Hydrology Resource Report for the Northern Tongass Integrated Weed Management Environmental Assessment

USDA Forest Service
Tongass National Forest

Reed Canary Grass beginning to establish on cobble bar

Photo by Joni Johnson

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Date: September 25, 2018
Updated: July 23, 2019

Regulatory Framework

Federal and state laws, policies and regulations control the use of herbicides on National Forest system lands, including the Clean Water Act and the Federal Water Pollution Control Act. Section 208 of the 1972 amendments to the Federal Water Pollution Control Act (Public Law 92-500) specifically mandated identification and control of non-point source pollution. Clean Water Act Section 303(d)(2) requires States submit, and EPA approve or disapprove, lists of waters for which existing technology-based pollution controls are not stringent enough to attain or maintain State water quality standards and for which total maximum daily loads (TMDLs) must be prepared. Currently, no impaired waterbodies occur within project area boundaries.

The Tongass National Forest Land and Resource Management Plan (USDA Forest Service 2016) provides direction to protect and manage water resources. Forest Plan standards and guidelines for water resources relevant to this project include but are not limited to the following direction: "Maintain water quality and quantity to protect the state-designated beneficial uses"; "Apply Best Management Practices (BMPs) to all land-disturbing activities as a process to protect the beneficial uses of water from nonpoint sources of pollution"; "Seek to avoid adverse impacts to soil and water resources (such as accelerated surface erosion or siltation of fish habitat) when conducting land use activities on wetlands, flood plains, and riparian areas"; "Maintain water quality consistent with Alaska Water Quality Standards (18 AAC 70) and protect source watersheds consistent with the federal Safe Drinking Water Act and the Alaska Drinking Water Regulations (18 AAC 80)". Forest Plan management objectives for riparian areas include but are not limited to the following direction: "Maintain riparian areas in mostly natural conditions for fish, other aquatic life, old-growth and riparian-associated plant and wildlife species, water-related recreation, and to provide for ecosystem processes, including important aquatic and land interactions"; "Protect water quality by providing for the beneficial uses of riparian areas".

The National Best Management Practices for Water Quality Management on National Forest Lands provides direction for chemical use management activities, including the application of herbicides (USDA Forest Service 2012). The stated objective for BMPs related to chemical use near waterbodies (BMP Chem-3) is to "Avoid or minimize the risk of chemical delivery to surface water or groundwater when treating areas near waterbodies". Further direction includes but is not limited to the following: "To help protect surface waters and wetlands from contamination, a buffer zone of land and vegetation adjacent to the waterbody may need to be designated"; "Determine the width of a buffer zone, if needed, based on a review of the project area, characteristics of the chemical to be used, and application method"; "Prescribe chemicals and application methods in the buffer zone suitable to achieve project objectives while minimizing risk to water quality"; and "Avoid, minimize, or mitigate unintended adverse effects to water quality from chemical treatments applied directly to waterbodies" (BMP Chem-4).

Invasive and non-native plant (hereafter "weeds") management activities are designed to enable compliance with State requirements in accordance with the Clean Water Act for the protection of waters of the state of Alaska, and are subject to the Forest-wide standards and guidelines related to water quality and riparian management areas (RMAs). Best Management Practices (BMPs) will be applied in planning, implementing and maintaining weed management activities.

Permitting Requirements

This project will require a state of Alaska pesticide-use permit, as well as an Alaska Pollution Discharge Elimination System (APDES) permit, in response to the requirements of the Clean Water Act, Section 402 prior to implementing herbicide treatments. Permitting requirements for herbicide application are rigorous and can be reviewed at http://www.dec.state.ak.us/eh/pest/requirements.html. State reporting and monitoring requirements associated with these permits would occur annually.

Analysis Area

Watersheds

Treatment areas for this project were analyzed at the 6th level Hydrologic Unit Code (HUC). HUCs are unique identifiers used in a standardized watershed classification system developed by the US Geological Survey (USGS). Hydrologic units are watershed boundaries organized in a nested hierarchy by size from the largest (regions) to the smallest (cataloging units) and can be viewed as the "address" of a particular watershed. Watersheds are spatially located landscape features uniformly mapped for the entire United States at multiple scales. The 6th level HUC is the scale commonly used to determine the potential effects of management activities, rather than processes or functions of ecosystems (RIEC 1995). It is helpful in this analysis for determining potential cumulative impacts for weed management; in particular, limits on the rate and exposure of herbicides within a stream network. Potential site-specific effects and herbicide delivery mechanisms are also discussed below.

This 6th level HUC also corresponds to the analysis scale used for the national Watershed Condition Framework (WCF), completed by the US Forest Service in 2011 (USDA Forest Service 2011). The WCF system is a national forest-based, reconnaissance level evaluation of watershed condition that can be aggregated for a national assessment of watershed condition. The WCF system classifies watersheds based on a core set of national watershed condition indicators. The system uses multiple data sources to establish criteria for indicators describing three watershed condition classes - "functioning properly", "functioning at risk", and "impaired function" (ibid). The WCF evaluation was completed on all 6th level Hydrologic Units in the Forest Service system, including the watersheds analyzed for this project. However, the WCF scores on Tongass watersheds do not include an evaluation of invasive terrestrial species due to incomplete invasive plant data on the Tongass. As a result, WCF scores were not used in this analysis. As additional information on invasive plant distributions and extent becomes available, invasive terrestrial species will be included in future calculations of WCF scores for Tongass watersheds.

Cumulative Effects

The spatial boundaries for analyzing the cumulative effects to aquatic resources (water quality, riparian condition) are also defined by the 6th field HUC boundary as described above. Watersheds provide a natural boundary to assess previous, current, and future activities and how they affected natural processes at the project scale. All management activities have a temporal component associated with recovery of the environment/natural process to pre-management conditions. These timeframes can be short or long-term, depending on the activity. For example, hydrologic recovery following clearcut timber harvest is relatively long-term, expected to require between 10 and 30 years (in the Pacific Northwest) to allow sufficient vegetation regrowth (Hicks et al. 1991; Jones 2000; Moore and Wondzell 2005), whereas replacing a culvert is expected to have short-term water quality effects lasting from hours to days.

Past, present, and projects occurring in the reasonably foreseeable future considered in this analysis are listed in the "Catalog of Events" located in the project record. A number of these projects have the potential to increase the spread of weeds. Recreation projects such as trail maintenance and reconstruction projects, cabin replacements, and improvements to day-use facilities have the potential to increase the risk of weed introduction to these areas through increased visitation. Stream restoration projects have the potential to transfer weeds to riparian environments through heavy-equipment use and the transfer of large trees from upland areas into the streams and floodplains of the restoration reaches. Ongoing road maintenance, as well as road building associated with timber sales and the increased vehicle use associated with these sales has the potential to transfer weeds. Similarly, administration sites have a higher risk for establishment and transfer of weeds due to common activities in these areas. These risks are largely mitigated through the application of Forest-wide standards and guidelines, project-specific BMPs, Alaska Department of Environmental Conservation (ADEC) and Clean Water Act pesticide permitting processes, contractual project requirements, and project design features as described below. Cumulative effects to aquatic and riparian resources from past, present, and future projects will occur, with potential risk levels associated with each Alternative described below.

Affected Environment

Methods

Potential effects of weed treatments are described in terms management indicators relating to water quality characteristics of streams (sedimentation, turbidity, temperature) and physical habitat (riparian areas, channel margins). These indicators are used in combination with the proposed treatment method, type of herbicide, technical literature, previous studies, monitoring information, subject matter experts and professional judgment to evaluate current condition, the effects of the proposal, and to compare alternatives. Where appropriate, mitigation measures employed to offset or minimize adverse effects are identified.

Streams

Streams represent the physical conduit transporting water, wood, sediment, organic material and their chemical constituents downstream and out of the watershed. In the context of this analysis, streams and ditches can act as a transport mechanism for weed species and herbicides. Weeds transported along a road system can enter the aquatic environment at stream/road crossing locations. Once transported downstream, weeds may enter the terrestrial environment through riparian areas. Similarly, herbicides can be transported downstream of an application site via streams and ditches.

Streams are defined according to process group and channel type descriptions located in the Riparian Buffer Standards and Guidelines in the Tongass Forest Plan (2016). Fluvial process groups describe the interrelationship between watershed runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes (Table 1). Channel types further categorize streams using physical attributes such as channel gradient, channel width, channel pattern, stream bank incision and containment, and riparian plant community composition.

Table 1. Fluvial process groups recognized on the Tongass National Forest

Process Group	Process group abbreviation	Defining characteristic of group
Alluvial Fan	AF	Channels occurring on alluvial fan landforms
Estuarine	ES	Channels that are influenced by tides
Floodplain	FP	Low-gradient channels on broad flood plains
High-gradient Contained	HC	High-gradient channels contained by steep valley walls
Moderate Gradient Contained	MC	Moderate-gradient channels contained by steep valley walls
Moderate-gradient, Mixed-control	MM	Moderate-gradient channels with some flood plain development
Large Contained	LC	Large, low-gradient channels contained by steep valley walls
Glacial Outwash	GO	Channels associated with glaciers or recently glaciated terrain
Palustrine	PA	Very low-gradient, placid channels draining wetlands

Streams on the Tongass National Forest are also classified by value classes from I to IV indicating levels of habitat use by fish populations and are delineated according to the criteria described in the Aquatic Habitat Management Handbook (USDA Forest Service 2001).

Class I - Streams and lakes with anadromous or adfluvial fish or fish habitat; or high-quality resident fish waters, or habitat above fish migration barriers known to be reasonable enhancement opportunities for anadromous fish.

Class II - Streams and lakes with resident fish or fish habitat and generally steep (6-25 percent or higher) gradient (can also include streams with a 0-6 percent gradient) where no anadromous fish occur, and otherwise not meeting Class I criteria.

Class III – Streams are perennial and intermittent with no fish populations or fish habitat, but have sufficient flow or sediment and debris transport to directly influence downstream water quality or fish habitat capability. For streams less than 30% gradient, special care is needed to determine if resident fish are present.

Class IV - Other intermittent, ephemeral, and small perennial channels with insufficient flow or sediment transport capabilities to have immediate influence on downstream water quality or fish habitat capability. Class IV streams do not have the characteristics of Class I, II, or III streams, and have a bankfull width of at least 0.3 meters (1 foot).

Non-streams: Rills and other watercourses, generally intermittent and less than 1 foot in bankfull width, little or no incision into the surrounding hillslope, and with little or no evidence of scour.

