WSDA 2012); these are not expected to be used. Adjuvants are expected to have lower toxicity and faster dissipation and degradation rates than most herbicides proposed for use. Surfactants (spreaders) and oils (stickers) often add to the efficacy and toxicity of active ingredients. Commercial formulations or adjuvants that include petroleum and metals are highly effective biocides, causing acute, chronic, and transgenerational effects among sensitive aquatic and terrestrial organisms.

Use of adjuvants in the proposed action is not expected to appreciably increase the toxicity of herbicides. Dyes are not expected to contain toxic substances or be used in ways that could cause adverse effects to fish or prey.

Chemical spills

There is very low risk of herbicide and fuel spills from the proposed action due to comprehensive measures designed to prevent and contain any chemical spills. Protective measures address spill control, containment, clean up, and reporting procedures. Adverse effects from fuel toxicity are unlikely because equipment refueling of ATVs, trucks, and tractors will not occur within 100 feet of open water.

Summary of APMP effects on salmon and steelhead

Over the duration of the proposed action, the manual, mechanical, and biological treatments are expected to kill or injure very few fish, with impingement of fish on blades of mechanical choppers likely the only direct source of mortality/injury to juvenile salmon and steelhead in and along weed beds. Relatively few fish will be exposed to the mechanical choppers because their use is limited to July 1–September 15, when most juvenile salmonids will tend to be offshore, along sparse aquatic vegetation and current, and not in the areas where mechanical choppers will be used. The manual, mechanical, and biological treatments (along with the chemical treatments) can cause indirect adverse effects on fish through activity-caused disturbance/displacement and thus increased exposure to predation, and through killing/reducing vegetation which in turn: reduces cover and increases exposure to predation, temporarily

reduces DO, and temporarily reduces abundance of the prey species associated with the aquatic vegetation. Those effects from disturbances/displacement and vegetation reduction associated with the program treatments as a whole are discussed below, after the summary of direct effects (lethality and sublethality) expected on fish and prey from the proposed treatments with herbicides.

Over the duration of the proposed action, herbicide applications to riparian, emergent, and submerged plants are expected to cause direct adverse effects on listed fish. Fish lethality is expected from submerged applications of diquat, 2,4-D, endothall, and SCP before mixing. Fish lethality is expected from submerged applications of only high-rate concentrations of fluridone and triclopyr TEA before mixing. Fish lethality is also expected from high-rate target concentrations of 2,4-D and glyphosate. Lethality is not expected from unmixed or target applications of imazamox and imazapyr.

Exposures of fish to high-rate target concentrations of glyphosate (which is proposed only for emergent applications) will generally be very brief, as the target concentration is delivered at the nozzle, a substantial portion is delivered to emergent plants, and the portion that lands on water is rapidly diluted. However, glyphosate and 2,4-D may be used for treatment of emergent plants in very shallow, still water in the spring, when sensitive life stages of fish will be present and some fish likely exposed, at least briefly, to lethal concentrations. The duration of exposure to unmixed and target concentrations of 2,4-D will be longer in submerged applications and more likely to kill exposed fish; however, with timing restricted to July 1–September 15, sensitive life stages will not be present, and most older subyearling and yearling fish will be offshore, near margins of treatment areas, where dilution is continuous and exposure time likely limited to a few hours. Exposure of fish to submerged applications of diquat, endothall, and SCP present somewhat lesser risk of killing fish than with 2,4-D. There will likely be sublethal adverse effects on fish from diquat, as summarized below.

Chemical testing and documented lethality typically are based on at least 24-hour exposures. However, as noted above, short duration exposures have been shown to kill fish in some limited testing, and we cannot assume exposures of a few hours do not kill some fish when 24-hour exposures kill 50 percent of fish. A cautious approach to translating adverse effects from in vitro lethality studies is also warranted by the unknowns and potential added toxicity of the “inert” ingredients (such as PAHs and metals) in the formulations used, and by the additional chemical and physical stressors fish experience in the action area. Additive effects from “inert” ingredients such as petroleum and heavy metals can include increased oxidative stress, acute and chronic lethality, neurotoxicity, lower fitness, reduced growth, and reduced survival of some exposed individuals.

Sublethal effects are expected from unmixed and target concentrations of diquat and target concentrations of glyphosate, which will reduce growth, increase oxidative stress, degrade and deplete immune response, and reduce locomotor activity and cognitive predator avoidance that will cause some fish to die from the exposure or from increased predation. Glyphosate is expected to cause chronic endocrine disruption, and may have transgenerational effects to a relatively small number of exposed fish and prey. Sensitive prey will likely die from most applications of herbicide.

Most instances of lethality and sublethality are expected during the first 3 years of flowering rush EDRR treatments. Otherwise, few fish from affected populations will be exposed to harmful project-related disturbances during summer. Spring-season broadcast applications of diquat and glyphosate will cause significant sublethal harm to relatively small numbers of exposed fish that may later die from the injury, have slowed migration and/or, reduced growth that lowers survival, or suffer increased predation.

As noted above, prey base for fish will be reduced by direct toxic effects of herbicides on prey, but also will be reduced, at least temporarily, by all forms of treatments killing and reducing vegetation which fosters production and proliferation of certain prey species. Juvenile salmonids feeding in treatment areas will thus likely have less food available. Sustained multi-week reductions in prey are unlikely given the flowing waters of many application sites, relatively fast degradation rates of active ingredients, limits to size of treatment areas within the action area as a whole, and likely regrowth of some vegetation (in some cases native vegetation replacing non-native vegetation) within weeks. Daily treatments of contiguous 2- to 5-acre blocks within the same treatment area may increase the extent and the duration of vegetation loss and chemical concentrations that are adequate to kill invertebrates and reduce prey abundance over longer periods, which may cause reductions in growth among some fish in these situations. However, because applications will occur only once in the same place each year, we find it unlikely that juvenile salmonids will suffer growth related effects that manifest into population level impacts.

Physical, biological, and chemical applications will cause many instances of disturbance and temporary displacement of fish from their habitat during the program, which will cause some increase in exposure to, and instances of predation of juvenile salmon and steelhead. Predators including channel catfish, bass, and northern pikeminnow are abundant and well distributed within the action area, and risk of predation from increased exposure is generally high. Displacement of fish will likely be temporary and inconsequential in most cases, but sustained displacement to more exposed habitats may occur with removal of vegetation that fish had used for cover, and in instances when fish can detect and tend to avoid certain herbicides applied in and along their holding/feeding areas.

Herbicides proposed for use are acutely toxic to sensitive plants and primary producers well below application concentrations. Treatments of dense monocultures and large areas (maximum 2 to 5 acres) will reduce DO levels from dying plants that will likely cause lethality of fish and prey in confined or ponded water, cause fish to avoid treated areas for short periods of time afterward, and will cause reductions in growth of juvenile fish.

2.4.1.3 Relevance of Fish Effects to Populations, MPG, DSP/ESUs Viability

Effects to individual fish may, in turn, affect the attributes associated with the VSP that the ESUs and DPSs comprise. As summarized above, NMFS believes that over the 10-year term of the program there will be adverse effects on individual salmon and steelhead from impingement on mechanical choppers, lethal and sublethal toxicity to fish from herbicide applications, localized reduction in prey base caused by herbicide toxicity to prey and by killing/removal of vegetation, displacement of fish/increased predation caused by treatment activities and removal of vegetative

cover, and physiological stress on fish caused by reduced DO associated with areas of killed vegetation.

Those effects, however, will involve small percentages of the populations present in the treatment areas during the main program activities and low likelihood of adverse effect to most individuals that are present/exposed. For instance, the biggest effects on fish from the program likely involve submerged treatments of flowering rush in McNary pool, but relatively few fish will be killed or harmed sublethally due to summer timing that has the vast majority of year classes' migrants out of the area and most remaining fish positioned offshore where exposures would be limited. Similarly, spring treatments in shallow waters, while they expose many more fish including sensitive lifestages, also involve much lower volume of chemicals and lower concentrations such that very small proportions of fish exposed will likely experience sublethal effects and extremely small proportions would be killed in treatment areas. The treatment areas are a small percentage of the available spring rearing habitats in the action area in any given year, which also reduces proportion of populations exposed and adversely affected. Overall, few fish from affected populations will be exposed to and experience harmful project-related effects.

