

FISH HABITAT ASSESSMENT IN THE OREGON DEPARTMENT  
OF FORESTRY ASTORIA NORTH STUDY AREA

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July, 2006

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## **Fish Habitat Assessment in the Oregon Department of Forestry Astoria North Study Area**

### **Project Description**

A collaborative project between the Oregon Department of Forestry (ODF) and the Oregon Department of Fish and Wildlife (ODFW) was initiated to synthesize aquatic habitat and fisheries information for the Lower Columbia River drainages to assist in the development of operational management plans, stream habitat restoration projects, habitat conservation planning, and watershed analysis. The project summarizes the condition of stream habitat, the distribution and abundance of salmonid fishes, and the potential for restoration. The ODFW Aquatic Inventories Project has conducted stream habitat surveys as part of its basin survey project and habitat assessment project under the Oregon Plan for Salmon and Watersheds. The goal of these surveys was to document the status and trends of stream conditions in coastal drainages. These surveys in conjunction with fish distribution, fish presence, potential barriers to passage, and past restoration activities form the basis of the analyses.

The watersheds comprising the Astoria North project area are in northwestern Oregon and drain into the Lower Columbia River (Map 1). The primary watersheds are the Lewis and Clark River, Youngs River, Klaskanine River, Big Creek, Gnat Creek, and Plympton Creek. The Astoria North project area, as delineated by ODF ownership, is comprised of segments of each drainage rather than watershed boundaries. Within this, ODF ownership is concentrated to the east of Big Creek in the Gnat, Hunt, and Plympton Creek drainages. In the remainder of the study area, ODF ownership is less contiguous (Map 2). Table 1 lists the surveyed streams in relation to the major river basins in the Astoria North project area. Non-ODF land ownership in the watersheds includes private industrial, private non-industrial, state, and miscellaneous (Map 2). The area delineated by ODF ownership is referred to as the Astoria North project area; the area delineated by ODFW for this aquatic assessment is termed the Astoria North study area. If information is presented or discussed for land outside the project area, it is specifically stated. Maps display habitat features in surveyed streams throughout the study area to provide context, whereas the table and figures present data from streams on ODF lands in the project area.

The Lower Columbia basin is comprised of four level IV ecoregions as defined by Thorson et al. (2003) (Map 3). The lower Columbia study area is underlain primarily by relatively soft marine sedimentary rock. The Coastal Lowland ecosystem includes the lower reaches of the Lewis and Clark, Youngs, and Skipanon rivers, and is characterized by estuarine marshes and wetlands, and wet forests on old marine terraces. Much of this ecoregion is within the historic Columbia River floodplain. The upper reaches of the aforementioned rivers, the majority of the Klaskanine River watershed, and the lower ends of Big and Gnat Creek are within the Coastal Uplands ecoregion. This ecoregion includes headlands and mountains of marine sedimentary geology that were formally dominated by Sitka spruce. With the exception of the eastern most edge of the study area which is volcanic, the remaining area is in the Willapa Hills ecoregion, an ecoregion of more gentle landscape with silt and clay-textured soils.

## *GIS coverages – sources and scales*

Three digitized maps layers were used for different features of this synthesis. The primary layer is the 1:100,000 USGS stream layer. It is a standardized and routed coverage, and has a unique latitude and longitude field associated with each stream (Hupperts 1998). Fish distribution and aquatic habitat data are joined to the 1:100,000 coverage. The Coastal Landscape and Analysis and Modeling Study (CLAMS: <http://www.fsl.orst.edu/clams/>) provided a 1:24,000 coverage and a standardized 6th field Hydrologic Unit coverage. The CLAMS coverages displayed all streams at a 1:24,000 scale, and determined the valley width, mean annual flow, gradient, and channel size. The highest resolution coverage was developed for Oregon Department of Forestry (ODF) at the 1:12,000 scale. We used this layer to display a generalized (no species information) map of salmonid distribution. Because of the different development processes, the data cannot be integrated across scales, but are displayed in the same projection (Map 4).

## **Fish Distribution and Abundance**

Chum (*Oncorhynchus keta*), coho salmon (*O. kisutch*), fall Chinook salmon (*O. tshawytscha*), and winter steelhead (*O. mykiss*) occur in the main tributaries of the Lower Columbia basin (Map 5). Additionally, resident and anadromous cutthroat trout (*O. clarki clarki*) (Map 6) and Pacific lamprey (*Lampetra tridentata*) are present (Map 7). Non-salmonid native species are present in both basins; however, their distributions are not well documented.

## *ESA Designations*

Coho, fall Chinook, and chum salmon are listed as threatened under the federal Endangered Species Act in the Lower Columbia Astoria North study area (<http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/>).

## *Fish Populations*

Chum salmon were considered extirpated from tributaries on the Oregon side of the Columbia River, though occasionally they are observed in Big, Little, and Klaskanine creeks and at Oregon hatcheries. These may be from naturally producing populations or strays from Washington tributaries or hatcheries. Regardless of origin, adult chum salmon are observed in the lower sections of large rivers in the fall, and juveniles are occasionally collected in sloughs and in the estuary. Adult chum salmon spawn in the fall, usually peaking in November.

The fall Chinook salmon populations are predominately hatchery-produced fish. Naturally-produced fall Chinook salmon are present in most tributaries to the lower Columbia, but they are a combination of wild and hatchery origins. Hatchery programs are numerous and varied, including net pens, STEP (Salmon Trout Enhancement Program), and ODFW hatcheries. The fish contribute to the various commercial and recreational fisheries in the Columbia River,

as well as help meet US/Canada treaty obligations. Adults return from September to December, with peak spawning occurring in October.

Spring Chinook salmon are released from hatchery facilities in Youngs Bay and Gnat Creek. The adults return from February through July. It is not known whether any spawn naturally.