Riparian Management Areas

Stream class and channel process group help determine the extent of the Riparian Management Area (RMA) (Table 2). RMAs are areas of special concern to fish, other aquatic resources, and wildlife, and are designed to protect riparian zone interactions between streams, floodplains, riparian wetlands and uplands (Paustian 2004). RMAs are mapped in Geographic Information Systems (GIS) according to a buffering routine where RMA widths are assigned to each Process Group stream segment and riparian polygons delineated by soil types and wetland plant communities (Paustian 2004). These GIS generated RMAs can be queried for planning purposes, with final RMA buffer widths determined by site-specific assessment of riparian vegetation and soils, extent of the flood-prone width, occurrence of secondary floodplain channels, topography, and other indicators.

Table 2. RMAs vary in width from the edge of the stream channel according to process group and stream value class.

Process Group - Stream Class	RMA Stream Buffer
Alluvial Fan (AF) – Class I, II, III	The greater the distance of the active portion of alluvial fan or one site potential tree height from the active portion of the channel (140 feet)

Process Group - Stream Class	RMA Stream Buffer
Floodplain (FP) - Class I & II	The greater the distance of one site potential tree height (130 feet), the 100-year flood plain, riparian vegetation or soils, or the riparian associated wetland fens
High-gradient Contained (HC) – Class I & II	The greater distance of 100 feet or to the top of the V-notch (side-slope break)
High-gradient Contained (HC) – Class III	Within the v-notch to the break in the side-slope
Moderate-gradient Contained (MC) – Class I & II	The greatest distance of the area within 100 feet of the stream or to the top of the side-slope break
Moderate-gradient Contained (MC) – Class III	Area from the stream to the side-slope break
Moderate-gradient, Mixed –control (MM) – Class I & II	The greatest distance of one site potential tree height (120 feet), the 100-year flood plain, riparian vegetation or soils, or riparian soils, or riparian associated wetland fens
Large Contained (LC) – Class I & II	The greatest distance of the area within 100 feet of the stream or to the top of the side-slope break
Large Contained (LC) – Class III	Area from the stream to the side-slope break
Palustrine (PA) – Class I & II	The greater distance of 100 feet from the streambank, the 100-year flood plain, the extent of riparian vegetation, riparian soils, or riparian associated wetland fens
Lakes & Ponds – Class I & II	The greatest distance of 100 feet from the shoreline, the riparian vegetation, or associated wetland fens

RMAs are used in this analysis to aid in risk assessments associated with high value stream channels. For example, weed species located along a Class I Floodplain (FP) channel will pose a greater risk than the same population located along a Class IV High gradient, contained (HC) channel due to the relative biological value associated with each channel type. RMA buffer distances will serve as an analysis tool to aid in this assessment.

Reference Condition

Reference condition for this project is assumed to be the natural vegetative condition prior to the establishment of non-native plant species.

Existing Condition

Watersheds

One hundred fifty-one 6^{th} level HUC watersheds have known populations of weeds within the project area. Half of one-percent or less of the area in these watersheds contains weeds, and most (134) contain less than 20 acres of weed populations (Table 3). The Muddy Creek-Alsek River watershed in the Yakutat Ranger District has the highest infestation acres of all project area watersheds.

Table 3. Summary of the 6th HUC watersheds with the highest known infestations of weeds within the project area.

Watershed Name	Infested Acres	% Watershed Infested
Muddy Creek-Alsek River	383.3	0.5
Outlet Endicott River	98.1	0.3
Eastern Channel-Frontal Sitka Sound	90.9	0.3
Salmon Creek-Frontal Gastineau Channel	61.5	0.1
White Pass Fork-Skagway River	46.1	0.2
Salt Lake Bay-Frontal Port Frederick	43.9	0.2
Pleasant Island	39.4	0.2
Freshwater Bay-Frontal Chatham Strait	37.0	0.1
Sister Lake	34.2	0.2
Headwaters Endicott River	33.4	0.1

Water Quality

Waters in Alaska are protected for all uses according to standards outlined in the Alaska Water Quality Standards (ADEC 2017a). Numeric criteria standards are established according to protected use classes and subclasses. The Alaska Integrated Water Quality Monitoring and Assessment Report provides information on water bodies within the state that do not fully or partially support their designated beneficial uses, known as the Alaska Impaired Waters list. The list uses three categories to describe the extent of impairment including the following: (4a) impaired water but not needing a Total Maximum Daily Load (TMDL), the TMDL has been completed; (4b) impaired waters with "other pollution controls" and expected to meet standards in a reasonable time period, not needing a TMDL; (5) water impaired by pollutant(s) for one or more designated uses and requiring a TMDL, Clean Water Act Section 303(d) listed (ADEC 2017b). Table 4 summarizes the most recent (2010) impaired waters list in the project area, which is pending final EPA approval (ibid). Invasive treatments in these locations require coordination with the ADEC Division of Water to determine if an Alaska Pollutant Discharge Elimination System (APDES) Pesticide General Permit (PGP) is sufficient or additional permitting would be required.

Table 4. 2010 Impaired Waters within the project area[1].

Category	Alaska Id#	Waterbody	Location	Area of Concern	Water Quality Standard	Pollutant Parameters	Pollutant Sources
4a	10301-005	Duck Creek	Juneau	N/A	Dissolved Gas, Residues, Toxic & Other Deleterious Organic and Inorganic Sub-stances, Fecal Coliform Bacteria Turbidity	Low Dissolved Oxygen, Debris, Iron, Fecal Coliform Bacteria, and Turbidity	Urban Runoff, Landfill, Road Runoff, Land Development
4a	10203-005	Granite Creek	Sitka	N/A	Turbidity Sediment	Turbidity, Sediment	Gravel Mining
4a	10203-601-001	Herring Cove of Silver Bay	Sitka	102 acres	Residues	Bark & Woody Debris	Log Storage from former Pulp Mill Operations
4a	10301-004	Jordan Creek	Juneau	3 miles from tide-water upstream	Dissolved Gas, Residues, Sediment	Debris, Sediment Low Dissolved Oxygen	Land Development, Road Runoff
4a	10203-602	Klag Bay	West Chichagof Island	1.25 acres	Toxic & Other Deleterious Organic and Inorganic Substances	Metals – Arsenic, Cobalt, Copper, Lead, Manganese, Mercury, Silver, Zinc	Mining
4a	10301-001	Lemon Creek	Juneau	N/A	Turbidity Sediment	Turbidity, Sediment	Urban Runoff, Gravel Mining
4a	10301-014	Pederson Hill Creek	Juneau	Lower two miles	Fecal Coliform Bacteria	Fecal Coliform Bacteria	Septic Tanks
4a	10303-004	Pullen Creek (Lower Mile)	Skagway	Lower mile of Pullen Creek	Toxic & Other Deleterious Organic and Inorganic Substances	Metals – Cadmium, Copper, Lead, Zinc	Industrial
4a	10203-601	Silver Bay	Sitka	6.5 acres	Residues Toxic & Other Deleterious Organic and Inorganic Substances	Pulp Residues, Logs, Bark & Woody Debris, Sediment Toxicity due to Wood Decomposition By-products	Industrial, Historical Pulp Mill Activity

Category	Alaska Id#	Waterbody	Location	Area of Concern	Water Quality Standard	Pollutant Parameters	Pollutant Sources
4a	10301-017	Vanderbilt Creek	Juneau	N/A	Turbidity Residues Sediment	Turbidity, Debris, Sediment	Urban Runoff
Category 5; Section 303(d) listed	10203-002	Katlian River	N. of Sitka, Baranof Island	4.5 miles	Sediment, Turbidity	Sediment, Turbidity	Timber Harvest
Category 5; Section 303(d) listed	10303-601	Skagway Harbor	Skagway	1 acre	Toxic & Other Deleterious Organic and Inorganic Substances	Metals – Cadmium, Copper, Lead, Mercury, Zinc	Industrial
Category 5; Section 303(d) listed	10204-501	Hawk Inlet	NW Admiralty Island	0.96 acres	Toxic & Other Deleterious Organic and Inorganic Substances	Metals – Cadmium, Copper, Lead, Mercury, Zinc	Mine Ore Transfer Facility
Category 5; Section 303(d) listed	10203-010	Kimshan Cove	N. of Sitka, Baranof Island	18 acres	Toxic & Other Deleterious Organic and Inorganic Substances	Metals - Copper	Mining

[1]The most recent "Alaska's FINAL 2012 Integrated Water Quality Monitoring and Assessment Report" (ADEC 2013b) provides additional information regarding the status of the TMDL's for these streams.

Sedimentation and Turbidity

Water quality data including suspended sediment and turbidity data is available through active and historic United States Geological Survey (USGS) stream gages for a small portion of the streams in the project area. Assessments of potential sedimentation and turbidity resulting from the proposed activities are necessarily qualitative. Changes in turbidity are assumed to occur concurrent with increases in suspended sediment; therefore, effects related to "sedimentation" in this analysis represent changes in the water quality parameters of suspended sediment and turbidity. Generally, in Southeast Alaska, suspended sediment loads in non-glacial streams in undisturbed watersheds are very low, with most naturally occurring turbid flows occurring in glacially fed or tidally influenced waters (Schmeige et al. 1974; ADEC 2017a).

Percentage of watershed area comprised of roads has been used to help quantify the risk of flow-related impacts to aquatic systems, including sediment introduction into streams (Cederholm et al. 1980). Similarly, metrics associated with roads can serve as a surrogate for estimating potential risk of herbicide delivery to streams in this analysis. Currently, approximately 1,115 miles of roads occur in project area watersheds (90.1 miles decommissioned). This estimate includes all roads, NFS and temporary, ever built regardless of age. In Washington's Olympic

Peninsula, accumulation of fine sediment in streambeds was found to be highest in basins where the road area exceeded 2.5 percent of the basin area (Cederholm et al., 1980). A statistical relationship between fine streambed sediment and watershed disturbance has not been reported in Southeast Alaska studies (Bryant et al., 2004; Woodsmith et al., 2005). Nonetheless, Cederholm's suggested threshold provides a way to evaluate the potential impacts of roaded area in the affected watersheds in comparison to findings elsewhere in the Pacific Northwest. Percent basin area as roads and road density levels are considered very low in watersheds containing the highest known acreage of weed infestations (Table 5).

Table 5. Road density and % Watershed as Roads in watersheds with the highest known individual site infestations (acres).