The proposed action should not influence the productivity, spatial structure, or genetic diversity of the ESA-listed salmonid populations. Collectively, effects will not be substantial enough to influence VSP criteria at the population scale, the viability of the MPGs and ESU/DPS are also not expected to be affected.

2.4.2 Effects on Critical Habitat

Critical habitat within the action area has an associated combination of physical and biological features essential for supporting spawning, rearing, and migrating salmon and steelhead populations. The critical habitat PBFs most likely to be affected by the proposed action include forage, cover/shelter, water quality (chemical, shade/temperature, turbidity), and substrate quality.



Figure 16. McNary levee system ditch, showing typical vegetation management and exposed water.

2.4.2.1 Water Quality

Vegetation is a key component of small stream, floodplain, riverine, and lacustrine ecosystems. Numerous processes and structures balancing water quality and the function of riparian and aquatic habitat are affected by vegetation. Vegetation affects hydraulic (current, waves) and thermal dynamics of rivers and lakes by shading sunlight, slowing flow, stabilizing sediments, and filtering suspended particles (Dosskey et al. 2010). Aquatic vegetation recycles oxygen and carbon dioxide, usually increasing DO, which is particularly beneficial for listed salmonids. Vegetation recycles nutrients, filters contaminants, repels and reduces algae (Gross 2007), and affects sediment processes by providing a network of plant roots and organic biomass to stabilize shorelines, stream banks, and floodplains, reducing shoreline erosion and increasing water clarity. Waters with the most riparian and aquatic vegetation and best water quality tend to have highest invertebrate and zooplankton community richness (Dodson et al. 2005) and, consequently, more salmonids. In turn, the distribution and growth of vegetation interacts with salinity, light, temperature, nutrients, current and substrate, and other properties of water and the environment.

The water quality PBF in the action area will likely be adversely affected by the loss of/dying vegetation causing at least temporarily reductions in DO. Rapid consumption of oxygen from dying vegetation over large areas could result in a greater demand for DO (USDA 2014). The proposed action includes herbicide treatment of 2- to 5-acre areas each day, in a serial and contiguous pattern (e.g., 10- to 25-acre solid blocks could be treated each work week. Weekly applications to 25-acre areas are limited to submerged treatments during summer. In confined habitats (canals, drains, small streams, ponds and sloughs with small outlets) DO levels will drop enough to cause lethality of fish and prey and thereby substantially degrade the water quality PBFs for 2 to 3 weeks over relatively large areas.

Properly functioning aquatic and riparian communities are extremely limited within the action area. Non-target plants within, adjacent to, and downstream of treatments will be inadvertently killed by the proposed action. Water quality in small parts of the action area will be temporarily and locally degraded due to mechanical and manual treatments, herbicide inputs, locally increased water temperature from reduced shade after invasive plants are killed, and resuspension of sediments and disturbance of shallow water habitats during treatment. The proposed action is expected to produce turbidity in small areas (<1-acre) and low intensities.

The water quality PBF will also be reduced from introduction of herbicides. Submerged applications before mixing will include concentrations of 2,4-D, diquat, endothall, fluridone, triclopyr TEA, and SCP that will kill sensitive aquatic invertebrates directly in their path. Unmixed low-rate concentrations of fluridone and unmixed or mixed target concentrations of imazamox and imazapyr are not expected to kill aquatic or terrestrial invertebrates. Target (mixed) concentrations of 2,4-D, diquat, triclopyr TEA, and SCP) are expected to kill sensitive aquatic and terrestrial invertebrates during and after emergent, submerged, and riparian applications. Low-rate target concentrations of glyphosate are not expected to cause acute lethal effects to aquatic or terrestrial invertebrates. Glyphosate and diquat at all proposed concentrations will have substantial sublethal and latent effects on aquatic and terrestrial invertebrates, leading to reduced survival and production for locally exposed communities. Glyphosate stably sorbs to most soils yet readily runs off plant and rock surfaces into water. In water glyphosate is highly mobile, does not readily sorb to wetted sediments or organic matter, and phytotoxicity may persist for 1–2 months along with that of its metabolite AMPA. Diquat applied to water sorbs readily and strongly to organic matter and sediments; however, in clear flowing water of serial reservoirs organic material is limited in water columns and diquat may not reach sediments. Diquat phytotoxicity in water may persist for several weeks if not bound to detritus or sediments and could still contribute sublethal toxicity when ingested and metabolized by benthic invertebrates (Williams et al. 1984). Project-introduced glyphosate, its metabolite (AMPA), PAHs, and metals could persist in the action area and contribute to degraded baseline water quality. These instances and levels would reduce the water quality PBF in the short term and contribute to persistence of impairment of the water quality PBF in the action area.

Background levels of herbicides in waters of the action area are below lethal effects levels for salmonids and their forage by typically about two to three orders of magnitude (0.1 ppb versus 10–500 ppb). However, glyphosate may slightly contribute to baseline loads. Background levels of herbicide are expected to be below effects thresholds for nontarget aquatic plants and other primary producers by about one to three orders of magnitude (0.1 ppb versus 1–270 ppb), but herbicide added by the proposed action will contribute to baseline levels each year.

Concentrations will dissipate after a few days or weeks in water after application, and residues in plants and sediments will degrade within days to months and most within a single year. Overall, the proposed action will slightly contribute to degraded water quality PBFs in the long-term, and water quality PBFs will be detectably impaired in localized areas for short periods each year.

2.4.2.2 Substrate

Removing and reducing aquatic vegetation will expose areas of substrate and could alter sediment scour or aggradation in small areas. Substrate mats may resuspend small amounts of fine sediments at installation, during maintenance, and removal. Substrate mats cover substrates during use and leave open areas afterward. Among the manual methods proposed, substrate mats may have the greatest potential to alter substrate function, but they only affect relatively small areas, such as under marina boat lanes or around swimming areas, within larger surrounding areas of vegetated substrate. Manual and mechanical treatments of small areas will re-suspend and deposit only small amounts of sediment, with visible plumes expected to remain less than 300 feet in length and depositions in small areas immediately below disturbed sites. Chemical treatments will contaminate substrate sediment at low levels, but only temporarily as these herbicides will mostly degrade each year. Project-introduced glyphosate, its metabolite (AMPA), PAHs, and metals could persist in the action area and contribute to degraded baseline sediment quality. These instances and levels would result in small, localized effects on the substrate PBF in the short term and contribute slightly to longer-term impairment of the substrate PBF.

Aquatic vegetation is important to rearing, overwintering, and migrating juveniles and to migrating and staging adult salmonids in the action area. Water and soil temperatures can be strongly reduced by shade from riparian or aquatic vegetation (Dosskey et al. 2010). Sediment quality in small disparate sites within the action area may be slightly and temporarily degraded due to mechanical and manual treatments, herbicide inputs, locally increased temperature from reduced shade after invasive plants and some incidental nontarget plants are killed, and the limited resuspension of sediments and disturbance of shallow water habitats during treatment. Overall, the proposed action will slightly contribute to degraded substrate PBFs in the long-term and result in small but detectable impairment of the PBFs in localized areas for short periods each year.