Coho salmon reside extensively throughout the mainstem and larger tributaries. There are few naturally-produced populations in the Lower Columbia drainage. Of the 1,000 - 4,000 adult coho salmon estimated to spawn in the study area during the past 4 years, only an average of 100 were wild fish. Most spawning occurs from October through December. Hatchery programs operate at Big Creek and in net pens in Young's Bay, as well as STEP programs at local schools. Coho distribution is similar to steelhead (Map 5).

Winter steelhead reside extensively throughout streams in the Astoria North study area (Map 5). Naturally produced fish return from January through May, but spawn primarily in March through May. Hatchery fish are raised in Big Creek, Gnat Creek, and the Klaskanine River. Most winter steelhead spawn during late December and January. In 2004, 2000 redds were estimated for all streams inclusive of and west of Scappoose Creek that drain into the Columbia River.

Pacific lamprey distribution has yet to be mapped, and surveys targeting Pacific lamprey are few.

Anadromous and resident cutthroat trout are present and all production is natural (Map 6). They are not the focus of any population monitoring program; therefore, counts of adults are unknown. It appears that the searun/anadromous component maybe severely depressed. Spawning timing is late summer through early winter.

ODFW Aquatic Inventories Project conducted fish presence / absence surveys in the Lower Columbia Astoria North project area from 1992 – 2000. The data were an indication of fish presence / absence at the time of the survey, for general distribution of fish, and they were used as a guide for management and land use activities. Crews snorkeled or electrofished the survey units, sampling salmon, trout, sculpin, lamprey, and sucker.

Within streams on ODF lands in the project area, the most common salmon/trout species present is cutthroat. However, coho salmon are present in Mill and the lower reaches of Gnat Creek, and steelhead are present in Mill Creek, the upper Klaskanine drainage, Gnat Creek, Plympton Creek, and West Creek. Coho salmon and steelhead have recently been introduced to Big Creek above the hatchery and may be present in the upper most reaches on ODF land. Anadromous fish are not allowed to pass Gnat Creek hatchery.



### *Historic Fish Distribution*

Lacking historic fish distribution information, we used a map of stream size and gradient developed by the Coastal Landscape Analysis and Modeling Study (CLAMS: <http://www.fsl.orst.edu/clams/>) to identify areas above current fish distribution that could have potentially supported salmon in the past (Maps 8 and 9). We assumed that fish distribution in the Lower Columbia basin would be limited by stream gradient if impediments such as physical barriers or poor habitat were not present. Current distribution of some anadromous species appears to be limited by man-made (including hatcheries) barriers, natural barriers, and habitat degradation. The distribution of anadromous fish in Big Creek above the hatchery is limited. Chum and Chinook are excluded, and only wild coho salmon and steelhead are passed above the hatchery. Gnat Creek Hatchery prevents the passage of adult salmon and steelhead. Chum salmon extent has diminished because of loss or severe degradation of estuaries and lower river habitat. Chum salmon currently observed may be strays from Washington streams or hatcheries, or represent some natural production in Oregon streams.

### *Salmon and Lamprey life history in coastal basins*

Chum salmon spawn in lower reaches of the larger rivers and tributaries. Fry hatch in early spring and move quickly downstream to the estuary. Migrating fry form schools in estuaries, remain close to shore for a few months and finally disperse to enter the ocean.

Chinook salmon return September to December with peak spawning activity observed in October. Chinook salmon prefer to spawn in larger streams at the tail crest of pools and glides and tend to use larger substrate to build redds. As the fry emerge in early spring, some will migrate immediately to the estuary while others will remain in freshwater until early summer. After spending the summer and early fall in the estuary they will migrate to the ocean. Juvenile Chinook salmon can be found in the estuary most months of the year. Most Chinook salmon will remain in the ocean an average of 3 to 4 years. Upon return from the ocean, the adult fish often hold in the estuary until the rains increase the river water levels and then return to their native streams to repeat the cycle. Habitat requirements for adult Chinook are clean, ample gravel and cobble for spawning, cold, clean, well-oxygenated water, and deep pools for cover. Juvenile Chinook need cool, clean water, pools, and large wood debris for cover while in their freshwater environment. Estuaries and associated wetlands provide vital nursery areas for the juvenile fish prior to their departure to the ocean.

Coho salmon begin returning to their natal watershed in the fall after spending 6 months to 1.5 years in the ocean. They prefer to spawn in the smaller tributaries and have been observed in the upper reaches of the mainstem rivers as well. After hatching, fry emerge in early spring and remain in their freshwater environment for a complete year. Thus, due to this life history trait, high quality habitat conditions are necessary year-round in order to insure survival during summer and winter. Favorable attributes include off-channel habitat and beaver pond habitat to provide refuge from high velocity winter flows, large wood debris to provide cover from predators, and low levels of fine sediment in spawning gravel.

Winter steelhead return to their natal streams from December through April after spending from 1 to 3 years in the ocean. Unlike other Pacific salmonids, steelhead are iteroparous and may survive after spawning to return to the ocean and repeat the cycle. Spawning occurs in March and early April. After the fry emerge they remain in small streams for the first summer, but commonly migrate to larger streams and rivers in their second year. Juveniles usually stay in their freshwater environment for two years before migrating to the ocean in the spring. Habitat requirements include clean, ample gravel for spawning, cold, clean, well oxygenated water, deep pools and large wood debris for cover.