Watershed Name	Watershed Area (mi^2)	Existing Road Miles	Road Density (mi/mi^2)	% Watershed As Roads
Muddy Creek-Alsek River	110	16.4	0.1	0.1
Outlet Endicott River	44	0.0	0.0	0.0
Eastern Channel-Frontal Sitka Sound	53	9.1	0.2	0.1
Salmon Creek-Frontal Gastineau Channel	94	32.7	0.3	0.3
White Pass Fork-Skagway River	39	0.0	0.0	0.0
Salt Lake Bay-Frontal Port Frederick	32	22.9	0.7	0.5
Pleasant Island	36	0.0	0.0	0.0
Freshwater Bay-Frontal Chatham Strait	52	17.4	0.3	0.3
Sister Lake	22	0.0	0.0	0.0
Headwaters Endicott River	42	0.0	0.0	0.0

[1] Percent Watershed As Roads calculated as: {(Existing road miles * 5,280ft/mi*40ft (assumed clearing width) / 43,560 ft^2/acre) / watershed size (acres)} * 100

Temperature

The Alaska Water Quality Standards for "growth and propagation of fish…" are "may not exceed 20 degrees C at any time" and are specifically 15 degrees for migration and rearing areas, and 13 degrees for spawning areas and egg and fry incubation. For all other water, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms (ADEC 2017a). Previous correspondence with USGS personnel indicated the 20-degree standard is exceeded most years on approximately half of the non-glacial streams in southeast Alaska (Solin pers. comm. 2009). Data from three case-study watersheds on Prince of Wales Island indicate temperature limits are exceeded even in unmanaged watersheds under conditions of higher than normal air temperature (Tucker and Thompson 2010). The effects of past upland and riparian harvest on maximum stream temperatures were thought to be masked by local watershed characteristics and ambient weather conditions in the above study, suggesting the current numeric criteria for maximum stream temperature exceedance may be too stringent to reflect natural conditions in headwater basins in southeast Alaska (ibid).

Forest Plan Standards and Guidelines provide for the protection of riparian buffers on all fish-bearing and Class III streams through designation of RMAs. RMA buffers reduce the risk of increased stream temperatures through shading provided by the riparian vegetation. Previous harvest within the RMA occurred in many of the project area watersheds prior to the passage of the 1990 Tongass Timber Reform Act (TTRA), which subsequently provided buffers for all fish-bearing streams. This harvest may have raised stream temperatures on isolated stream reaches; however, sufficient vegetation regrowth has occurred since the passage of the TTRA for previously harvested riparian areas to recover.

Riparian Condition

Riparian areas encompass the zone of interaction between aquatic and terrestrial environments associated with streams, lakeshores, and floodplains, and display distinctive ecological conditions characterized by high species diversity, wildlife value, and resource productivity (USDA Forest Service 2016). Riparian vegetation generally ranges from emergent plant communities, to mosses, lichens, liverworts, ferns, grasses, sedges and rushes, alder, and conifer-dominated tree stands. Riparian areas have high species diversity, wildlife value, and resource productivity, and are the primary areas potentially affected by weed removal within this analysis. Approximately 87 acres of weed infestations are known to occur within RMAs within the project area. Watersheds with the highest known acreage of reed canarygrass infestations within RMAs include the Upper Ahrnklin River watershed in the Yakutat Ranger District, and the Humpback Creek watershed in the Hoonah Ranger District (Table 6).

Table 6. Highest known RCG acreage within RMAs of Class I, II, and III streams

Watershed Name	Infested Acres Within RMA
Upper Ahrnklin River	2.8
Humpback Creek	1.0
Spasski Bay-Frontal Icy Strait	0.9
Upper Ahrnklin River	0.7
Freshwater Creek	0.5
Antlen River	0.5
Salmon Creek-Frontal Gastineau Channel	0.5
Tawah Creek	0.5
Tawah Creek	0.4
Gypsum Creek-Frontal Iyoukeen Cove	0.3

The estuarine riparian area occurs at the mouths of watersheds with estuarine landforms (located along inlets and deltas at the head of bays). Water level fluctuations, channel morphology, sediment transport, and water chemistry are influenced to some degree by saltwater inundation in these environments. Riparian areas in these environments can be several hundreds of feet wide on large river deltas and generally consist of saltwater marshes, meadows, mudflats, and gravel deltas that are depositional environments. Stream channels within estuaries are usually single to multiple thread channels, shallowly entrenched, and poorly constrained, with finely textured alluvium easily eroded by currents and wave action. As such, these environments are highly sensitive to upstream disturbances. Sedge and grass communities dominate the riparian vegetation. The interplay of the above factors results in the relative condition of a riparian site.

Riparian vegetation stabilizes stream banks and acts as a filter to prevent the runoff of soil into streams. Riparian vegetation also provides large and small wood to streams, adding to habitat complexity and providing cover and food sources for aquatic organisms. Aquatic ecosystems have evolved with certain vegetation types; weeds do not necessarily provide similar habitat.

Approximately 13.5 acres of RCG are mapped along Class I and II streams and wetlands in the project area. RCG is extremely aggressive and often forms persistent monocultures in wetlands and riparian areas. Infestations threaten the diversity of these areas, since the plant outcompetes native plants and grows too densely to provide adequate cover for small mammals and waterfowl. Where RCG grows in water, it can slow the movement of water carrying sediment and lead to increased siltation along drainage ditches and streams. Once established, RCG is difficult to control because it spreads rapidly by rhizomes.

Treatment sites within or adjacent to Class I salmon streams will be a high priority when determining annual treatment locations due to the potential threat to important anadromous stream habitat. Approximately 11.3 acres of RCG are located within Class I RMAs, with the largest known single infestations occurring in the Upper Ahrnklin River watershed (Table 6). The effect of weed treatments on riparian site conditions is evaluated among alternatives in this analysis.

Roads

Roads are one of the primary vectors for weeds to enter the project area. Roads and disturbed areas near roads, such as recreation sites, administrative sites, and skid trails in young growth forest are the most common area. Native soil has been removed along roads, and fill and surfacing have been placed within the road prism. The road drainage network has been implicated as a potential sediment source to stream channels (Wemple and Jones 2003; Wemple 1996; Megahan and Kidd 1972; Reid and Dunne 1984). Sediment delivery can be used as a surrogate for herbicide delivery. Ditches may extend the stream network and act as delivery routes or intermittent streams during high rainfalls, or as settling ponds following rainfall events. The potential exists for roadside ditches to transport herbicides into the stream network, particularly in areas where broadcast treatments along roads have been used (Wood 2001).

Herbicide may be used in or along roadside ditches in Alternative 2. Treatment acres along these ditch lines in any watershed are low and sites are scattered across large road and stream networks. Since this project proposes the use of broadcast spraying herbicides in Alternative 2, the potential exists for herbicide to collect in ditches and enter streams.

Proximity to stream crossings is one of the primary determinants of exposure to herbicide properties, with the most significant exposure occurring at or near confluences with perennial streams (NMFS BO 2007). Because these locations represent points of likely encroachment into riparian areas, the number of stream crossings within a watershed can help assess risk of spread. Culverts with infestations of targeted weed species within a 30-foot radius of the culvert were assessed during roadside surveys (Table 7). The largest infestations of targeted species within proximity to culverts were dominated by reed canarygrass. These are small roadside populations in the Upper Ahrnklin River and Gypsum Creek-Frontal Iyoukeen Cove watersheds (0.40 and 0.39 acres) in the Yakutat and Hoonah Ranger Districts respectively. The primary proposed control for these populations is to use an aquatic-based version of glyphosate in combination with hand pulling, depending on site conditions. Not all stream crossings are located on roads with a high risk for herbicide delivery.

Table 7. Summary of watersheds with the highest number of stream crossings within a 30-foot radius of known populations of target species within the project area.

Watershed Name	Stream Crossings	Infestation Size (acres)
False Island-Frontal Peril Strait	31	0.24
190102110501	13	0.05
Pavlof River	10	0.03
Spasski Creek	8	0.02
Freshwater Bay-Frontal Chatham Strait	7	0.03
Freshwater Creek	7	0.25
Gypsum Creek-Frontal Iyoukeen Cove	7	2.40
Iris Meadows	7	0.03
Iyouktug Creek	4	0.03
Antlen River	3	0.04

Municipal Watersheds and Domestic Water Supplies

The Alaska Department of Environmental Conservation (ADEC), Division of Environmental Health's Drinking Water Program formed a Drinking Water Protection group. This group completes Source Water Assessment Reports for all public water systems (groundwater and surface water) and helps develop Drinking Water Protection Plans for all Community and Non-Community Water Systems (ADEC 2017c). ADEC's Drinking Water Program requires Public Water Systems (PWS) to comply with the state drinking water regulations, in accordance with the Federal Safe Drinking Water Act and Amendments. Three different categories of PWS supply water to consumers, including the community water system (C), which is a system expecting to serve, year round, at least 25 individuals; a non-transient non community water system (NTNC), which regularly serves the same 25 or more individuals for at least 6 months of the year; and non-community water systems (NC), which regularly serves at least 25 individuals each day for at least 60 days of the year (ADEC 2017c).

The Drinking Water Protection Group completes Source Water Assessment reports which delineate the boundaries of source drinking water, identify risks to contamination, and determines the vulnerability of the source drinking water (ADEC 2017c). Locations of all PWS throughout southeast Alaska (Figure 1), including detailed site information and sources of contamination is available on the ADEC website at http://dec.alaska.gov/eh/dw/dwp/protection-areas-map.html. Drinking water protection zones are classified A – F, with protection strategies dependent on existing and potential contaminant sources throughout a community. Numerous PWS occur within the project area with mapped protection zones "A" and "B". Zone "A" depicts a boundary indicating several months' time of travel for groundwater or a 1,000-foot buffer area around surface waters supplying public water sources, while zone "B" depicts a 2-year time of travel for groundwater or a 1-mile buffer area for surface areas. Figures 2 and 3 are examples of maps available on the website from the Yakutat area.

Proposed weed treatments in proximity to public water systems are discussed in each alternative below. Before any weed management activities in PWS source watersheds are authorized, ADEC, and the affected municipality, and /or owner/operator of the water system must be consulted (USDA Forest Service 2016, App. C-2). Herbicide treatments within 1,000 feet of a municipal water supply or public water source must be coordinated with the water user, manager, or local Municipal Water board. The Project Design Features (PDF) for herbicide use are outlined in the "Effects Common to All Action Alternatives" section below. By following these PDF's and project Best Management Practices (BMP), proposed weed treatments within PWS watersheds will not create or maintain a condition that has a significant potential to cause or allow the pollution or contamination of a public water system.