2.4.2.3 Cover/Shelter and Forage

Vegetation provides structural cover and food for listed salmonids and their forage. Aquatic plants are important to the altered habitats of the action area for many reasons including water purification, nutrient recycling, affecting flow patterns, and creating discrete habitat as physical structure in the water column (Cowx and Welcomme 1998). Lusardi et al. (2018) found macrophytes supported up to nine times greater abundance of invertebrates than gravel habitats, doubled invertebrate drift rates, and reduced water velocity by up to 42-fold. Aquatic plants provide refugia for zooplankton, cover and forage for larger invertebrates and other prey, and cover and forage for rearing salmonids. Shallow lakes with the most riparian and aquatic vegetation and best quality water tend to have highest zooplankton community richness (Dodson et al. 2005). Studies have documented the importance of biological interactions between aquatic plant species (Titus and Stephens 1983, Doyle et al. 2003), physical factors (Barko et al. 1984; Barko and Smart 1986; Madsen et al. 2001), and chemical properties of the environment (Titus et al. 1990; Pagano and Titus 2004; Engelhardt 2006).

In small streams of the Mill Creek project area, riparian and aquatic vegetation is used year-round by all ages of juvenile steelhead for cover and production of their forage, and by adult steelhead during winter and spring for cover. In larger rivers and reservoirs of the lower Snake

and Columbia Rivers, shoreline vegetation may be relatively less important as cover for older juveniles during summer yet remain important to fry and subyearlings (Connor et al. 2015). During late spring and summer in these large rivers and reservoirs, many subyearlings and older juveniles move offshore where riparian and aquatic vegetation remains important for their forage production (Bennett et al. 1983, in Gottfried et al. 2011). Reservoirs may decrease zooplankton diversity from that found in rivers and natural lakes (Simoes et al. 2015) and nearly half of the organic matter used by zooplankton in reservoirs may come from allochthonous (outside) sources (Emery et al. 2015). Riparian and aquatic vegetation along rivers produce insects and other invertebrates that may drift downstream for miles and provide preferred food for salmonids even in deep reservoirs (Gustafsson et al. 2010).

Studies from around the world and this region document benefits and use of riparian and aquatic vegetation by juvenile salmonids (Halvorsen and Jorgensen 1996; Beland et al. 2004; Henning et al. 2006; Dosskey et al. 2010; Inoue et al. 2013). Juvenile salmonids near stream mouths in Lake Washington were usually close to peripheries and associated with shoreline and overhanging vegetation (Tabor et al. 2006; Tabor et al. 2011). Rearing juvenile Chinook salmon were found along entire sections of shoreline with large numbers present in open areas near boat ramps. However, there were three times fewer in developed areas of riprap or bulkheads (Tabor et al. 2006; Tabor et al. 2011). In the lower Willamette River, shorelines with vegetation were habitats used by rearing and migrating subyearling Chinook salmon (Friesen et al. 2007). Beechie et al. (2005) found fry or juvenile Chinook, chum, and coho salmon used aquatic vegetation for cover in the lower Skagit River. Hardy et al. (2006) quantified preferential use of emergent and other vegetation as escape cover by salmonid fry and some older juveniles in the Klamath River. Lusardi et al. (2018) found juvenile steelhead preferentially selected macrophyte habitat at a rate 3.2 times greater than the five other habitat types available and macrophyte habitat accounted for approximately 40 percent of all subyearling steelhead observed.

Salmonids and their prey depend on riparian and aquatic vegetation throughout the action area. The cover and forage PBFs will be at least temporarily reduced in function by each type of treatment, including mechanical treatments, which will temporarily reduce target and nontarget vegetation, and associated epiphytes (primary producers that are attached to plants). Substrate screens will temporarily eliminate benthic organisms by the area and duration of use, and reduced densities may persist for weeks or months afterward. Natural cover and prey habitat, within the treatment area will be reduced by treatments with the proposed herbicides, which will be applied in concentrations proven effective at killing aquatic plants. Several studies evaluated toxicity to plants and expected unmixed and mixed concentrations will cause severe reductions in living plants within treatment areas. Larger treatment areas, especially those with consecutive daily and contiguous 5-acre (submerged) or 2-acre (emergent) applications will have increased impact, as food resources will be less available over increasingly greater areas extending a few weeks of each relatively short growing season after each treatment. Migrating juveniles will likely spend less time in these areas as they are moving downstream, and therefore they may find more food further from the treatment area. Slower moving juveniles, rearing at lower densities for extended periods may have less food for extended periods (1–3 weeks) during the growing season, thereby the temporarily reduced function of the forage PBF occurs at a time when it will affect some fish.

The extent of effects to riparian and aquatic habitat cover and forage PBFs is primarily related to the extent of the treatment area, and the type, duration, and repetition of treatments. Protective measures ensure that harm to nontarget plants will be incidental or only in nuisance situations, and localized and temporary. Fall-season applications will reduce growth and reestablishment of vegetation until the following spring. During spring, spot-spraying of emergent and riparian target plants will limit incidental reductions of native plants and algae. The chemicals proposed for use are formulations designed for aquatic use that dissipate and degrade fairly rapidly. Vegetation does tend to regrow annually in treatment areas, particularly those managed for vegetation control and site maintenance.

The action's short term, distributed, and yet annually repeated effects on cover and water quality PBFs occurs in combination with baseline effects on riparian vegetation that is killed 15 feet or more from water or when water levels are lower within exposed shorelines of reservoirs from the COE's terrestrial plant control program (COE 2012a). Low seral stages of vegetation with reduced perennial growth of trees and other plants have been consistently maintained resulting in depauperate riparian ecosystem function, which ultimately warms waters and near-water lands throughout the District and contributes to degraded water temperatures in shallows and surfaces of even large rivers and reservoirs. Dampening of riparian vegetation and associated PBFs has occurred through time and is likely to continue under the APMP.

Factors affecting prey species are likely to temporarily reduce the forage PBF in treatment areas. The growth of juvenile salmonids is largely determined by the availability, consumption rate, and energy content of prey in freshwater systems (Mundie 1974; Beland et al. 2004; Sergeant and Beauchamp 2006; Tiffan et al. 2014). Food supplementation studies have shown a clear relationship between food abundance and size on the growth rate and biomass yield of juvenile salmonids (Mason 1976; Wankowski and Thorpe 1979). More large-bodied invertebrates are produced in aquatic and riparian vegetation than in open areas without either type or any vegetation (Gustafsson et al. 2010; Inoue et al. 2013; Lusardi et al. 2018). Activities that kill or otherwise reduce vegetation and woody material have potential to reduce the abundance of macroinvertebrates and reduce the energetic efficiency for growth in salmonids (Lusardi et al. 2018). Less or smaller-sized food can also induce density-dependent effects, such as increased competition and altered emigration timing as prey resources are reduced (Gustafsson et al. 2010; Inoue et al. 2013; Tattam et al. 2013). These considerations are important because juvenile growth is a critical determinant of subsequent freshwater and marine survival (Higgs et al. 1995; Thompson and Beauchamp 2014) and adult return (Arthaud et al. 2010). Chinook smolt survival increases with body-length during migration and in the ocean (Zabel and Williams 2002; Mebane and Arthaud 2010; Macneale et al. 2010), particularly in altered systems. In the action area, smaller wild-reared smolts may migrate at slower rates and use shallower peripheries of channels. These fish depend on size and maximum growth rates for survival, and are vulnerable to predation, competition, starvation or exhaustion (Muir and Coley 1996; Macneale et al. 2010; Davis et al. 2018).

Salmonid prey are typically more sensitive to the proposed herbicides than fish. Terrestrial insects in emergent, riparian, and terrestrial vegetation above or near the surface of water may be killed from applications of herbicides. Herbicide toxicity will be reduced as herbicide dries, is taken up by plants, and continues to degrade. The forage base for salmonids is expected to be

reduced by chemical treatment in riparian, emergent, and submerged application areas and afterward as plants die. This reduction will be temporary and similar habitat will be available outside of treatment sites. Water and soil concentrations of herbicide dissipate and degrade to low levels within a few days, and invertebrates will soon reestablish the area with regrowth of vegetation after 3 weeks. At treatment sites, prey abundance and productivity are expected to be measurably reduced for days to weeks after treatment. The forage PBF will be at least temporarily and locally reduced by the proposed treatments.