Coastal cutthroat trout may exhibit four main life history strategies; an anadromous form that migrates to the estuary and/or ocean before returning to freshwater to spawn, an adfluvial form that migrates from a lake to smaller tributaries to spawn, a fluvial form that migrates to small streams from other parts of the watershed to spawn, and a resident form that both resides and spawns in small streams. Both anadromous and resident cutthroat trout are found throughout the mainstem and tributaries of the Lower Columbia basins, but specifically resident cutthroat tend to be found in the upper headwater reaches of the tributaries. In freshwater, adult cutthroat typically reside in large pools while the young reside in riffles. Resident fish spawn in March and April. Anadromous adult timing is late summer through early winter. Fry emerge from the gravel in about 2 months. The young utilize slow flowing backwater areas, low velocity pools, and side channels for rearing. Young cutthroat can spend 1 to 9 years in fresh water before they migrate to the estuaries and ocean in the spring, but most commonly it is three years from emergence. Adults usually spend less than 6 months in the ocean before returning to spawn. Like steelhead, sea-run cutthroat trout usually survive after spawning and will return to the ocean in late March or early April.

Pacific lamprey are anadromous. Mating pairs construct a nest by digging, using rapid vibrations of their tails and by moving stones using their suction mouths. Adults die within days of spawning and the young (ammocoetes) hatch in 2-3 weeks. The juveniles swim to backwater or eddy areas of low stream velocity where sediments are soft and rich in dead plant materials. They burrow into the muddy bottom where they filter the mud and water, eating microscopic plants (mostly diatoms) and animals. The juvenile lamprey will stay burrowed in the mud for 4 to 6 years and stay in the same habitat, rarely migrating within the stream system. They metamorphose into adults averaging 4.5 inches long. Lamprey migrate to the ocean in late winter during periods of high water. After 2 to 3 years in the ocean they will return to freshwater to spawn.

### **Habitat Survey Approach and Methods**

ODFW Aquatic habitat surveys were conducted in the Lower Columbia drainages on ODF property from 1992 – 2004 (Map 10; Table 1).

The habitat surveys describe the channel morphology, riparian characteristics, and features and quality of instream habitat during summer flow, following methods described in Moore et al. (1999) (<http://osu.orst.edu/Dept/ODFW/freshwater/inventory/publicatn.htm>). Each habitat unit is an area of relatively homogeneous slope, depth, and flow pattern representing

different channel forming processes. The units are classified into 22 hierarchically-organized types of pools, glides, riffles, rapids, steps, and cascades, as well as slow-water and off-channel pool habitat. Length, width, and depth were either estimated or measured for each habitat unit. In addition, water surface slope, woody debris, shade, cover, and bank stability were recorded. Substrate characteristics were visually estimated at every habitat unit. Estimates of percent silt, sand, and gravel in low gradient (1-2%) riffles were used to describe gravel quantity and quality. The surveys also provided an inventory of site-specific features including barriers to fish passage (e.g., falls or culverts), mass hillside failures, and beaver activity.

Riparian transects describe tree type and size, canopy closure, and ground cover associated with the floodplain, terraces, and hillslopes adjacent to the stream. Each transect measures 5 meters in width and extends 30 meters perpendicular to each side of the stream channel. The number and size of the trees recorded are extrapolated from these transects and summarized as the number of trees expected every 305 meters of stream length.

Descriptions of channel and valley morphology followed methods developed at Oregon State University and described in detail in Moore et al. (1999). Valley and channel morphology defined the stream configuration and level of constraint that local landforms such as hillslopes or terraces imposed upon the stream channel (Gregory et al. 1989; Moore and Gregory 1989). The channel was described as hillslope constrained, terrace constrained, or unconstrained. Channel dimensions included active (or bankfull) channel width and depth, floodprone width and height, and terrace widths and height. These descriptions of channel morphology have equivalents within the OWEB and Rosgen channel typing system (Rosgen 1994).

Two survey designs were used within the Astoria North study area. Surveys conducted in 1992 – 2004 followed a basins, or census, survey design. The basins survey followed methodology proposed by Hankin (1984) and Hankin and Reeves (1988). The sampling design is based on a continuous walking survey generally from the mouth or confluence of a stream to the upper reaches. Each stream is stratified into a series of long sections called reaches and into short habitat units within each reach. A stream reach is a length of stream defined by some functional characteristic. This may be a change in valley and channel form, an entering tributary, major changes in vegetation type, or changes in land use or ownership. Within a watershed, field crews survey major streams and a selection of small tributaries. The methodology provides flexibility of scale, allowing information to be summarized at the level of microhabitat, associations of habitat, portions or reaches of streams, watersheds, and subunits within regions. The continuous-survey approach provides field-based estimates of habitat conditions throughout a stream, describe habitat and hydrologic relationships among streams or landscape features, and permit stream-wide estimates of fish distribution and abundance.

The second survey design referred to as Oregon Plan surveys (OR Plan). This survey design was intended to provide estimates of habitat conditions across a broad geographic region. To accomplish this, we randomly selected sites in 1998 in the Lower Columbia and two sites fell within the Astoria North project area. Field protocol was similar to the basins surveys except that sites were 500 meters to 1,000 meters in length and some of the sites are designated to be resurveyed on a rotational design of one, three, and nine year intervals. The randomly selected

sites were combined with the basins survey reaches to describe aquatic conditions in the study area and are included in the summaries reported here.

### *Analysis*

Habitat data were summarized at the reach (basins surveys) or site (OR Plan surveys) scale to describe channel morphology, habitat structure, sediment supply and quality, riparian forest connectivity and health, and in-stream habitat complexity. Individual attributes include:

Channel morphology	Channel dimensions Channel constraint features, if any Gradient Percent secondary channels Floodplain connectivity
Pool habitat	Percent pool Percent slow, backwater, and off-channel pools Deep pools (>1m deep) Complex pools (contain > 3 pieces large wood)
Large wood	Pieces of large wood (>0.15 diameter and >3m length) Volume of large wood (m <sup>3</sup> ) Key pieces of wood (>0.6m diameter and >12m length)
Substrate	Percent fines, gravel, cobble, boulder, bedrock Percent fines and gravel in low gradient riffles
Riparian	Shade Density of conifer trees, by size category Density of hardwood trees, by size category

Results are presented in tables and as frequency distribution graphs and in GIS coverages. Values were standardized as a percent or by reach length. Habitat attributes were expressed as reach or site averages or displayed at the habitat unit level. Information from a reference database was used to provide a standard point of comparison. The basins and OR Plan surveys were integrated into coverages in a Geographical Information System (Jones et al 2001). The basins surveys were routed and displayed at the channel reach and habitat unit scales, and the random surveys were displayed as points with reach summary data.