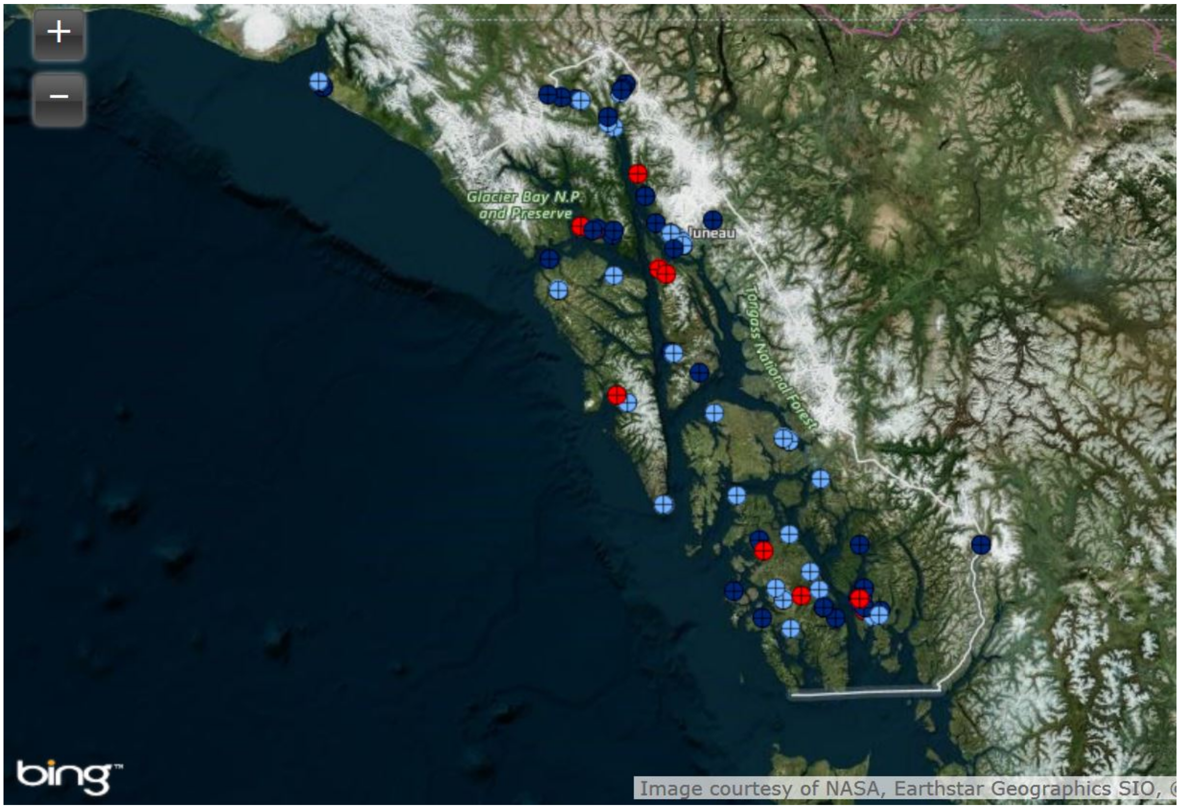

Figure 1. Southeast Alaska drinking water protection map, Division of Environmental Health, ADEC.

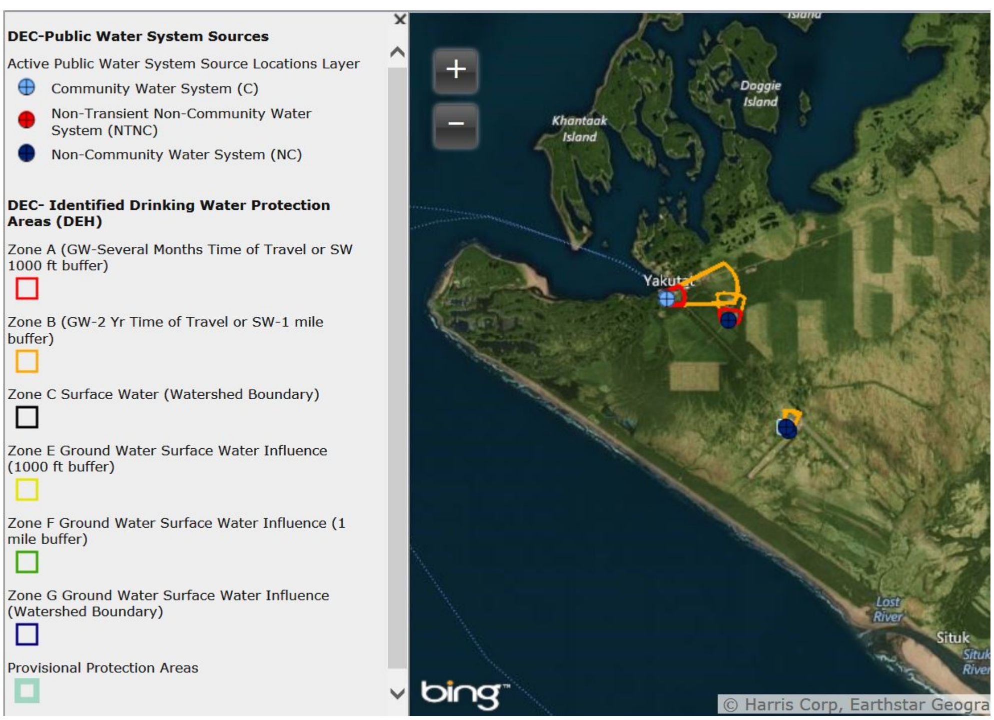

Figure 2. Yakutat Water Protection Map, Division of Environmental Health, ADEC.

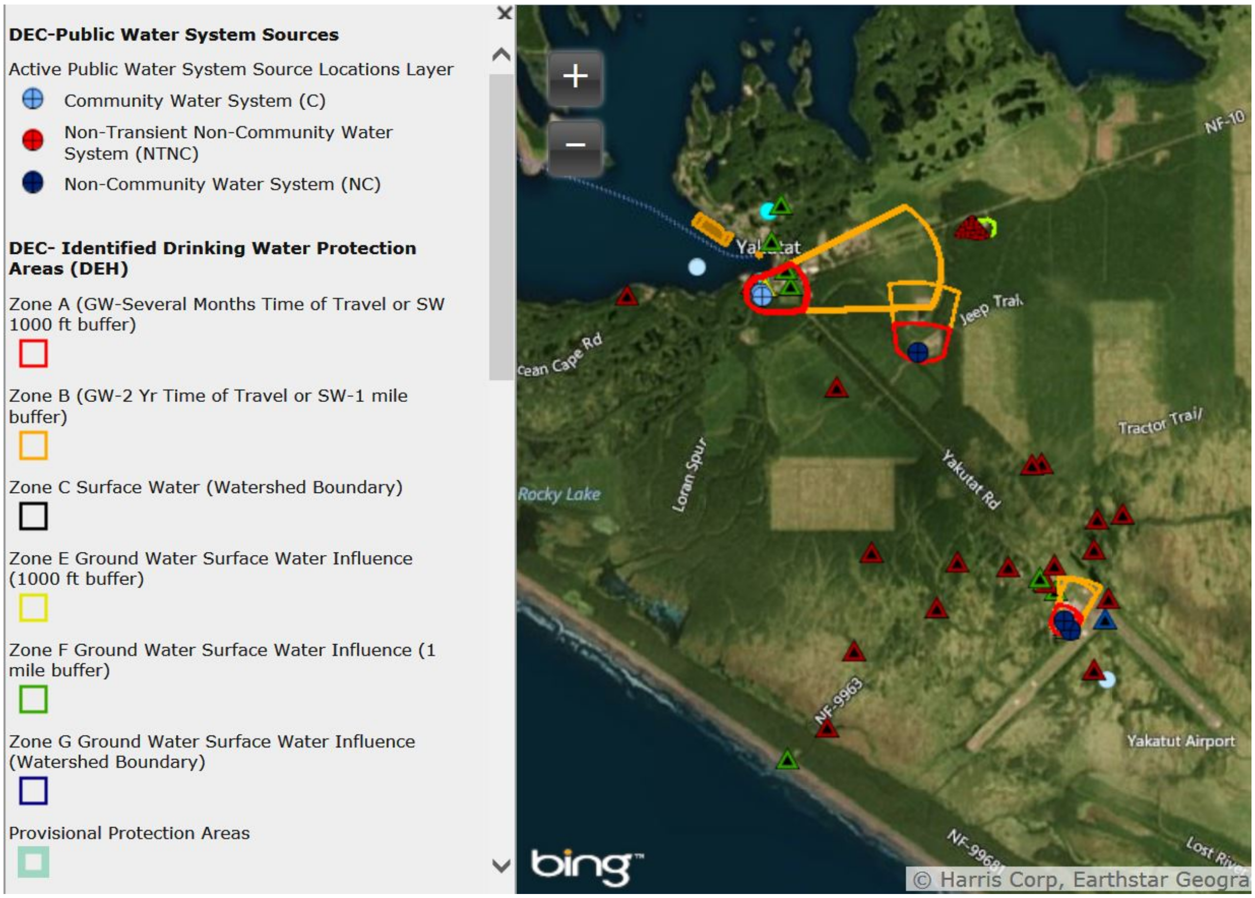

Figure 3. Yakutat Drinking Water Protection map with sites of interest, Division of Environmental Health, ADEC.

Environmental Effects

Environmental variables such as pH, temperature, and presence or absence of organic matter fluctuate widely depending upon season, weather, predominant vegetation type, disturbance, adjacent land uses, and other factors, making precise predictions of existing conditions and effects impossible. The ability to measure changes in suspended sediment, turbidity, temperature, or other water quality parameters in response to weed treatments is extremely limited due to the lack of baseline data and the natural range of variability of these parameters in response to climate and other factors. In response to this uncertainty, the current analysis uses the best available scientific information available in the literature to proceed with a credible comparison of the magnitude and extent of likely effects across alternatives. For each resource topic covered (water quality, riparian condition) the analysis includes a brief description of the affected environment and an evaluation of effects. Potential impacts are described in terms of type (beneficial or adverse), context (site specific, local or regional), duration (short-term or long-term) and intensity (are the effects negligible, minor, moderate or major) (Table 8).

The following definitions were used to evaluate the effects of the proposal, and to compare alternatives for water quality and riparian condition:

- Beneficial: A positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.
- Adverse: A change that moves the resource away from a desired condition or detracts from its appearance or condition.
- Direct: An effect that is caused by an action and occurs in the same time and place.
- Indirect: An effect that is caused by an action but is later in time or farther removed in distance but is still reasonably foreseeable.
- Short-term: An effect that within a short period of time would no longer be detectable as the resource is returned to its pre-disturbance condition or appearance. Short-term impacts may range from a few hours up to 10 years.
- Long-term: A change in a resource or its condition that does not return the resource to pre-disturbance condition or appearance and for all practical purposes is considered permanent.

Exceptions to these definitions are noted as applicable, since they are not a perfect fit for all effects.

Table 8. Thresholds for potential impacts to each aquatic resource for each level of intensity.