Riparian habitats are particularly important and sensitive, including mature trees and other shade, vegetation used as cover by salmonids, and vegetation producing preferred salmonid forage (Dosskey et al. 2010). Spot applications, removing patches or individual trees will leave only small openings that will typically close naturally each season from surrounding vegetation without further effort.

The proposed action includes treatment of 2-acre to 5-acre areas each day, which may expand in serial and contiguous patterns (e.g., solid blocks of habitat measuring 10–25 acres could be treated each work week). Target and non-target vegetation will be cleared by chemical treatments, which will reduce cover and food available for migrating and rearing salmonids. Weekly applications to 25-acre areas are limited to submerged treatments during summer, but 10-acre weekly clearings of emergent and riparian plants may also occur during spring. These large clearings will substantially reduce the functions of cover and forage PBFs over relatively large areas for 1–3 weeks, at least temporarily reducing function of cover and forage PBFs within treatment areas each growing season over the 10-year program.

2.4.2.4 Summary of Effects on Critical Habitat

In the altered and degraded habitats of the action area, riparian and aquatic vegetation are crucial for cover, shading water and substrates, and maintaining production of preferred salmonid prey. In the short-term, project activities will impair water and substrate quality, cover, and food PBFs for portions of each growing season. Longer term effects are possible, for instance from additional glyphosate degradants in the substrate, adding small amounts to low but detectable levels in the base line. The proposed action includes herbicide applications of 2-acre to 5-acre areas each day, which in floodplain habitat may expand in serial and contiguous patterns (e.g., solid blocks of riparian and aquatic plant habitat measuring 4–10 acres each work week, and up to 25 acres per week of submerged vegetation treated within areas during summer). These large clearings will substantially degrade cover and forage PBFs over relatively large areas for 1–3 weeks, temporarily reducing water quality, cover, and forage PBF functions in the treatment areas each growing season over the 10-year program.

2.5 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Pesticide use by state and private entities in the action area is expected to be maintained at current levels or slightly increase into the future. Various contaminants, including industrial by-products and pesticides, will likely continue to be delivered to the action area from upstream sources and local runoff. Increased awareness of toxic and carcinogenic effects and further state regulation may reduce use of certain pesticides; however, overall concentrations in runoff are not likely to be reduced for many years. The contamination of sediments should gradually improve with continued bans on legacy organochlorine-based pesticides; however, other sources and uses of other persistent organic pesticides will continue.

States of Idaho, Washington, and Oregon are reasonably certain to continue managing water quantity in a fashion that perpetuates baseline upstream water consumption and reduced flows through the action area. The annual hydrographs of the Snake and Columbia Rivers show significant reduction due to water use. Declines in peak flows during spring and summer are well documented (Brannon et al. 2004; Naik and Jay 2011). Fall and winter flows are impacted by groundwater use for irrigation and the resulting depletion of aquifers (Van Kirk and Naman 2012; Naik and Jay 2011). These continued impairments of water quantity will likely tend to perpetuate present features (including water levels and temperatures) of the altered ecosystem in the lower Snake River and McNary pool. Those present features of the action area will be further altered by the effects of climate change, as noted in the Environmental Baseline (Section 2.3, above).

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we combine the effects of the action (Section 2.4) with the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

There will be instances of lethal and sublethal effects on listed species caused by herbicides used in APMP. Mechanical and manual methods will likely kill or injure a few juveniles that attempt to hide in vegetation and are cut, covered, or crushed. Program effects will also include increased risk and incidence of predation of juvenile salmon and steelhead caused by their temporary displacement from cover by small and temporary disturbances, turbidity, avoidance of low concentrations of herbicide, and temporary loss of small patches of nonnative vegetation. There is low risk of indirect effects from herbicide toxicity or of reduced growth and fecundity from the small areas of nonnative vegetation removal and associated temporary effects on prey base. Overall, few fish from affected populations will be exposed to harmful project-related disturbances. The effects of the proposed action will not likely be great enough to appreciably reduce the VSP parameters of listed species within the action area. Collectively, because effects will not be substantial enough to influence VSP criteria at the population scale, the viability of the MPGs and ESU/DPS are also not expected to be affected. Baseline conditions for salmonids

in the action area are expected to remain the same or be slightly reduced by climate change over the 10-year duration of the action. Cumulative effects from future non-federal activities are expected to perpetuate conditions in the baseline. Given the conditions described above for the status of the species, baseline, and cumulative effects, the proposed action is unlikely to appreciably reduce the likelihood of the survival and recovery of the species analyzed in this Opinion.

The proposed action will primarily affect the PBFs of forage, cover, substrate quality, and water quality. Juvenile salmonids in the action area depend on both terrestrial and aquatic insects. Both will be negatively affected by the proposed action. However, these effects will be localized (primarily treatment patches) and temporary. Water quality will be adversely affected through several mechanisms. As aquatic vegetation dies, it will cause reductions in DO. These effects will also be localized and of short duration. Water quality will also be negatively affected by the actual herbicides that are being applied under the proposed action. The effects on water quality in the immediate areas of application could be severe and render those areas unsuitable for salmonids until the retardant dissipates; a matter of minutes or hours in most cases. Detectable, lower levels of herbicide may occur for several months. The proposed action will degrade the water quality PBF in the short term, but will not contribute to a long-term reduction in function of that PBF. Effects to substrate from the proposed action will occur as patches of aquatic vegetation die and the substrate is exposed to wave and current action. These effects will be small but sediment PBFs will be impaired in localized areas for short periods of time each year. In terms of the overall action area, the effects on PBFs from the proposed action will be localized and short-term. Baseline conditions for salmonids in the action area are expected to remain the same or be slightly reduced by climate change over the 10-year duration of the action. Cumulative effects from future non-federal activities are expected to perpetuate conditions in the baseline. Because these effects will be localized and short-term, even considering the status of critical habitat, cumulative effects, and baseline conditions, the proposed action will not likely reduce the conservation value of designated critical habitat.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' Opinion that the proposed action is not likely to jeopardize the continued existence of SRB steelhead, SR spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon, UCR spring Chinook salmon, MCR steelhead, and UCR steelhead or destroy or adversely modify their designated critical habitat.

2.8 Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly

impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.8.1 Amount or Extent of Take

The proposed action is reasonably certain to result in incidental take of ESA-listed species. NMFS is reasonably certain the incidental take described here will occur, because fish from seven ESUs/DPSs are known to occur in the action area and the proposed action includes effects that may cause harm through death or injury of individual fish that are exposed to unmixed and mixed concentrations of herbicide and, reduced DO levels after treatment, of very few fish that directly contact mechanical treatments, and from temporary displacement of fish from treatment areas that are reasonably certain to lead to increased levels of predation on ESA-listed species. There will also be short-term decreases in cover and forage for listed fish that will likely adversely affect a few fish.

Monitoring or measuring the number of salmon or steelhead actually harmed during project activities is not feasible. This is because it is not possible without knowing the precise number of juveniles hiding in vegetation and substrate or the exact locations where treatments may occur; this is highly variable between locations and time periods. Additionally, bodies of fish that suffer lethality or reduced fitness from herbicide toxicity and reduced DO levels, or that are victims of predation will not be visible. For these reasons, NMFS will use surrogates for measures of the extent of take caused by the proposed action.

We expect that the number of fish that are harmed or killed by herbicide toxicity, physical contact with mechanical vegetation removal, DO reductions, reduced prey and cover, and increased predation as a result of displacement will be proportional to the amount of chemical applied and size of single and contiguous treatments. In turn, because vegetation controls are measured in volume of herbicide per acre, amounts of chemical used will be proportional to the acreage treated. For this reason, the number of acres treated per year is a suitable surrogate for the amount of herbicide used and the harm caused by vegetation treatments under APMP.