Individual stream survey reports for the Lower Columbia are available from the Aquatic Inventories Project in Corvallis. Metadata for the GIS coverages is available online at <http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm>. An interpretation guide for aquatic habitat data is available online at <http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm>

Reference conditions

Reference values (Table 2) were derived from streams in areas with low impact from human activities (e.g. wilderness or roadless area, late successional forest or mature forest). A total of 124 reference sites, surveyed between 1992 and 2003, were selected within the Oregon Coast Coho ESU (from Sixes River to the Necanicum, including reaches of the upper Umpqua in the Cascade ecoregion) to represent conditions within the range of coho salmon. Many of the streams surveyed by ODFW in the Lower Columbia Astoria North study area were also within the range of coho salmon. However, no reaches in the study area were part of the reference data set. Each site was inspected using USGS 7.5 minute topographic maps for human-caused stressors such as roads, development, and forest management. A summary of reference site characteristics follows:

<b>Attribute</b>	<b>Value</b>
Number of Reaches or Sites	124
Distance Surveyed - Total (km)	161.9
Reach or Site Length (m)	
Mean (median)	1306 (971)
Range	174 - 6776
Active Channel Width (m)	
Mean (median)	9.28 (7.28)
Range	1.5 – 31.5
Gradient (%)	
Mean (median)	2.8 (2.3)
Range	0.5 – 19.2
Ownership	primarily federal
Ecoregions	Coastal 80% Cascades 20%
Geology	Sedimentary 72% Volcanic 21% Mixed 7%

While few of the sites were completely absent of human influence, we assumed that the reference sites represented a natural range of conditions. The range of data for each reference stream variable was subdivided into quartiles, 0-25%, 25-75%, and 75-100%. The value within each of the three quartiles was labeled as either low, moderate, or high. Thus, we considered that the 25<sup>th</sup> and 75<sup>th</sup> quartile breakpoints represented the values we considered low or high within a natural context. The middle 50% quartile was considered a moderate or average level. We used these values not to predict historic conditions in the Lower Columbia Astoria North project area, but to more broadly represent the potential range of historic conditions in lower gradient (<5%) fish-bearing streams in Oregon, and to provide a point of comparison for the subsequent analysis.

## Aquatic Habitat Conditions

### *Aquatic Habitat overview*

The ODFW Aquatic Inventories Project has conducted aquatic habitat surveys in the Lower Columbia since 1992. There are approximately 99 kilometers of surveyed stream habitat associated with 75 identified reaches within the ODF Lower Columbia Astoria North project area (Map 10). Table 1 lists the streams surveyed. Most of the streams surveyed in the project area were small to moderate sized tributaries, based on active channel width. The active channel width (bankfull width) on the surveyed streams ranged from 1.4 – 60.0m (average of 8.1m and a median of 6.7m). The gradient ranged from 0.5% to 31.7% (5.8% average and 5.0% median) (Table 3). Of the 99 kilometers of stream surveyed, 61km (n=39) had an average gradient greater than 5 percent. Of the 61km, approximately 14km (n=14) had an average gradient greater than 9 percent. Tables 5A and 5B provide all the stream reaches and habitat conditions for the selected attributes within the project area.

Thirteen core habitat attributes considered important for successful spawning, rearing, and survival throughout various fish life history stages were analyzed. These core attributes are the amount of pool habitat, quantity of deep pools per kilometer, percent of slackwater habitat, percent of secondary channel area, percent of fines and gravel substrate found in riffle units, percent bedrock substrate, large wood pieces, volume, and key pieces, shade, and large conifers in the riparian zone. The values derived from these core attributes are compared to habitat breakpoints of the reference stream reaches and conditions. Reference sites provide a general context and range of stream attributes of minimally human-influenced sites. They are intended to provide a point of comparison to view the relative differences between streams and reaches within a drainage network. Reference values are not meant to be prescriptive, that is, to indicate the value each reach of stream must attain.

The aquatic habitat surveys in the Astoria North project area attributes were compared to the reference values, as displayed as cumulative frequency distributions (cdf) (Figures 1-8). The cdfs indicate that the habitat quality was similar for the project area as a whole and the small stream (upstream of coho distribution) reaches. The majority of the surveyed streams on ODF land were much steeper than those of the reference set, regardless of small stream status. Approximately 50 percent of the active channel widths of the project area streams were similar to reference values. Although the streams were steeper, the percent secondary channel area was much greater than the reference values, thus demonstrating connectivity. Many of the remaining habitat attributes revealed relatively simple, low quality habitat. The percent pools was quite a bit lower than the reference value, the amount of silt and organic substrate was quite high, and the number of wood key pieces were low. Without large wood in the riparian zone or in the stream, the dynamic ability of winter flows to scour deep pools was reduced. The number of countable pieces of wood was a bit greater than the reference cdf curve, and the wood volume was more inline with the reference values for approximately fifty percent of the cumulative stream length. For small streams and the project area streams, the number of large (>50cm dbh) riparian conifers was similar to reference values for fifty percent of the stream length. The number of very large riparian conifers (>90cm dbh) was very low.