Aquatic Resource	Negligible	Minor	Moderate	Major	Impact Duration
Water Quality	Neither water quality nor hydrology would be affected, or changes would be either undetectable or if detected, would have effects that would be considered slight, detectable only at the site.	Changes in water quality or hydrology would be measurable, although the changes would be small and localized to the site or affected stream reach. No mitigation measure associated with water quality or hydrology would be necessary.	Changes in water quality or hydrology would be measurable at the stream reach or subwatershed scale. Mitigation measures associated with water quality or hydrology would be necessary and the measures would likely succeed.	Changes in water quality or hydrology would be readily measurable readily measurable at the stream reach or subwatershed scale and would have substantial consequences. Mitigation measures would be necessary, and their success would not be guaranteed.	Short-term refers to recovery in less than several days. Long-term would refer to recovery, following treatment, requiring longer than several months.
Riparian Condition	Any effects to the RMA would be below or at the lower levels of detection. Any detectable effects would be slight.	Effects to RMAs would be detectable, site-specific and relatively small and short-term to individual plants.	The effects to RMAs would be detectable and readily apparent. The effect could be site-specific or over a relatively large localized area.	Effects to RMAs would be observable over a relatively large localized or regional area. The character of the RMA would substantially change.	Short-term refers to a period of less than 10 years. Long-term refers to a period longer than 10 years.

Herbicide Transfer Vectors

Potential for contamination and degradation of water quality are influenced by many factors including infestation size, herbicide type, application rate and method, proximity to water, soil composition, and rainfall following application.

Drift and Runoff

Drift is the most likely vector for herbicides contacting water from riparian area or emergent vegetation treatment sites. The potential for drift varies with the herbicide application method. Drift is primarily associated with broadcast treatments used in agricultural settings, and to a lesser extent from roadside applications from a boom-mounted truck, neither of which is proposed with this project. "Broadcast" treatments in this project are conducted using a backpack sprayer and deliberate hand-held application with a spray wand, similar to sprayers used for weed-control at home. While overspray of non-target vegetation may occur, it is narrowly applied by hand in a focused manner at close range. As such, the potential for drift with this project is low.

Herbicide can also move from the treatment location into adjacent areas through runoff from slopes, roads, and ditches. Roadside ditches can act as herbicide delivery routes to streams during high rainfall events or as settling ponds following rainfall events.

Previous Monitoring Results

Berg (2004) compiled monitoring results for broadcast herbicide treatments given various buffers along waterbodies. The results showed that any buffer helps lower the concentration of herbicide in streams adjacent to treatment areas. In California, when buffers between 25 and 200 feet were used, herbicides were not detected in monitored streams (detection limits of 1 to 3 mg/m^3) (ibid).

Imazapyr has been shown to exhibit a rapid rate of decay in both water and sediment after application to estuary mud. In a study evaluating imazapyr in aquatic environments, imazapyr was applied at 1.5 pounds acid equivalent per acre to a plot of bare mudflat approximately 100 feet by 100 feet in the upper intertidal zone of Willapa Bay in Washington (Patten 2003). Herbicide applications were made 1.5 hours after the tide receded from the site. When the tide came in 3.1 hours after treatment, water samples were collected. The quantity of imazapyr remaining in the water approached zero by forty hours after application and the quantity remaining in sediment approached zero by four hundred hours following application. Similarly, in a study where imazapyr was aerial sprayed without a buffer, the stream concentration was 680 mg/ml. With a 15-meter buffer, the concentration was below detectable limits (Berg 2004).

In a study to assess whether herbicide use along road shoulders was a significant contributor to the load of herbicides carried by streams in Oregon, runoff associated with several herbicides including sulfometuron methyl and glyphosate was tested (Wood 2001). Rainfall was simulated at rates of 0.33 inches an hour at 1, 7, and 14 days after treatment in the spring; in the fall the road was again sprayed and the ditch line was checked during natural rainstorms for three months. Samples collected on the road shoulder in the spring had concentrations of nearly 1,000 ppb of glyphosate that could potentially leave the shoulder. Glyphosate was not found at the shoulder, ditch line or stream after spraying in the fall. This study suggests the greatest risk of herbicides moving off site occurs from large storms soon after herbicide application.

Berg (2004) also reported that herbicide applied in or along dry ephemeral or intermittent stream channels may enter streams through runoff if a large post-treatment rainstorm occurred soon after treatment. This risk is minimized if weather conditions and soil saturation levels are considered prior to spraying. If a large rainstorm occurs, sediment contaminated by herbicide could be carried into streams. Since most ditches within the project area are heavily vegetated, this is less likely to occur than in a drier environment.

The question of whether glyphosate can persist in soils and water was studied in an agricultural setting in Argentina. A study to determine the effects of Roundup® on periphyton colonization and water quality, total phosphorous significantly increased in treated waters of different types including “clear” waters with aquatic macrophytes and/or metaphyton and “turbid” waters with great occurrence of phytoplankton or suspended inorganic matter (Vera et al. 2010). This increase was attributed to Roundup® degradation that favored eutrophication, the process causing a dense growth of plant life and subsequent death of animal life from lack of oxygen resulting from excessive richness of nutrients in a waterbody. The same study noted a delay in periphytic colonization in treated waters and a long-term shift from “clear” to “turbid” waters and concluded that agricultural practices involving the use of herbicides such as Roundup® affect non-target organisms and water quality, modifying the structure and functionality of freshwater ecosystems (ibid).

Another study to determine the environmental fate of glyphosate and its major degradation product, aminomethylphosphonic acid (AMPA) in surface water and soil of agricultural basins in Argentina found that in the stream samples taken, the presence of glyphosate and AMPA was relatively more frequent in suspended particulate matter and sediment than in water (Aparicio et al. 2013).

Herbicide concentrations in the agricultural settings in which these studies occurred are significantly higher than what is proposed in this project. Based on the most recent Forest Service use reports, the typical glyphosate application rate is about 2 lb a.e. (acre equivalent)/acre, with most terrestrial applications using rates ranging from 0.5 to 8 lb a.e./acre (SERA 2011). The agricultural use of glyphosate in the United States is greater than Forest Service use by a factor of over 2900, and as such, Forest Service programs are not thought to contribute substantially to general concentrations of glyphosate nationally (ibid).

The biodegradation of glyphosate in seawater was quantified in a study using standard “simulation” flask tests with native bacterial populations and coastal seawater from the Great Barrier Reef (Mercurio et al. 2014). The authors quantified half-life degradation rates of glyphosate and AMPA under different temperature and light conditions and found that glyphosate is moderately persistent in marine water under low light conditions and is highly persistent in the dark. AMPA was detected under all temperature and light conditions, confirming that degradation was mediated by the native microbial community. Results from the study found a maximum persistence time of 315 days in the dark at 31ºC for glyphosate, which was the longest persistence reported for this herbicide at the time of the study. The study indicated glyphosate is less persistent under low-light conditions with lower water temperatures (47 days at 25ºC). Water temperatures in southeast Alaska typically range from approximately 2º - 16º C in the summer months, with maximum ADEC water quality standards for temperature not to exceed a range from 13º - 15º C for fisheries-related designated uses (ADEC 2017a).

The Washington State Department of Agriculture (WSDA) in partnership with the Washington State Department of Ecology over the past decade, have monitored pesticide residues in surface waters from selected urban and agricultural watersheds to assess pesticide presence and concentrations in salmon bearing streams. Results of the most recent triennial report for pesticides in salmonid-bearing streams indicate pesticide levels measured at most study sites were rarely found at concentrations above aquatic life criteria or water quality standards (WSDA 2011).

Water quality monitoring for this project would occur using national BMP protocols established for chemical use, including herbicide application, as described under "Regulatory Framework" above. Forest-wide BMP monitoring is conducted at least once every two years on a random selection basis.

Accidental Spill

Concentrations of herbicides in the water due to an accidental spill depend on the rate of application and the streams' ratio of surface area to volume. The persistence of the herbicide in water depends on the length of stream where the accidental spill took place, velocity of stream flow, and hydrologic characteristics of the stream channel. The concentration of herbicides would decrease rapidly downstream due to dilution and interactions with physical and biological properties of the stream system (Norris et al.1991).

Project design features reduce the potential for spills to occur, and if an accident were to occur, minimizes the magnitude and intensity of impacts. The ADEC pesticide use permit contains transporting requirements addressing spill prevention and containment.

Effects Common to All Alternatives

Though the effects would vary in amount and location, the effects of the different types of treatments are similar for all alternatives. Where alternatives differ slightly in approach, the sections below describe the difference and the effect/s of those differences.

Water Quality

Water quality considerations common to both action alternatives include potential sedimentation, turbidity due to hand-pulling methods and potential eutrophication, and temperature changes. The potential effect of herbicides on aquatic resources occurs in both action alternatives. The potential to influence water quality parameters is minor due to the small portion of any watershed that would be treated. These potential effects are discussed below.

The Alaska state water quality standards antidegradation policy states that existing water uses and the level of water quality necessary to protect existing uses must be maintained and protected, and that if the quality of water exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality must be maintained and protected unless the State allows the reduction of water quality for a short-term variance (ADEC 2017a).

Sedimentation and Turbidity

Sediment can be introduced into streams from natural and management-related processes, including mechanical weed treatments. Short term increases of suspended sediment and turbidity can be expected from the removal of vegetation and exposure of bare soil. Turbidity caused by eutrophication associated with the breakdown of glyphosate is not expected due to the low application amounts and rates proposed, compared to the agricultural settings in which this effect has occurred.

Manual and mechanical treatments along stream banks could accelerate sediment delivery to streams through ground disturbance. However, only a small portion of the treatment areas are in stream-side environments, therefore ground disturbance is not a significant concern. Modification of surface ground cover can also change the timing of runoff.

Mechanical control can be very effective for new infestations of weeds and when populations are few. The localized soil disturbance from mechanical removal of weeds could reduce soil stability until plants have reestablished on the disturbed sites, which could result in reduced water quality in drainages after significant rain events. This impact would be minimized by tamping the soil back into place after removal of the weeds and by using this method only on small infestations. Mechanical control is expected to have short-term, negligible, localized, and adverse impacts on water quality and water quantity.

Cultural control would have a minor, long-term, beneficial impact on water quality by returning native vegetation to currently infested areas. Low-risk methods are not likely to be used, but could include covering plants, “tarping”, with plastic sheeting. Aquatic and riparian treatment areas comprise a very small portion of any watershed for both action alternatives and are relatively short-lived. The methods discussed above could have a negligible, short-term, localized, adverse impact on water quality. Project PDFs and pesticide permit stipulations will help mitigate this potential.