The extent of incidental take anticipated and analyzed in the Opinion is exceeded if:

1. Area disturbed by vegetation control exceeds 400 acres (approximately 5 percent of the littoral zone/riparian area acreage in the project area) in any year, or
2. Area disturbed by vegetation control exceeds 4,000 acres (approximately 50 percent of the littoral zone/riparian area acreage in the project area) over 10 years.

Surrogates 1 and 2 function as effective reinitiation triggers because they represent annual and overall limits for each activity and the consultation is for a 10-year period. Reinitiation could

therefore be triggered earlier than when the proposed action is completed. The authorized take includes only take caused by the proposed actions within the action area as defined in this Opinion. The extent of take is a specific threshold for reinitiating consultation. Should any of these limits be exceeded, the reinitiation provisions of the Opinion apply.

2.8.2 Effect of the Take

In the Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.8.3 Reasonable and Prudent Measures

“Reasonable and prudent measures” are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

The COE shall:

1. Minimize incidental take from APMP activities through implementation of all precautionary measures.
2. Ensure completion of a monitoring and reporting program to confirm that the terms and conditions in this ITS are effective in avoiding and minimizing incidental take from permitted activities and that the extent of take is not exceeded.

2.8.4 Terms and Conditions

The terms and conditions described below are nondiscretionary, and the COE or any contractor must comply with them in order to implement the RPMs (50 CFR 402.14). The COE or any contractor has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement RPM 1:
 - a. Ensure no more than 400 acres are treated in a single year and no more than a cumulative 4,000 total acres are chemically treated over 10 years.
 - b. Ensure that proposed conservation measures and BMPs are followed, including treatment seasons and any applicable state seasons that may be more restrictive.
 - c. Broadcast applications will only be used on monocultures of emergent and riparian target plants after June 1.

- d. Use low application rates whenever practicable to effectively control targets yet minimize adversity to native plants, listed salmonids and their prey.
 - e. Ensure that herbicide formulations used do not include petroleum or heavy metals.
2. The following terms and conditions implement RPM 2:
 - a. Monitor and report the global positioning system (GPS) location, size, and distribution of mechanical, and substrate mat treatments.
 - b. Monitor and report annually each year's application of chemicals on District lands and waters.
 1. The annual implementation monitoring report shall contain:
 - GPS coordinates, dates, acres of applications;
 - Aquatic acres treated at each site;
 - Application rate (lbs/acre);
 - Approximate nozzle depth used during submerged applications;
 - Formulation used;
 - Approximate depth of water during application;
 - Approximate flow rate in application area (cubic feet per second);
 - Areas and sites of native vegetation treated as targets;
 - Submit terrestrial and aquatic monitoring reports together.
 2. Work with NMFS to set-up a sampling design to test concentrations and mixing of submerged herbicide treatments at different depths and water exchange rates. A minimum of six grab samples shall be collected. In the first year of the program, testing dilution rates of dye can be used as a surrogate for concentrations of herbicide. The grab sampling of water to test concentrations of herbicide shall take place in the second year of the program and, at a minimum, every 3 years thereafter. If sampling determines that mixing is not occurring as described in the Opinion, the COE shall adjust their delivery methods as needed.

3. The annual efficacy monitoring report, vegetation management shall contain:
 - Area and distribution of native and invasive vegetation;
 - Reestablishment and coverage of invasive and native vegetation in previously treated areas;
 - Native vegetation propagation areas;
 - Cumulative relative change and status.
4. Maintain and compile information that may help reduce fish exposure and limit impacts:
 - Peripheral and floodplain habitats that may serve as rearing habitat;
 - Sites with low water movement, low conductivity, nonuniform mixing;
 - herbicide movement and dissipation properties within and downstream of submerged application sites and afterward;
 - Contact Washington Department of Fish and Wildlife; Oregon Department of Fish and Wildlife, and Idaho Department of Fish and Game annually for their updated results of juvenile fish sampling along shorelines in McNary pool and elsewhere in the APMP action area; based on that information discuss with NMFS adjustments to timing and/or location of herbicide treatments that can appreciably reduce exposure of juvenile salmon and steelhead to herbicide treatments.
- c. Notify NMFS of EDRR changes or additions.
- d. Operators will monitor and report injured or dead fish found at the time of treatment or afterward that were likely caused by the action.
- e. Submit annual reports by May 1st of each year following program activities to:

National Marine Fisheries Service
Attn: Ken Troyer
800 East Park Boulevard
Plaza IV, Suite 220
Boise, Idaho 83712-7768

2.9 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and

endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

The following recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the COE:

- To mitigate the effects of climate change on ESA-listed salmonids, follow recommendations by the Independent Scientific Advisory Board (2007) to plan now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures. In particular, implement measures to protect, reestablish, and restore vegetative components of riparian forests, shorelines, wetlands, and floodplains, including vegetated buffer strips throughout the District. Adjust management of ditches and drains by using appropriate vegetation to shade and filter water and sediments.
- Seek opportunities to protect undeveloped areas or restore developed areas of the Snake and Columbia River floodplains into the future, including researching, establishing, and restoring extensive acreages of functioning native vegetation communities on levees, riprap, embankments, canals, and drains. Research and apply functioning aquatic and riparian vegetative communities along the lower and upper edges of fluctuating water zones.
- Develop a riparian and aquatic vegetation management plan among regional COE Districts that will improve ecosystem function and resilience throughout the Columbia River Basin.

Please notify NMFS if the COE carries out these recommendations so that we will be kept informed of actions that minimize or avoid adverse effects and those that benefit ESA-listed species or their designated critical habitats.

2.10 Reinitiation of Consultation

This concludes formal consultation for the COE's APMP.

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

To reinitiate consultation, the COE should contact the NMFS Idaho State Habitat Office in Boise, Idaho, and refer to the NMFS number assigned to this consultation.

3. MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (Section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the COE and descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fisheries Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The PFMC designated EFH in the states of Washington, Oregon, and Idaho for the freshwater life stages of Chinook salmon and coho salmon (PFMC 1999). The action and action area for this consultation are described in the Introduction to this document. The action area includes areas designated as EFH for various life-history stages of Chinook and coho salmon. Habitat areas of Particular Concern in the action area that would be adversely affected by the action are local areas of cover and food producing vegetation.

3.2 Adverse Effects on Essential Fish Habitat

Based on the information provided in the BA and the analysis of effects presented in the ESA portion of this document, NMFS concludes that the proposed action will have the following adverse effects on EFH designated for Chinook and coho salmon: (1) Disparate and temporary reductions in water quality from aquatic herbicides applied in, or incidentally sprayed on water, dying vegetation reducing DO, incremental temperature increase from site reductions in shade, and small areas of short-lived turbidity; (2) disparate and temporary reductions in substrate condition from activity-associated sediment deposition, herbicide retention in sediment, and mats covering small areas of substrate; (3) temporary and local reductions of cover for salmonids and reduction in their forage associated with loss of vegetation and toxicity of herbicides to some prey species; and (4) a small amount of decreased safety within the EFH, i.e., increased exposure to predators associated with both loss of cover used by salmonids in the treatment areas and activity-caused disturbances that will displace some fish, at least temporarily.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS believes that the terms and conditions in Section 2.8.4 of this document will also help avoid, mitigate, or offset the impacts of the action on EFH. The conservation recommendations below are similar, but not identical to the ESA Terms and Conditions:

- a. Ensure that proper plans and protective measures are followed, including BMPs, protective measures, and terms and conditions to limit herbicide concentrations, treatment area, and impacts to fish and their prey.
- b. Ensure that herbicide labels are followed, including recommendations for shoreline length limits, pond proportion limits, delay periods and notices.
- c. Ensure that spill prevention and containment measures are followed during control activities and notify NMFS of any chemical or fuel spill of 1-gallon or more.
- d. Limit use of herbicide formulations that include high-toxicity adjuvants, PAHs, and metals in riparian and aquatic habitats.
- e. Limit spring-season herbicide applications when practicable.
- f. Manage for properly functioning vegetation to shade water, shorelines, and floodplains and to increase production of aquatic invertebrates and terrestrial insects.
- g. Map and monitor the general locations and distribution of invasive vegetation and the relative area of native vegetation throughout the program term.
- h. Monitor and report the annual and cumulative amounts, types, and distribution of all applications of chemicals on District lands and waters.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, approximately 8,000 acres of designated EFH for Pacific coast salmon. This area was estimated as the riparian and peripheral aquatic area of the action area within the District.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the COE must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations, unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS conservation recommendations, the COE must explain its reasons for not following the recommendations, including the scientific justification for any

disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The COE must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the COE. Other interested users could include operators, contractors, grantees, citizens of affected areas, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this opinion were provided to the COE. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They

adhere to published standards including NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01, et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this Opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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APPENDIX A

The Walla Walla District includes three areas of responsibility (AORs) in the action area. Aquatic and riparian habitat among AORs is shown in Table A-1. The general locations of projects, habitat management units (HMUs), recreation areas, and outgrant areas are listed by AOR (Tables A-2 through A-4).