It is difficult to make a generalized statement about the stream reaches on ODF land in the Lower Columbia Astoria North project area. Some stream reaches lower in the basin, such as Mill, Peterson, and North Fork Gnat Creeks, had good pool habitat (slackwater or deep pools), moderate wood levels, and good secondary channel habitat. Big Creek and its tributaries and Plympton Creek reaches met at least the moderate level for number of pieces, wood volume, and key pieces of wood. Those meeting the high reference value for deep pools often had low percent pool habitat. Some reaches meeting the high reference value for number of wood pieces didn't meet the high reference value for shade. One can't say that a specific watershed or stream consistently met the high reference value, though many reaches met the moderate reference value range for habitat attributes.

### *Relationship of fish populations to aquatic habitat*

The surveys described components and processes that contribute to the structure and productivity of a stream and fish community. The Aquatic Inventories Project selected attributes to describe important indicators of sediment supply and quality, instream habitat complexity, and riparian forest community. These variables were summarized for reaches and sites on ODF lands within the Astoria North project area in Tables 5A and 5B. As mentioned earlier, we also used cumulative frequency distribution graphs to examine the survey data on ODF lands (Figures 1 through 8). The frequency distribution graphs are useful for determining medians and percentile values and for comparing the differences in distribution of values between multiple strata. These graphs also illustrate the habitat values with comparison to reference conditions.

The response of salmonid fishes to the character of aquatic habitat varies by life stage and time of year. Adult fish seek deep pools for holding areas while preparing to spawn and need gravel and cobble substrate that is free of fine materials to build redds and deposit eggs. Furthermore the redds require a steady flow of oxygenated water to allow the eggs and alevins to mature. Increasing amounts of fine sediments (<2mm) increases the mortality of eggs in the gravel (Everest et al. 1987). The amount of silts and fines associated with riffles is an indicator of embeddedness in spawning areas. A high percentage of fine sediment can settle (embed) in the interstitial spaces of the gravel and armor it such that it is difficult for spawning fish to dig an adequate redd (nest) and prevent oxygenated water from reaching the eggs. Fine sediment values less than 8% are desirable (Table 2). The median value among the project areas was high at 37% (Tables 4 and 5A, Map 11, and Figure 2).

After emergence in the spring, salmonid fry typically remain in freshwater for a few weeks to two years before migrating to the ocean, depending on species. Edge cover and backwater habitats are particularly important to the survival of fry in the spring, though less so as they grow and move into larger pools during the summer. The distribution of juvenile salmonids is limited primarily by the availability of pool habitat, food resources, and acceptable water quality. In the winter, coho salmon parr prefer complex pool habitat which has low velocity refugia from high winter stream flows. This habitat is often found in the form of off-channel alcoves, dam pools, and beaver ponds (Nickelson 1992). Complex off-channel habitats are also important in these large stream reaches during the winter. Large wood is an important structural component contributing to the complexity of these preferred habitats (Sedell 1984). Juvenile

coho salmon extend their distribution downstream in the winter to inhabit areas previously limited by high water temperature, including tidally influenced wetlands. Juvenile steelhead and cutthroat trout are more opportunistic in regards to habitat type, residing in pools, riffles, rapids, and cascades. Additionally, pools provide resting places and over-wintering habitat for fish. Deep pools, those greater than or equal to 1 meter deep, provide temperature refugia and provide year-round cover.

The amount of available pool habitat in the Astoria North project area differed depending upon the type of pool. The Astoria North project area median value for percent pool habitat was 12.6, which was at the moderate level. Fourteen reaches met or exceeded the high reference value (>45% pool habitat), most of these were on North Fork Gnat Creek and Tributary A and Mill Creek. The median project area value for deep pools (>1m deep/km) was just above low at 0.4 (Tables 4 and 5B). The high reference value was 3 or more deep pools (Table 4 and 5B, Figure 5, Map 12). One third of the deep pools were on Gnat Creek. Slackwater pools included backwater habitat, dammed pool, and beaver ponds. The Astoria North project area median value was 0.5%. Mill, Peterson, and North Fork Gnat Creeks and a scattering of others met the high reference value (greater than 7% of total available habitat) (Table 4). Sixteen reaches met or exceed the high reference value (Table 5B).

Instream wood serves many functions in a stream channel. The wood helps to scour deep pools, provide cover and nutrients, trap sediment, and provide cover from predators. Wood acts as an obstacle at higher flows, forcing the stream to cut new channels, to scour new pools, and to create undercut banks. Channel morphology and amount of secondary channel indicate relatively high connectivity to the floodplain. Secondary channels increase the potential habitat available to fishes, particularly to juveniles. Often the habitat has slower moving water than the primary channel. It provides over-wintering and summer rearing habitat for juvenile fish. A high level of secondary channels is 5.3% or more of the total channel area, which 50 of the 75 reaches in the project area met or exceeded (Map 14).

Riparian vegetation is indirectly an important component of fish habitat. The riparian trees stabilize the bank, are a recruitment source of woody debris, buffer against flood impacts, and provide shade. Stabilized stream banks are more likely to develop undercut banks, which serve as important cover for fish and are less likely to contribute fine sediments. The canopy cover (shade) in the majority of reaches rated either moderate or high in relation to the reference conditions (Map 12). Shade cover is due to a riparian composition consisting predominantly of hardwood species (red alder) 3-30 cm dbh and a narrow active channel. The project area median value for large riparian conifers is moderate at 61.0, while the very large riparian conifer value was zero. There were no very large conifers (90+cm dbh) observed in the riparian zones of any of the reaches (Tables 4, 5B, Figure 7). Few riparian conifers is a limiting factor for recruitment of large wood (greater than 60 cm dbh) into the channel and thus a limiting factor for increasing pool habitat and scouring deeper pools. Although all trees are important and contribute to the river system, conifers are particularly important as they tend to grow larger than deciduous trees; therefore, they remain in the river system longer before deteriorating and provide greater hydraulic function.