Temperature

Two ecological mechanisms related to weed treatments can potentially lead to increased stream temperatures. Removal of riparian vegetation and the resultant increase in solar radiation has been shown to increase stream temperatures (Beschta et al. 2000), and the replacement of woody riparian shrubs and trees by plants like RCG can increase stream temperature and alter stream channel morphology (Lavergne and Molofsky 2004; Fierke and Kauffman 2006). Due to the small areas of potential aquatic and riparian treatment sites using manual, mechanical and cultural methods, the effect to changes in stream temperatures would be negligible, short-term and localized.

Riparian Condition

Weeds can adversely affect the functioning of riparian areas. If weeds replace riparian conifers and hardwood trees, large woody material inputs could be reduced, affecting stream stability, morphology and fish habitat. The primary weed species of concern occurring within the RMA is RCG. This plant is known to disrupt native wetland plant communities, alter stream flow and degrade wildlife habitat (Lyons 1998). RCG is a circumboreal plant that is reported to have dramatically increased in abundance in temperate North America approximately 40-60 years ago in response to increased soil nitrogen enrichment, impaired hydrology, and construction impacts to wetlands (Lavoie et al. 2005). RCG is thought to have been introduced to southeast Alaska as a forage and stabilization species. Most populations of RCG are associated with human disturbances, such as boat launches, roads, bridges, and recreation sites. RCG has, however, spread from these locations along river corridors. Although most RCG populations within the project area are currently small, if their growth and spread is unchecked, the likelihood they will adversely affect aquatic systems increases. In other parts of its range, RCG often dominates the shorelines of lakes, ponds, rivers, and wetlands, hindering regeneration of woody and herbaceous native plant communities and reducing habitat suitability for some animal species. When RCG encroaches into active channels it can accelerate siltation of rock and sand bars, reduce the active-channel area, and alter fluvial dynamics (Comes et al. 1981; Heutte et al. 2003). These changes to stream geomorphology may contribute to reduced suitability for salmonids.

RCG can begin to spread vegetatively shortly after seedling establishment. A dense network of rhizomes capable of excluding the growth of other species can form within a single growing season. Although seedling establishment of RCG is restricted to high-light canopy gaps, rhizomes often extend into low-light areas (Maurer and Zedler 2002). RCG establishment from seed is typically much greater in saturated than flooded soils. It can, however, invade under a wide range of hydrologic conditions by shifting its growth strategy (Conchou and Pautou 1987). Tussock-forming plants allocate more resources to shoots than roots, an advantage under flooded conditions. As water-levels recede, these plants shift allocation to favor lateral spread. This "plastic response" to hydrology allows RCG to be better suited to water-level fluctuations occurring at a magnitude and frequency greater than many other perennial wetland species. High nutrient additions also favor RCG over other species.

Himalayan blackberry and Japanese knotweed can act as a sediment trap and fish barrier. Japanese knotweed has poor bank holding capacity, which leads to more bank erosion and sedimentation of streams in high winter flows (Shaw and Seiger 2003). While knotweed may provide shade, native streamside hardwoods and conifers are much taller, therefore knotweed-dominated areas may be associated with higher water temperatures than areas with native forest communities. Knotweed can spread rapidly due to its ability to reproduce vegetatively. Root and stem fragments, as small as ½ inch (1cm) can form new plant colonies. Seasonal high-water events and floods sweep plants into rivers and creeks, then fragment and disperse knotweed plant parts throughout the floodplains and cobble bars. The fast-growing knotweed then takes advantage of the freshly disturbed soil to become established. Because it grows faster than most other plant species (including native species and most other weeds) it quickly outgrows and suppresses or kills them (Soll 2004). Currently, the only Himalayan blackberry identified in the project area occurs in downtown Sitka as an ornamental. Japanese knotweed occurs in the Hoonah District (0.02 acres), Sitka District (9.5 acres), and Juneau District (20.1 acres). Blackberry is on the Tongass "watch list" and will be approached using an Early Detection Rapid Response (EDRR) strategy to treatment (see below).

Native vegetation growth may change as a result of infestation, and the type and quality of litter fall, and quality of organic matter may decline, which can alter or degrade habitat for aquatic organisms. Primary and secondary consumers that form the basic food source for fish and other aquatic organisms may be indirectly affected. Reed canarygrass infestations threaten the diversity of these areas, since the plant chokes out native plants and grows too densely to provide adequate cover for small mammals and waterfowl. If these populations continue to grow without treatment, they will likely continue to spread. Where they spread, banks could become less stable leading to changes in suspended sediment, and substrate character and embeddedness. Potentially this could lead to diminished pool frequency and quality.

Use of any of the proposed treatment methods could initially result in negligible, short-term, localized, adverse impacts on riparian condition primarily due to the short-term disturbance associated with these treatments. In the longer-term, treating weeds such as RCG that have colonized along stream channels and out-competed native species would improve overall riparian condition.

Early Detection Rapid Response (EDRR)

The action alternatives (Alternatives 2 and 3) will use the EDRR approach for new or unknown infestations. This approach is necessary because the precise locations of individual target plants, including those mapped in the current inventory are subject to rapid and/or unpredictable change, and the typical NEPA process would not allow for rapid response; infestations may grow and spread into new areas during the time it usually takes to prepare NEPA documentation. The intent of the EDRR approach is to treat new infestations when they are small so the likelihood of adverse treatment effects is minimized. The approach is based on the premise that the impacts of similar treatments are predictable, even though the precise location or timing of the treatment may be unpredictable. Treatments under EDRR would be completed using the same methods and management direction as those proposed for known infestation sites, including Forest Plan direction as described, BMP practices for water quality management, Alaska Department of Environmental Conservation water quality standards (ADEC 2017a), and the project design features described below. The protective measures established for known infestations would work equally well for EDRR sites identified in the future since design features such as herbicide use buffers near waterbodies, application methods, timing of herbicide applications, etc. would still apply. As such, the effects of EDRR treatments are expected to be the same or within the same range as those for known infestations, and are analyzed in the direct, indirect and cumulative effects by Alternative below.

Project Design Features for Aquatic Resources

- The design features below are intended to minimize the potential impacts of herbicide use on aquatic resources. Design feature criteria are categorized according to subject. These criteria will be implemented as necessary according to the weed treatment plan updated annually. Product Labels (BMP 15.2; Chem-2)
    - Herbicide use would comply with standards on herbicide selection, tank mixing, licensed applicators, and use of adjuvants, surfactants and other additives.
    - Carefully review labels and ensure that application is consistent with the product’s directions.
    - Use only aquatic formulations or low aquatic risk herbicides on saturated soils, or those with seasonally high water tables, where label restrictions allow.
- Erosion Control (BMP 12.17; AqEco-2; Forest Plan 4-61)
    - Apply erosion control measures (e.g., silt fences) and native revegetation (e.g., mulching, native grass seeding, planting) for manual treatment where detrimental soil disturbance or de-vegetation may result in the delivery of measurable levels of fine sediment (Landwehr et al. 2012).
- Buffers / Spray Distance to Water (BMP 15.5; Chem-3)
    - Aquatic-based formulations of all herbicides may be applied up to water’s edge using hand application, spot spraying, or broadcast techniques. Aquatic-based formulations of glyphosate and imazapyr may also be used to treat emergent vegetation directly over water using hand application or spot spraying.
    - In Alternative 2: Minimum distance to water is 100 feet for broadcast treatments of all proposed herbicides. (this PDF does not apply to Alternative 3).
    - Begin application of pesticide products nearest to the aquatic habitat boundary and proceed away from the aquatic habitat; do not apply towards a waterbody.
    - Herbicide spray equipment would not be washed or rinsed within 150 feet of any waterbody, stream channel, or roadside ditch with flowing or standing water present (or as far as possible from the waterbody where local site conditions do not allow a 150-foot setback). All herbicide containers and rinse water will be disposed of in a manner that would not cause contamination of waters.
    - Mixing and loading of herbicide(s) would take place a minimum of 150 feet from any waterbody, stream channel, or roadside ditch with flowing or standing water

    present (or as far as possible from the waterbody where local site conditions do not allow a 150-foot setback).
  - In Alternative 2: In the marine environment, aquatic-based formulations of glyphosate and imazapyr can be applied on National Forest System land to the mean high tide line during low/outgoing tides with spot-spray and hand/select methods; in Alternative 3, this PDF is adjusted to read: In the marine environment, aquatic-based formulations of glyphosate and imazapyr can be applied during low/outgoing tides
- Public Water Sources (PWS) / Supplies (BMP 15.5; Chem-3)
  - Before authorizing herbicide use within public water system source watersheds, consult with ADEC, the affected municipality, and/or the owner/operator of the water system.
  - Review the completed Source Water Assessment for the PWS watershed, available from ADEC prior to authorizing weed management activities in these watersheds.
  - Herbicide use within 1,000 feet of domestic wells or public water supplies will be coordinated with the water user, manager, or local Municipal Water board.
  - Minimum distance to surface waters is 200 feet for herbicide application within municipal watersheds.
  - All herbicide application, storage, chemical mixing, refilling and post-application equipment cleaning is completed at least 200 feet from domestic wells or public water sources, and in accordance to label guidance relative to water contamination. (BMP Chem-5)
  - All known unclassified (private) water sources will receive the same consultation given to public systems, as outlined above, prior to herbicide application if located within a PWS source watershed. If located outside a PWS source watershed, consultation will occur if herbicide application is proposed within 1,000 feet of surface waters of known unclassified water sources.
- Identify Riparian Areas (BMP 15.5; Chem-3)
  - Forest Service personnel will identify riparian areas according to methods outlined in the Tongass Riparian Management Area standards and guidelines prior to implementation of herbicide application. Forest Service specialists will work closely with herbicide applicators to ensure project design features are implemented.
- Weather Conditions (BMP Chem-3)
  - Consider current and recent meteorological conditions. Rain events may increase pesticide runoff into adjacent water bodies. Saturated soils may inhibit pesticide penetration.
  - Do not apply pesticides when wind speeds exceed 7 mph.

Effects by Alternative

Both action alternatives have the potential to influence water quality and riparian condition as discussed below, but effects are expected to be minor due to the small portion of any watershed that would be treated. Treating weeds would improve riparian stability where plants such as RCG have colonized along stream channels and out-competed native species. All weed treatments bear some risk that removing plants could exacerbate stream instability; the annual treatment plan accounts for these areas and prescribes mulching, seeding and planting as needed to revegetate riparian and other treated areas.

Direct application of herbicide over water would only be considered where infestations are directly within a waterbody, for example, reed canarygrass growing within a pond in a wetland. These are considered "waters of the U.S."[1] under ADEC definitions and would require a permit. These types of treatments would be extremely rare, as most known weed infestations do not occur within a waterbody. This purposeful application, as well as other weed treatments along water's edge near wetlands, stream channels, or ditches may result in some herbicide entering surface waters.