Table A-1. Distribution of aquatic and riparian acres among AORs.

AOR	Submerged Lands	Riparian Areas
Snake River West	6,492	2,616
Snake River East	8,507	948
Mill Creek	77	71
Total	15,076	3,635

McNary and Snake River West AORs

The McNary and Snake River West AOR (McNary pool and associated lands downstream of McNary) includes District lands around Lake Wallula and the Tri-City levee system associated with the McNary Project, Ice Harbor Lock and Dam (Lake Sacajawea), Lower Monumental lock and Dam, and upstream on the Snake River to the Joso train bridge (River Mile [RM] 57, Lake Herbert G. West; Table A-1; Figure A-1).

- **Operating Projects: McNary Lock and Dam (including McNary Levees in the Tri-Cities), Ice Harbor Lock and Dam, and Lower Monumental Lock and Dam³.** From Wallula Gap (approximately RM 309) upstream in the Columbia River past the mouth of the Yakima River and past Leslie Grove Park in the City of Richland, Washington to RM 356.5; up the Yakima River from its mouth through the City of Richland approximately 5.5 miles to the Van Giesen Street bridge in the City or West Richland (approximately RM 6.5); and up the Snake River from its confluence with the Columbia River (RM 0) upstream to the Joso train bridge (RM 57).
- **Counties.** Benton, Franklin, Walla Walla, and Umatilla.
- **Hydrologic Unit Codes (HUC).** 17020016, 17030003, 17070101, 17070101, 17070102.

Tables A-2, A-3, and A-4 in their respective AOR description sections below list HMUs and recreations areas. Outgrant areas where aquatic pest management activities would occur have an asterisk and orange cells.

Table A-2. McNary and Snake River West HMU and Outgrant Areas.

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
Walla Walla Yacht	Snake River West	Lake Wallula	McNary Dam	Marina	Columbia	312
Toothaker	Snake River West	Lake Wallula	McNary Dam	HMU	Columbia	319
Two Rivers	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	324
Pasco Boat Basin*	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	328
Columbia Park*	Snake River West	Lake Wallula	McNary Dam	Park/Marina	Columbia	331

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
Yakima Delta	Snake River West	Lake Wallula	McNary Dam	HMU	Columbia	334
Chiawana HMU	Snake River West	Lake Wallula	McNary Dam	HMU	Columbia	335
Chiawana Park and Road	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	335
Richland Yacht Club*	Snake River West	Lake Wallula	McNary Dam	Marina	Columbia	335
Wye Park*	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	336
Richland Bend	Snake River West	Lake Wallula	McNary Dam	HMU	Columbia	337
Howard Amon Park*	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	338
Leslie R. Grove Park*	Snake River West	Lake Wallula	McNary Dam	Park	Columbia	340
Taylor Flat	Snake River West	Lake Wallula	McNary Dam	HMU	Columbia	340
Sacajawea State Park	Snake River West	Lake Wallula	McNary Dam	Park	Snake	1
Yakima River Delta	Snake River West	Lake Wallula	McNary Dam	Park	Yakima	3
Hood Park	Snake River West	Lake Wallula	McNary Dam	Park	Snake	4
Martindale	Snake River West	Lake Wallula	McNary Dam	HMU	Snake	4
Burbank Heights	Snake River West	Lake Wallula	McNary Dam	HMU	Snake	5
Ice Harbor North Shore	Snake River West	Lake Wallula	McNary Dam	HMU	Snake	6
Locust Grove/Martindale	Snake River West	Lake Wallula	McNary Dam	Park	Snake	6
Ice Harbor	Snake River West	Lake	Ice Harbor	HMU	Snake	9
Ice Harbor Dam	Snake River West	Lake	Ice Harbor	Park	Snake	10
Ice Harbor Dam Visitor	Snake River West	Lake	Ice Harbor	Park	Snake	10
Ice Harbor Marina*	Snake River West	Lake	Ice Harbor	Marina	Snake	11
Charbonneau	Snake River West	Lake	Ice Harbor	HMU	Snake	11
Charbonneau Park*	Snake River West	Lake	Ice Harbor	Park	Snake	11
No Name	Snake River West	Lake	Ice Harbor	HMU	Snake	11
Lake Charlene	Snake River West	Lake	Ice Harbor	HMU	Snake	12
Levey (Levy)	Snake River West	Lake	Ice Harbor	HMU	Snake	13
Big Flat	Snake River West	Lake	Ice Harbor	HMU	Snake	16
Quarter Circle	Snake River West	Lake	Ice Harbor	HMU	Snake	16
Fishhook	Snake River West	Lake	Ice Harbor	Park	Snake	17
Fishhook	Snake River West	Lake	Ice Harbor	HMU	Snake	18
Lake Emma	Snake River West	Lake	Ice Harbor	Park	Snake	19
Nineteen Mile	Snake River West	Lake	Ice Harbor	HMU	Snake	19
Lost Island	Snake River West	Lake	Ice Harbor	HMU	Snake	23
Lost Island (Votaw)	Snake River West	Lake	Ice Harbor	HMU	Snake	23
Hollebeke	Snake River West	Lake	Ice Harbor	HMU	Snake	25
Snake R. Junction	Snake River West	Lake	Ice Harbor	HMU	Snake	26
Walker	Snake River West	Lake	Ice Harbor	HMU	Snake	30
Couch Landing	Snake River West	Lake	Ice Harbor	HMU	Snake	32
Burr Canyon	Snake River West	Lake	Ice Harbor	HMU	Snake	36
Windust	Snake River West	Lake	Ice Harbor	Park	Snake	38
Windust	Snake River West	Lake	Ice Harbor	HMU	Snake	39
Mathews	Snake River West	Lake	Ice Harbor	Park	Snake	41
Devils Bench	Snake River West	Lake West	Lower	Park	Snake	42
Lower Monumental Dam	Snake River West	Lake West	Lower	Park	Snake	42
Magallon	Snake River West	Lake West	Lower	HMU	Snake	45
No Name	Snake River West	Lake West	Lower	HMU	Snake	45
Skookum	Snake River West	Lake West	Lower	HMU	Snake	48
Ayer Boat Basin	Snake River West	Lake West	Lower	Park	Snake	51
Ayer	Snake River West	Lake West	Lower	HMU	Snake	52
Fifty-Five Mile (55 Mile)	Snake River West	Lake West	Lower	HMU	Snake	55
Joso	Snake River West	Lake West	Lower	HMU	Snake	57
No Name 2	Snake River West	Lake West	Lower	HMU	Snake	51

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
Lyons Ferry	Snake River West	Lake West	Lower	HMU	Snake	57
Walker	Snake River West	Lake	Ice Harbor	HMU	Snake	32
Sacajawea State Park	Snake River West	Lake Wallula	McNary Dam	Park	Snake	1
Yakima River Delta	Snake River West	Lake Wallula	McNary Dam	Park	Yakima	3



Figure A-1. McNary AOR.