Very few streams within the project area support coho salmon. Mill Creek, the lower reaches of Gnat Creek, and the uppermost reach on Big Creek contain coho salmon. We completed an overall assessment of the status of streams within the range of coho salmon in the lower Columbia River ESU (Anlauf et al. 2006). The findings indicated that the capacity and quality of summer and winter rearing habitat for juvenile coho on ODF lands was limited and of low to moderate quality. However, Mill Creek and the lowest reach of Gnat Creek on ODF land have a high intrinsic potential (Map 21) and currently have a high (Mill Creek) and moderate (Gnat Creek) capacity and quality of rearing habitat. Reaches on Gnat Creek provide the greatest opportunity to expand the quality and rearing capacity for coho salmon on ODF lands.

### *Small streams*

Coho salmon usually reside in low and moderate gradient streams, usually less than 5 % gradient. Higher gradient streams above coho salmon distribution, referred to as “small streams” in this document, are home to steelhead, cutthroat trout, sculpin, lamprey, amphibians, and other organisms. Small streams are a vital piece of the ecosystem and while they tend to function differently from larger streams, they may also be managed differently. Their importance may be overlooked due to the small channel width, lack of anadromous fish distribution, and at times, intermittent flow.

Approximately 60 percent of the streams ODFW Aquatic Inventories Project surveyed in the Astoria North project area (1:100,000 scale) is above the distribution of coho salmon, referred to as small streams in this document. Not surprisingly based on the amount of continuous ODF property, the majority of the streams are located in the Gnat, Hunt, and Plympton Creek watersheds (Map 15). Though represented separately in this analysis, small streams were incorporated in the larger analysis for the Astoria North habitat assessment. Small streams usually have a narrower active channel and higher gradient than streams within the distribution of coho salmon (Table 7). Yet in the Astoria North project area the geomorphologic features were more similar. The small streams had the similar median active channel width (5.2m) to the project area as a whole (6.7m). The median gradients were similar as well, 6.3% and 5.0%, respectively. The small stream and project area reaches had similar values for most of the thirteen habitat parameters. The exceptions being wood pieces and volume for which the small stream value exceeds the project area, the percent pool habitat and percent bedrock for which the value is lower (Figures 9-16, Table 6).

Small streams are less suitable areas for instream restoration due to the steep gradient (Table 11). Small streams are among the areas considered low priority for instream restoration by Thom and Moore, 1997. Restoration is best accomplished in a passive fashion by protecting the riparian areas. The condition of the riparian areas influences the rate and character of input of large wood debris and sediment to the system.

## *Flood surveys*

ODFW Aquatic Inventories Project surveyed a selection of stream reaches following the large flood event that occurred during February 1996 (Jones et al. 1998). Due to the structure of the sampling, we are only able to describe conditions in the Astoria North project area relative to the degree and extent of habitat alteration associated with the floods at specific sites. The sample size in this study area is too small to generalize to the whole study area. The survey sites were randomly selected by ODFW from previously surveyed streams; each was one kilometer in length.

Thirteen one-kilometer reaches were surveyed in the North Coast; 3 were on ODF property in the Astoria North study area (Map 16). The data were evaluated and placed into categories according to level of flood impact. Highly impacted reaches showed evidence of debris torrents at the scale of full valley floor scour or deposition extending for more than 7 channel widths in length. Characteristics of moderately impacted reaches include various large scale channel modifications, such as channel relocation, new channel formation, deposition of new gravel bars. Reaches with low impact ranged from no perceivable impact, high water impact (clearing of litter from low terraces and floodplain), or scour and deposition patches (localized scouring or deposition). Although described here, there were no reaches with high impact in the study area.

In the three flood sites on ODF land in the project area, surveyors observed mass failures and moderate or low impact from the flood. The reach on Gnat Creek had low impact. The two sites on Plympton Creek each were moderately impacted and had mass failures. In general, streams in the Lower Columbia basin experienced some debris torrents, channel morphology adjustments, and redistribution of habitat units, sediment, and wood. Due to the low number of surveys in this area, it is unwise to generalize the impact of the 1996 flood on the entire study area. The sites do show a range of flood impacts in the stream channel from the 1996 flood event. Fish use post-flood is dependent upon the extent and type of flood impact. Those with lesser impact or that are lower in the watershed may see fish use return sooner than those heavily impacted.

Flooding may alter the stream channel habitat. How floods impact fish habitat depends upon the intensity of the movements, the age and type of material on the hillsides and in the stream channel, and the channel morphology (gradient, valley width index) of the valley. Especially evident in winter storms and flood events, material from the hillsides is carried into the channel and moved downstream. Management of upslope land that is mindful of large-scale events will benefit stream processes prior to and potentially minimize downstream impact during flood events.

## *Barriers*

Barriers and potential barriers to anadromous and resident fish exist in most riverine systems due either to human-caused or natural processes. A barrier, which includes culverts, dams, velocity barriers, natural falls, lack of sufficient water flow, etc., is defined as an

impediment to the movement of any fish at any life stage. There are 167 potential barriers as determined by Streamnet in the Astoria North study area and 17 on ODF property (Map 17 and Table 8). These barriers are located both within and outside known fish distribution. Fish distribution may extend beyond a partial barrier because the barrier may be specific to a species or life stage, or at a particular time of year.

The Streamnet barrier database incorporated the culvert inventory database; therefore, culverts in the dataset are those which do not meet acceptable fish passage criteria, not necessarily those which prevent all fish at all times. Of the 17 listed barriers, 3 are culverts. These barriers are rated as to the degree, or lack thereof, of fish passage. One is thought to have complete blockage and two have unknown passage ability. Movement may be prevented due to high velocity of water through the culvert, incorrectly sized culvert, culvert deterioration, or debris blocking the culvert. Data are not available to assess fish presence above all of the potential barriers (Table 8 and Map 18).