Alternative 1 – No Action

Direct and Indirect Effects

Outside of areas where weed treatments can occur under the categorical exclusions 36 CFR 220.6(d) (3) (4) and (5), changes in plant composition and structure resulting from weed encroachment would be indirect, localized, and adverse to water quality and riparian condition. Where shallow-rooted weeds such as hawkweed, replaced deep-rooted native perennial plants in uplands, especially native graminoids, potential for soil erosion and waterway sedimentation would increase. Reed canarygrass could replace woody riparian shrubs and trees, alter stream channel morphology, and increase stream temperature (Lavergne and Molofsky 2004; Fierke and Kauffman 2006). RCG, as well as Tongass watch list species such as Bohemian knotweed and Himalayan blackberry, could replace riparian vegetation, change channel morphology, and reduce stream productivity (Urgenson et al. 2009).

Cumulative Effects

Cumulative effects on water and riparian resources in locations other than Forest Service administrative sites, as well as recreation sites and facilities, are expected to increase in the long-term as a result of restrictions on locations where weeds can be treated without additional environmental analysis. Impacts of weeds are currently negligible in most locations due to the limited area collectively occupied. Impacts of weeds in some areas, however, could change from

[1] "Waters of the US" is an official term defined by the Clean Water Act, Section 404 and includes wetlands. However, according the ADEC definitions of "waters of the US" they do not include wetlands unless it contains standing surface water. This is a distinctly different definition than CWA (citation on Turner and Johnson paper on ADEC permitting requirements, 2017).

negligible to moderate over the long-term as the area of weed occupation and influence on aquatic systems increases.

Conclusion

The ecological impact of this alternative is considered moderate, since untreated populations of weeds would continue to spread in areas where chemical treatments are not currently authorized, with the effects of such spread lasting into the foreseeable future. Similarly, EDRR would not be authorized, leading to less timely and effective treatments on new sites. Additionally, an integrated weed management approach would not be established that includes the possibility of weed treatments on non-federal lands (private, borough, State, tribal and other) to allow for a comprehensive weed management approach and enable partnerships with other landowners to use federal funding, if available. Due to fewer weed management opportunities compared to the action alternatives, abundance and distribution of invasive weed species is expected to increase more over time compared to the action alternatives. Adverse effects on aquatic and riparian systems would increase in the long-term as a consequence. As a result, Alternative 1 would result in negligible to moderate, long-term, adverse effects in relatively large localized areas resulting from the expected spread of invasive weeds, particularly RCG.

Alternative 2 – Proposed Action

Direct and Indirect Effects

Water Quality

Alternative 2 applies a high degree of caution to herbicide use. The types of chemical application methods proposed within 100 feet of any surface or subsurface stream or other water body (spot spraying, wicking, and injection) have negligible potential to harm beneficial uses of surface water and the function of aquatic organisms when project design features are applied. No broadcast spraying will be allowed within 100 feet of any surface or subsurface stream or other waterbody, therefore the potential for drift to enter the stream system is negligible. The use of herbicides adjacent and within waterbodies to control emergent vegetation will be allowed using only aquatic blend glyphosate and imazapyr. In addition to label instructions for each herbicide, PDFs for karst require a District/SO Geologist or Karst Specialist to review the treatment plans. A karst vulnerability assessment will be completed prior to any surface management practice, including the consideration of applying herbicide in karst terrain. These design features are expected to minimize impacts to karst lands in the project area.

The two herbicide properties that most affect the potential to contaminate surface or groundwater are solubility and persistence. Most herbicides for terrestrial uses should not be applied directly to water or to areas where surface water is present. A few exceptions of forestry herbicides labeled for aquatic areas include glyphosate formulations such as RoundUp Custom®, and imazapyr formulations such as Habitat® or Ecomazapyr 2 SL® (Osiecka and Minogue 2010).

The Environmental Protection Agency mandates that the maximum contaminant level (mcl) for glyphosate is 0.7 mg/liter (EPA 2018). Herbicide risk assessments conducted using a set of conservative scenarios and assumptions indicate contaminant levels for direct spray in a pond environment, as well as surface waters and streams are well under EPA levels for the proposed herbicide application rates (SERA 2011a). The Alaska state water quality standards and antidegradation policy states that concentrations of toxic substances in water may not exceed the numeric criteria for aquatic life for fresh water and human health for consumption of aquatic organisms shown in the Alaska Water Quality Criteria Manual or any chronic and acute criteria established for a toxic pollutant of concern to protect sensitive and biologically important life stages of resident species (ADEC 2017a). Additionally, no concentrations of toxic substances in water or in shoreline or bottom sediments that reasonably can be expected to cause adverse effects on aquatic life or produce undesirable or nuisance aquatic life can be exceeded (ibid). In Alternative 2, no broadcast spraying of any herbicides is allowed within 100 feet of water to minimize potential effects to non-target riparian vegetation.

The herbicides proposed for use in this alternative and their potential effects to water quality beneficial uses are described below.

Aminopyralid

It is improbable that aminopyralid applications would measurably degrade water quality due to herbicide properties and application location, type, and method. Aminopyralid has low to moderate solubility in water, degrades rapidly in sunlit water, and is of exceptionally low toxicity to invertebrates and vertebrates (SERA 2007). Consequently, if aminopyralid reached surface waters, it would be rapidly dispersed, and would be unlikely to cause any acute or chronic impairment of invertebrates and vertebrates. Any residual herbicide reaching the soil surface would be retained and biodegraded within the upper 12 inches of soil. Potential for offsite egress of the herbicide would be further minimized by adherence to label requirements and best safety practices. Potential for contamination of water via airborne drift of small droplets of herbicide, leaching to groundwater, or surface and subsurface runoff would be minimized by restriction to directed foliar backpack spray application, spray tank pressurization sufficient to achieve large spray droplet size, prohibition on spray application directly over water bodies, and application to dry sites when wind is minimal.

Glyphosate

Glyphosate would be used to manage weed species unaffected by aminopyralid (e.g., grasses). It also would be used to manage any weed species at sites occurring within or adjacent to surface water, such as RCG. Like aminopyralid, potential for water contamination would be low due to herbicide properties and application location, type, and method. This herbicide was designed to be applied to emergent weeds in all bodies of fresh and brackish water which may be flowing, non-flowing, or transient (Monsanto 2005). Glyphosate adsorbs strongly to soil particles once it enters the water, and this strong adsorption prevents excessive movement in the environment (Schuette 1988). Glyphosate is highly water soluble, with a half-life in water ranging from 35-63 days, and degradation in water is generally slow, since fewer microorganisms occur than in soil (ibid). Directed foliar backpack sprayer, cut-stem, or injection methods of application would be used as appropriate. In contrast to application of aminopyralid which could be applied to water's edge, aquatic formulations of glyphosate could be applied to emergent vegetation directly over water.

In an accidental acute exposure scenario (spills from 20-200 gallons), application rates of 2 lb a.e./acre result in hazard quotients exceeding potential toxicity values for sensitive species of fish, invertebrates, macrophytes, and algae (SERA spreadsheet, project record). Given the typical volumes associated with backpack sprayers (1-5 gallons), potential toxicity levels are still exceeded for sensitive species of macrophytes and algae, assuming accidental acute exposure (ibid). Maximum application rates of 8 lb a.e./acre proposed in Alternative 3 exceed potential toxicity levels for the same sensitive species as the lower application rates proposed in Alternative 2, given accidental acute exposure. When assuming backpack spray volumes using the same scenario at the higher application rate, potential toxicity levels are exceeded for sensitive species of fish, macrophytes, and algae (ibid). Accidental spill scenarios assume direct spills into ponds with surface areas of 1,000 m^2 and 1 meter deep.

Mobility and transport of residual glyphosate would be limited because most would bind with organic matter and sediment in soils and water. Residual herbicide would be mostly dissipated and biodegraded within two months in upland soils and within two weeks in water (SERA 2011a). The area subject to potential influence would be limited to infestation sites. Additionally, the potential for water quality degradation would diminish through progressive reduction of infestation and application area. Glyphosate use would be limited to commercial aquatic formulations that do not contain the surfactant POEA (i.e., polyethoxylated tallow amine), which has been shown to be toxic to some aquatic organisms. However, surfactants such as AGRI-DEX®, the least toxic of the glyphosate-compatible surfactants to aquatic organisms and fish studied to date, would be added to promote glyphosate efficacy (Monheit 2004).

Imazapyr

Imazapyr is a non-selective herbicide used for control of grasses, broadleaf weeds, vines, brush species, and riparian and emergent aquatic species (SERA 2011b). It is very highly water soluble, has moderate mobility in soils and toxicity of aquatic-based versions to fish and aquatic species is low, although the available acute and chronic toxicity data suggest that trout are more sensitive than other species (ibid). Maximum application rates, as suggested for Alternative 3, do result in hazard quotients exceeding potential toxicity levels for macrophytes and algae given accidental acute and non-accidental acute exposures (SERA spreadsheet, project record). When considering spill volumes associated with backpack sprayers typical of Forest Service applications, hazard quotients are still exceeded for macrophytes, highlighting the importance of proper handling and careful consideration of project design features when using maximum application rates. Degradation of this herbicide is influenced by many factors, but increases with increased temperatures, increased soil moisture, and decreased clay and organic matter content.

The primary form of degradation in water is photodegradation, with a half-life of approximately 2 days. This generally results in lower concern for water contamination due to its rapid photodegradation by sunlight. Imazapyr has been used to control emergent plants like reed canarygrass, which would be the likely target plant in this project. Bioaccumulation of imazapyr in aquatic organisms is low; therefore, the potential of exposure through ingestion of exposed aquatic invertebrates or other food sources to fish is reduced. Toxicity to fish is considered practically non-toxic (insignificant) based on tests conducted using standardized EPA protocols (ibid). Aquatic formulations of imazapyr could be applied to emergent vegetation directly over water. While effects to aquatic resources are considered minimal under all alternatives, no broadcast spraying of this herbicide is proposed within 100 feet of water due to potential effects to non-target vegetation in Alternative 1 or 2.