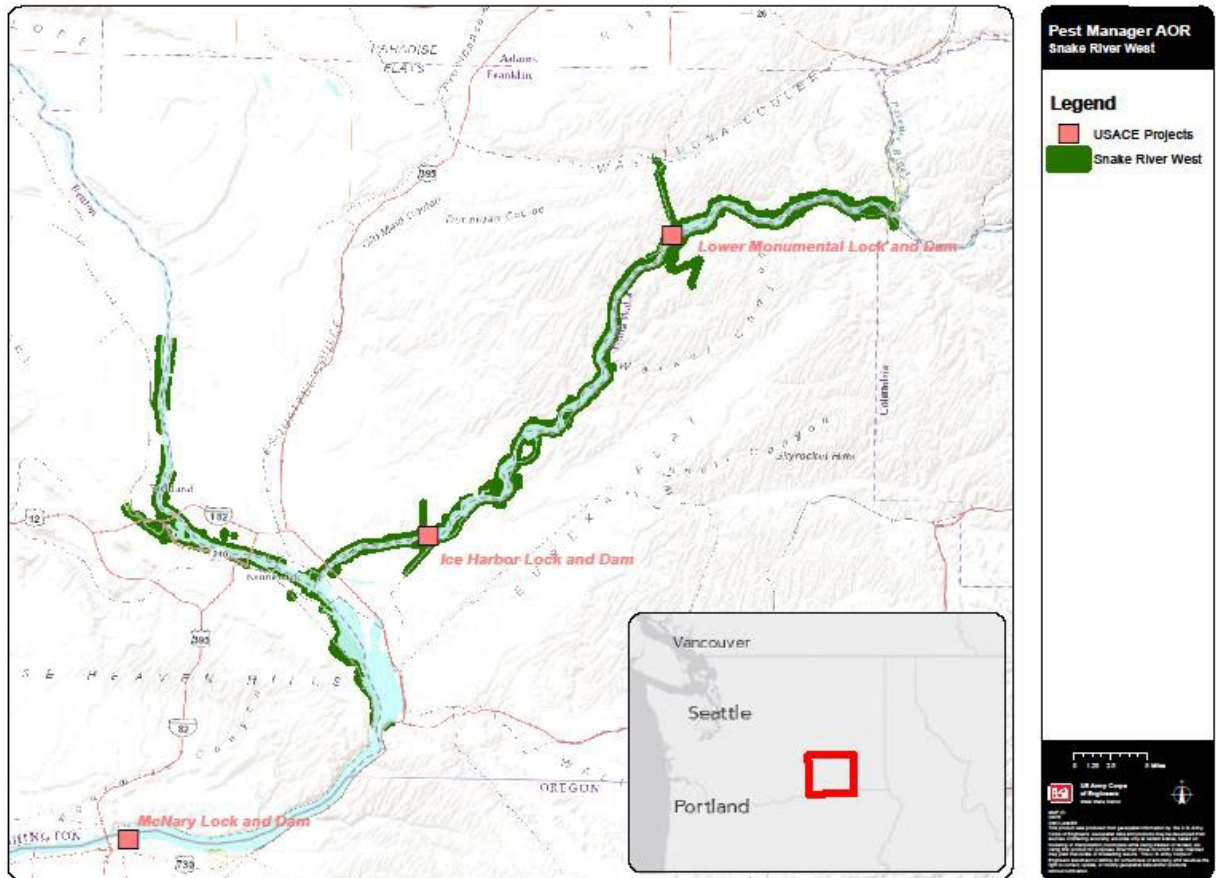


Figure A-2. Snake River West AOR.

Snake River East AOR

The Snake River East AOR includes the areas around Lake Herbert G. West (Lower Monumental lock and Dam), Little Goose Lock and Dam (Lake Bryan), and Lower Granite Lock and Dam (Table A-2; Figure A-2).

- **Operating Projects: Lower Monumental Lock and Dam⁴, Little Goose Lock and Dam, and Lower Granite Lock and Dam (including Lewiston Levees).** From the Joso train bridge (RM 57) upstream the Snake River to Asotin Slough (approximately RM 147.5), just outside (upstream) of the City of Asotin, Washington, and upstream in the Clearwater River 8.9 miles (RM 8.9) from its confluence with the Snake River in the City of Lewiston, Idaho. This also includes the Tucannon River from RM 0 to approximately RM 3.5, and all surrounding Corps lands.
- **Counties.** Asotin, Columbia, Garfield, Whitman, and Nez Perce.
- **HUCs.** 17060103, 17060107, and 17060306.

Table A-3. Snake River East HMU and Outgrant Areas.

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
North Lewiston	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Clearwater	3
Lower Goose	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Clearwater	6
Upper Goose	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Clearwater	7
Lyons Ferry	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	58
Sixty Mile	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	60
Joso East	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	61
Sargent	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	62
Tucannon	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	62
Alkali Flat	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	66
Riparia	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	67
Riparia	Snake River East	Lake West	Lower Monumental Dam	Park	Snake	67
Texas Rapids	Snake River East	Lake West	Lower Monumental Dam	HMU	Snake	67
Texas Rapids	Snake River East	Lake West	Lower Monumental Dam	Park	Snake	67
John Henley	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	68
Little Goose Dam	Snake River East	Lake Bryan	Little Goose Dam	Park	Snake	70
Little Goose	Snake River East	Lake Bryan	Little Goose Dam	Park	Snake	70
Little Goose Recreation Area (Little Goose Landing)	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	71
Flagpole Gulch	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	72
Browns Gulch	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	75
Hangar Dry Gulch	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	75
Ridpath	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	76
Phalen Gulch	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	77
Central Ferry	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	78
New York Island	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	78
New York Bar	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	81
Deadman Creek	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	83
Lower Deadman	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	83
Purrington	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	85
Willow Bar	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	86
Willow Landing	Snake River East	Lake Bryan	Little Goose Dam	Park	Snake	86
Penawawa	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	92
Rice Bar	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	93
Swift Island	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	94
Swift Bar	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	95
Beckwith (Beckwith)	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	98
Schultz Bar	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	100
Illia	Snake River East	Lake Bryan	Little Goose Dam	HMU	Snake	102
Illia Dunes	Snake River East	Lake Bryan	Little Goose Dam	Park	Snake	102

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
Illia Landing	Snake River East	Lake Bryan	Little Goose Dam	Park	Snake	102
Almota	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	104
Boyer Park and Marina*	Snake River East	Lake Bryan	Little Goose Dam	Park / Marina	Snake	105
Lower Granite Dam	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	108
Offfield Landing	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	108
Transmission Line	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	110
WaWaWai (Wawawai)	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	111
Wawawai Landing	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	111
Granite Point	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	114
Knoxway Canyon	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	116
Kelly Bar	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	118
Nisqually John	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	118
Nisqually John Landing	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	118
Blyton Landing	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	119
Centennial Island	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	120
No Name	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	124
Steptoe	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	127
No Name	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	128
Alpowa	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	129
Moses	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	130
Chief Timothy	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	132
Chief Timothy Habitat	Snake River East	Lower Granite Lake	Lower Granite Dam	Park	Snake	132
Silcott	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	132
Evans Pond	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	134
Water Tank	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	135
Wilma-North Clarkston	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	135
Golfcourse Pond	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	136
Confluence Island	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	139
Hells Gate	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	144
Tammany Quarry	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	144
Asotin Slough	Snake River East	Lower Granite Lake	Lower Granite Dam	HMU	Snake	146