Overall, fish passage as displayed by Streamnet is unknown. Incorporating anadromous fish use GIS layers enables a general view of passage (Map 18). Fish use is not mapped for two of the potential barriers, including an unnamed tributary of Gnat Creek with an impassable culvert (Record ID 1366). Notes describing Record ID 51367 and 51672 on Plympton Creek indicate natural falls which steelhead are able to navigate beyond, though they hinder coho. The falls on Knotts Creek (Record ID 55384) end steelhead and coho distribution. Resident cutthroat trout, lamprey, and sculpin may be present above the natural and human-caused barriers.

Additionally, aquatic habitat survey crews documented a few potential barriers to migratory fish, only three were on ODF land (Map 19). These included a step-over-bedrock 15 meters high on Gnat Creek; a cascade-over-boulder on McNary Creek; and a step-over-bedrock 3 meters high on the Klaskanine River. In these particular cases, Streamnet distribution indicates that these potential field-noted barriers do not prevent anadromous fish passage. In some cases, fish distribution stopped below, extended beyond, or was not mapped at the particular stream (usually a tributary).

The amount of aquatic habitat with restricted access or passage problems due to human-impacts in the Astoria North project area based on Streamnet barrier data may total 14.5 kilometers. This is because most potential barriers impacting fish distribution are natural falls. Information as to species and life stage affected is not available in the database. Conducting field surveys to improve documentation is recommended, although passage does not appear to be a major issue.

## **Restoration**

Restoration is a technique and process used in an attempt to improve stream habitat in the short term and to achieve long-term recovery goals. The goals of restoration range from improving spawning and rearing habitat to improving natural stream processes. Treatment projects focus on improving summer and winter rearing for juvenile salmonids, improving

spawning habitat, increasing channel complexity and connectivity, increasing nutrients in the stream, reducing sedimentation and bank erosion, and replanting native streamside vegetation. The quality of existing pools could be increased by recruitment of gravel, addition of wood pieces, or increased shade levels. Monitoring is a critical aspect of the restoration effort, as it is important to gauge whether the methods employed helped to achieve the desired effects. Achieving noticeable response may take several high flow events; biological response could take longer.

Since 1997, twenty-two instream projects funded by OWEB have been completed on ODF lands (Table 9, Map 20) in the Astoria North project area. The projects on ODF lands focused on instream enhancement, road/drainage improvements, and passage issues. Four projects placed large wood in the stream, seventeen improved fish passage, and eight improved the road and drainage system. Most projects addressed more than one issue.

In 1995, Barber, Moore and Nicholas identified stream reaches on ODF land in the Lower Columbia watershed for instream enhancement. The majority of the selected stream segments recommended for restoration was located on private land, while four were located on ODF land (Table 10, Map 22). Selection was made primarily from streams that had been earlier inventoried. It is undoubtedly the case that a great number of reaches not listed would make excellent candidates for instream restoration. Locations for potential instream enhancements could be determined by first locating areas of high intrinsic potential followed by consultation with an expert, such as ODFW restoration biologist (Map 21). Determination for site suitability will always require field checking to determine current conditions and needs. Generally, stream areas suitable for coho habitat enhancement are areas with unconstrained stream channels, <5% gradient, moderate size channel width (4-12 meters), and either have or are adjacent to a known coho population area (Table 11). Since 1997, none of the five recommended reaches has been treated. Criteria for instream restoration treatments within the Astoria North project area will require consideration of the dynamics of the larger river system.

**Summary of Fish Populations and Aquatic Habitat Conditions**  
**Department in the Oregon of Forestry Lower Columbia Astoria North Project Area**

***Fish distribution***

*What fish species are documented in the watershed?*

- Chum, coho salmon, spring and fall Chinook salmon, winter steelhead, resident and anadromous cutthroat, and Pacific lamprey are present in the Lower Columbia Astoria North study area. Sculpin, rainbow trout, and amphibians are present; the occurrence and distribution of other native fishes is not well documented.

*Are any of these species currently state- or federally listed as endangered, threatened, or candidates?*

- Coho, fall Chinook salmon, chum, and winter steelhead are listed as threatened under the federal Endangered Species Act in the Lower Columbia Astoria North study area (<http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/>).

*Are there any fish species that historically occurred in the watershed that no longer occur there? Map potential historical fish distribution.*

- Chum are believed to be extirpated from Oregon tributaries of the Columbia River; those in the Lower Columbia basin are thought to be strays from Washington.
- We believe current distribution is similar to historical distribution, barring barriers.

*Which salmonid species are native to the watershed, and which have been introduced?*

- With the exception of spring Chinook salmon, all of the aforementioned salmonid species are native to the watershed. The extent of the hatchery impact depends upon the species. For example, there are few naturally-produced coho stocks in the basin, as most are hatchery-produced. Non-native fish, including non-native salmonid stocks, may be present but have not been documented.

*Are there potential interactions between native and introduced species?*

- Because no introduced species have been documented, there are no known interactions between native and introduced fish.

***Current habitat conditions***

*Show current condition of key habitat characteristics.*

- Habitat surveys were conducted from 1992 – 2004 (Table 1 and Map 10).
- Habitat characteristics are listed in Tables 5A and 5B, graphed in Figures 1 through 8, and examples mapped in Maps 11-14.
- Small stream habitat surveys (stream sections upstream of coho distribution) are a subset of the overall Astoria North project area sites. They are represented in Tables 6 and 7, Figures 9 – 16, and Map 15.