Metsulfuron Methyl

Metsulfuron methyl is a selective pre-emergence and post-emergence sulfonyl urea herbicide used primarily to control many annual and perennial weeds and woody plants (SERA 2004). This herbicide is highly water soluble and is therefore susceptible to rainfall runoff and residue leaching, particularly through clay soils due to their low adsorption with this chemical. As such, a higher risk of off-site movement through runoff is assumed when using this herbicide in clay soils. This herbicide is a systemic compound that inhibits cell division in shoots and roots, primarily working through activity in the foliage and soil. It is injurious to plants at extremely low concentrations and may adversely affect non-target plants from drift or runoff. Exposure of fish and aquatic insects to this herbicide would primarily occur through direct contact with contaminated surface waters, but due to its very low toxicity for these animals the risk is considered low (WSDOT 2006). Like imazapyr, using maximum application rates results in hazard quotients exceeding potential toxicity levels for macrophytes and algae, given accidental acute exposures (SERA spreadsheet, project record). Results are the same regardless of whether considering herbicide volumes contained in a typical backpack sprayer or the much higher default spill volumes calculated in the SERA spreadsheets, highlighting the importance of proper handling of this herbicide when using maximum application rates. This herbicide would not be applied directly to water but may be applied to water’s edge using spot, hand/select or broadcast methods (Table 9). A study on the effects of metsulfuron methyl on inhibiting the zooplankton community within a boreal lake concluded that this compound did not elicit major impacts in the total zooplankton community and noted a general a lack of inhibitory effects on both phytoplankton and zooplankton (Thompson et al. 1993).

Table 9. Application method for perennial and wet intermittent streams, wet ditches, saturated soils, lakes, and ponds.

Herbicide	Spot (feet)	Hand/Select (feet)	Broadcast (feet)
Aminopyralid	Water’s edge	Water’s edge	Water’s edge
Metsulfuron Methyl	Water’s edge	Water’s edge	Water’s edge

Herbicide	Spot (feet)	Hand/Select (feet)	Broadcast (feet)
Glyphosate (Aquatic Formula*)	None	None	Water's edge
Imazapyr (Aquatic and terrestrial**)	None	None	Water's edge

*When combined with surfactants, POEA will not be utilized.

**Only aquatic formulations of imazapyr would be used over water.

Manual and Chemical Control

Effects of manual methods would differ between Alternative 2 and Alternative 3. Impacts would be consistent with those described under "Effects Common to All Action Alternatives" where manual methods would be applied exclusively to manage infestations comprising a few invasive plants (e.g., 10 or fewer per infestation area). With larger infestations the impacts of manual methods would decrease in Alternative 2 from minor, short-term negative effect to a negligible, short-term effect due to the potential for herbicide treatments on larger infestations. Soil erosion and sedimentation potential would be substantially reduced in Alternative 2 because soil and protective vegetation cover would not be as severely disturbed in order to remove weed roots. Instead, herbicide would be used to kill weeds in Alternative 2 while leaving most of the cover of non-target plants intact with one exception; on sites where weeds dominate ground cover, killing the weeds with herbicide could temporarily remove most of the protective ground cover of vegetation. In such a case, potential for erosion and sedimentation would temporarily increase then decline as cover of non-target vegetation increased.

Chemical control can be very effective for large infestations of weeds and for plants with growth habits that make mechanical control methods ineffective. If herbicides used for chemical control would be applied near water, it would be restricted to herbicides labeled for such use and they would be applied in accordance to label specifications and Project Design Features (PDF) to minimize overspray. Herbicide recommendations limiting the rate and method of application were developed considering the toxicity and environmental behavior of the four herbicides proposed in this project. Different application methods and locations are intended to allow for the maximum flexibility in herbicide use to treat all known situations in the project area, while minimizing risk of herbicide delivery to streams and adverse effects to water quality, fish, and the aquatic ecosystem.

Municipal Watersheds and Domestic Water Supplies

Coordination with municipal water boards and users would occur and herbicide use within 1,000 feet upstream (slope distance) of known water intakes would be coordinated with the water manager or land owner. Herbicide use would not occur within 200 feet of surface waters draining to a public water supply. Given the types of herbicide proposed and the manner they will be used, no plausible scenarios leading to drinking water contamination sufficient to affect public health are anticipated in this alternative. Concentrations of herbicides capable of reaching groundwater or streams are low and below levels of concern for people.

The potential to effect beneficial uses of waters near public water systems is minimized through pesticide permitting application requirements, project design features, and BMPs. In all alternatives, existing municipal watershed agreements would be followed.

Cumulative Effects

The impact to water quality from multiple weed treatment actions in combination with foreseeable future projects such as timber harvest, road construction and maintenance activities, thinning treatments, stream restoration, recreational site management (e.g. trail and cabin construction and maintenance), special use permitting, etc., conducted at multiple sites over a period of years would be negligible. This consequence is attributed mainly to the limited projected area of treatments; limited mobility of residual herbicide in the environment; minimal toxicity of herbicides to invertebrates and vertebrates; relatively rapid dissipation and biodegradation of herbicides; use of EDRR; and the application of BMPs and PDFs to minimize risk of water contamination. Since most documented infestations occur in uplands, new infestations would also likely occur primarily in uplands and fewer would occur in seasonal or semi-permanently flooded sites. Despite expected success at reduction and elimination of currently known infestations, new infestations will likely be identified as described under "EDRR" above, and some would require treatment with herbicide. Herbicide use could therefore be required over the long-term and water quality would continue to be negligibly affected. Current infestations are expected to decrease in extent with treatment. As a result, the potential for soil erosion and sedimentation is also expected to decrease with time in treated areas.

Conclusion

The quantitative estimate of contamination risk to surface waters and aquatic resources considers the properties of the four herbicides, the susceptibility of aquatic species to the chemicals, and local conditions. These factors were used to develop additional layers of caution through implementation of project design features (see above), which further reduces the risk of exposure to levels well below the thresholds of concern. Proposed uses of herbicide would result in a minor, short-term negative effect. However, this effect would decline to a negligible level corresponding with rapid reduction in size of infestations and herbicide usage in years following initial herbicide application, as discussed above. By removing weed species, native plant communities would be restored. This is expected to have positive effects on water quality and diminish the potential for increased sedimentation and altered instream habitat resulting from the presence of weed species. By implementing project design features and EDRR, the use of chemical control is expected to result in minor, short-term, localized, potentially adverse impacts on water quality. Long-term, the effects of herbicide application are expected to be negligible, localized, and beneficial to water quality and riparian condition.

Compliance with Forest Plan/Laws/Regulations

All alternatives in this environmental assessment meet or exceed Forest Plan Amendment, 2016 Standards and Guidelines, and are consistent with State and USDA Forest Service laws and regulations.

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Addendum – Alternative 3

This analysis was updated following the initial draft submitted in September 25, 2018 and updated in March 6, 2019. Alternative 3 was developed in response to several items which necessitated clarification and/or correction following review by experienced practitioners not involved in the original document. This addendum reflects the following changes, updates, and effects between action alternatives:

- Language regarding broadcast treatments in this project was clarified in the text to accurately reflect how this technique is applied.
- Broadcast spray buffers of 100 feet to water were removed in Alternative 3 since these were incompatible with control of reed canarygrass, the primary species of concern in riparian areas. Populations of this plant grow to water's edge and colonize mid-channel bars and other areas within the bankfull margins, altering flow dynamics by stabilizing previously mobile cobble bars and ultimately impacting fish habitat. Targeted broadcast spraying from a backpack is the only effective control method in these environments. Aquatic-based formulations would be used following herbicide label directions.
    - The effect of removing these buffers would be negligible since broadcast spray methods in a wildland context are minimally different than spot-spray methods. A backpack sprayer is used in both scenarios, with practitioners employing minimal spray distances and targeting invasive plants with a hand-held wand. Only aquatic-based formulations would be used in these environments.
    - The risk of impacting non-target riparian vegetation increases in this alternative.
    - The long-term benefit to riparian vegetation and instream fish habitat increases due to a more effective control method for reed canarygrass.
- The application rates of all herbicides analyzed in the SERA risk assessment spreadsheets increased to reflect maximum-allowed label concentrations. Analyzed glyphosate application rates increased from 2 to 8 lb a.e./acre to allow stem-injections in Japanese knotweed populations in the project area. Application rates analyzed in Alternative 2 were insufficient to effectively control these populations. Analyzed imazapyr rates of 0.45 lb a.e./acre in Alternative 2 were increased to 1.5 lb a.e./acre in Alternative 3, with known local populations requiring 1.0 lb a.e./acre to be effective. Similarly, analyzed application rates for aminopyralid increased from 0.078 to 0.11 lb a.e./acre, and

metsulfuron methyl increased from 0.03 to 0.15 lb a.e./acre, in Alternatives 2 and 3, respectively. The increased application rates reflect the maximum permissible by label in aquatic environments. This allows more flexibility when responding to control needs which vary by species and label. As such, SERA spreadsheets were updated with the increased application rates in Alternative 3, with the following results:

  - Hazard quotients remained well below potential toxicity levels for aminopyralid, given the maximum application rates.
  - Hazard quotients associated with maximum application rates of 8 lb a.e./acre proposed for glyphosate exceed potential toxicity levels for sensitive species of fish, invertebrates, macrophytes, and algae, given an acute accidental exposure scenario. Use of the lower application rate proposed in Alternative 2 results in similar potential risk to the same sensitive species given the same scenario.
  - Maximum application rates of imazapyr result in hazard quotients exceeding potential toxicity levels for macrophytes and algae given accidental acute and non-accidental acute exposures. The spill volumes assumed in the default SERA worksheets are higher (5-100 gallons) than would be typical with a backpack sprayer; however, spill volumes typical of backpack spray applications (1-5 gallons) still exceeded hazard quotients for macrophytes.
  - Maximum application rates of metsulfuron methyl also result in hazard quotients exceeding potential toxicity levels for macrophytes and algae, given accidental acute exposures (SERA spreadsheet, project record). Results are the same regardless of whether considering herbicide volumes contained in a typical backpack sprayer or the much higher default spill volumes (20-200 gallons) calculated in the SERA spreadsheet.
  - The risk of negative impacts to sensitive species of fish, invertebrates, macrophytes, and algae, given an acute accidental exposure scenario under maximum application rates, is higher and the overall effect is considered moderate in Alternative 3 compared with Alternative 2.
  - The long-term benefit to riparian vegetation and instream fish habitat increases in this alternative because the potential use of maximum application rates can improve the effectiveness of treatments in these environments.

- Conclusion: Herbicide use in Alternative 3 would result in a minor, short-term negative effects to water quality. However, these effects would decline to a negligible level corresponding with rapid reduction in size of infestations and herbicide usage in years following initial herbicide application. Positive, long-term effects on water quality, riparian condition, and ultimately instream fish habitat is expected by efficiently removing weed species and restoring native plant communities. Allowing broadcast spraying to water’s edge as well as using the maximum application rates where necessary would result in minor, short-term, localized, potentially adverse impacts on water quality. These effects would increase to moderate for sensitive species of fish, invertebrates, macrophytes, and algae, given an acute accidental exposure due to spill. Proper handling and careful consideration of project design features would minimize the potential for accidental spills, Long-term, the effects of herbicide application are expected to be negligible, localized, and beneficial to water quality and riparian condition.