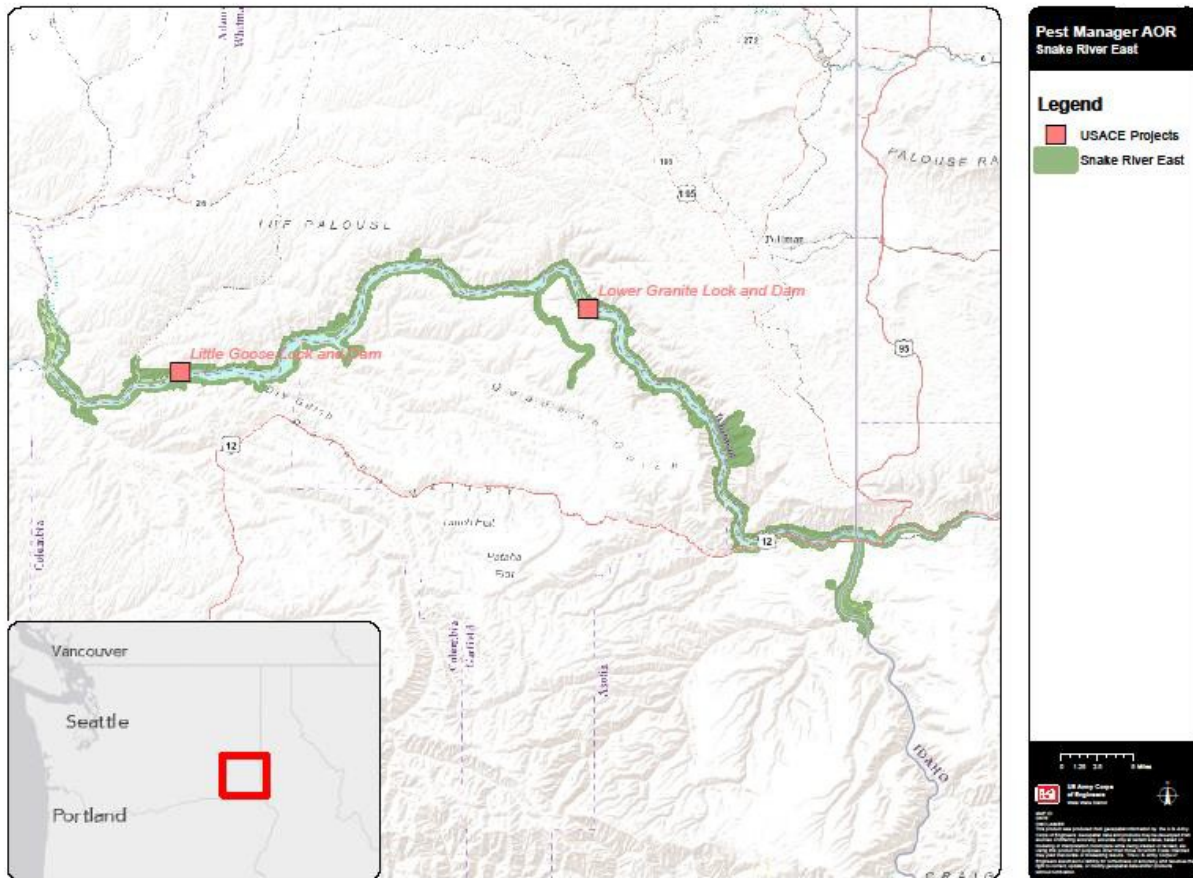


Figure A-3. Snake River East AOR.

Mill Creek AOR

The Mill Creek AOR includes areas of the Mill Creek channel and Bennington Lake. The areas where pest management activities occur in proximity to ESA-listed species or critical habitat at Mill Creek are limited to areas adjacent to Mill Creek and Yellowhawk Creek (Table A-3; Figure A-3).

- Mill Creek. The Mill Creek Project is approximately 3 miles east of the City of Walla Walla, Washington. It is composed of two major units: 1) the Mill Creek channel (RM 10.4 to RM 11.5); and 2) the off-channel reservoir – Virgil B. Bennington Lake – and the lands surrounding and adjacent to these two units.
- **Counties.** Walla Walla.
- **HUCs.** 17070102.

The single HMU at Mill Creek is not part of the proposed action. Recreation areas at Mill Creek are administered by the COE and are included in the Operations Areas (Table A-3).

Table A-4. Mill Creek HMU and Outgrant Areas.

Habitat/Recreation Area Name	AOR	Lake Name	Project Name	Recreation Area Type	River	River Mile
Bennington Lake	Mill Creek	Bennington Lake	Mill Creek	Park	Mill Creek	11
Mill Creek Recreation Trail	Mill Creek	Bennington Lake	Mill Creek	Park	Mill Creek	11
Rooks Park	Mill Creek	Bennington Lake	Mill Creek	Park	Mill Creek	11

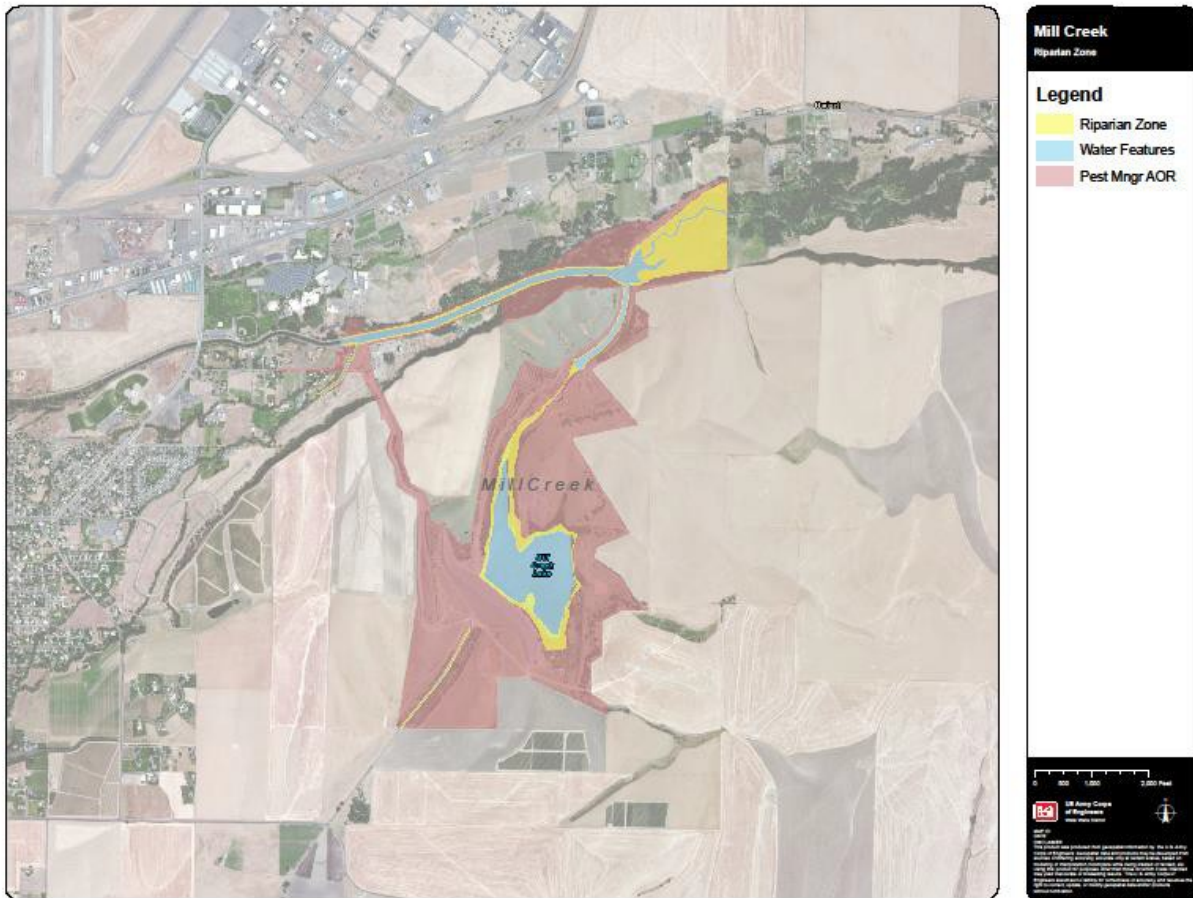


Figure A-3. Mill Creek AOR.