*Compare to reference streams for each characteristic.*

- Reference sites provide a general context and range of stream attributes of minimally human-influenced sites, and they are intended to provide a point of comparison to view the relative differences between streams and reaches within a drainage network. Reference values are not meant to be prescriptive, that is, to indicate the value each reach of stream must attain.
- Key benchmarks are presented in Tables 2 and 4 and individual stream reaches are compared to these benchmarks in Tables 5A and 5B, Figures 1-8, and Maps 11-14.
- Within the Astoria North project area, most of the median values for 13 habitat attributes are in the moderate level.
  - Percent pools: The median value for the project area was moderate (12.6%); thirteen reaches met or exceeded the high breakpoint level.
  - Deep pools/km: The median value for the project area was moderate (0.4/km); fifteen reaches met or exceeded the high breakpoint level.
  - Percent slackwater pools: The median value for the project area was at the moderate (0.5%) level; sixteen individual reaches met or exceeded the high breakpoint level.
  - Percent secondary channel area: The median value for the project area was high at 7.5%; fifty reaches met or exceeded the high breakpoint level.
  - Percent fines in riffle units: The median value for the project area was high at 37%; one reach met or exceeded the low breakpoint level. There were nine other reaches with a value <8, but these were reaches without riffles.
  - Percent gravel in riffle units: The median value for the project area was 28%; three reaches met or exceeded the high breakpoint level.
  - Percent bedrock: The median value for the project area was 1.4%; twenty-four reaches met or exceeded the low breakpoint level.
  - Pieces lwd/100m: The median value for the project area was moderate (18.6); thirty-three reaches met or exceeded the high breakpoint level.
  - Volume lwd/100m: The median value for the project area was 22.9; seven reaches met or exceeded the high breakpoint level.
  - Key pieces lwd/100m: The median value was 0.6; five reaches met or exceeded the high breakpoint level.
  - Number of conifers >50cm dbh/305m: The median value for the project area was moderate at 61.0; eight reaches met or exceeded the high breakpoint level.
  - Number of conifers >90cm dbh/305m: The project area and management area median value was low (0.0); no reaches met or met or exceeded the high breakpoint level.
  - Percent shade: The median value for the project area (91.3%) was high; 39 reaches met or exceeded the high breakpoint level.

*What stream reaches have high, moderate, and low levels of key pieces of large wood (>24-in) in the channel.*

- Key pieces/100m: The median value for the project area was 0.6 (low). The five reaches which exceeded the high level of 3 key pieces of large wood/100m were primarily on Big Creek. Fourteen of the 76 reaches did not have any key pieces.

*How many miles of fish-bearing or potentially fish-bearing streams are blocked by culverts, and where are these blockages?*

- Twenty-seven potential fish barriers were identified within the Astoria North project area. Two culverts are suspected to prevent fish passage (Record Id 55355 and 55356) based on fish distribution, but passage is unknown according to Streamnet; closer inspection is warranted. Four culverts are noted as impassable (completely or partially), one is noted as non-blocking, and the status of the remaining five is unknown. The other potential barriers are natural waterfalls (14); passage is unknown. A log jam is also noted to potentially prevent Chinook passage. It is possible that other barriers not noted here exist.
- The amount of aquatic habitat with restricted access in the Astoria North project area based on Streamnet barrier data is approximately 45 kilometers. The amount on ODF land resulting from passage problems may total 40 kilometers. Documentation as to the species and life stage affected by each barrier is limited. Field surveys to improve documentation are recommended. As five of the seven structures potentially limiting fish distribution are natural falls, attention should be directed towards the culvert issues as well as provide adequate habitat downstream of these falls.

### ***Analyze restoration potential***

*Which reaches have the most potential to increase fish populations?*

- Reaches with the most potential to increase fish production are those with high intrinsic potential that are within watersheds with high fish abundance. Secondarily, reaches within watersheds that have an abundance of pool habitat have the potential to respond to restoration treatments and improve fish productivity.
- A long term strategy to grow large conifer trees in the riparian area will improve conditions across the project areas and increase complexity of stream habitat for fish production as the trees naturally recruit to the channel. Although alders along the streamside serve important functions, large riparian conifers are necessary as well for their size and persistence in the system.
- Site selection will require an in-depth analysis of the unit level GIS and Oregon Plan site data coupled with field verification. Reviewing areas of high intrinsic potential (wide valley, low gradient, and low to moderate flow) (Map 21) combined with ground verification would be beneficial. Comparing areas of high intrinsic potential for coho salmon with locations that score well in the Limiting Factors and HabRate models will also help in selecting likely coho salmon restoration areas. Habitat complexity and floodplain connectivity requires the placement of large wood in selected stream segments to create complex pool and channel breaching opportunities. Taking advantage of the existing secondary channels will accelerate the process. Barber et al (1995) identified four potential reaches on ODF land for restoration, none of which have been treated (Map 22).
- Reduction of fine sediment in these drainages will require additional information to determine source, transport, and storage of sediment in the basin. The data available through the stream surveys only identify areas collecting excessive amounts of fine sediment.

- Site verification prior to restoration planning is necessary because many of the surveys are at least 10 years old and proper implementation depends on current site-specific factors.

*Which reaches have the most potential to meet or exceed benchmark levels?*

- All of the reaches have the potential to meet many of the benchmark conditions over time. Some of the data we have is from the 1990's and as such, should be reviewed to verify if conditions remain the same. Restoration and protection strategies can expedite the opportunity to improve aquatic habitat complexity, sediment, and riparian structure in the Astoria North project area.
- Examples of areas with high intrinsic potential for coho salmon include the following:
  - Reach one of Big Creek Tributary C.
  - Mill Creek.
  - Much of the lower and middle reaches of Gnat Creek.
  - The upper reaches of Plympton Creek.
  - Upper Davis Creek.

*What is the magnitude of possible additional habitat with restoration of access?*

- The two culverts potentially blocking upstream passage of fish should be examined. The culverts known to block passage and those with unknown passage ability should also be examined. Surveys are needed to determine the condition of the culvert, the ability of fish of many sizes and life stages and types to pass, and to document the quantity and quality of habitat for salmonid species above the culverts.

*What is the relative priority of barriers for removal, replacement, or repair?*

- The ODF and Streamnet barrier databases do not provide a lot of detail. Site checks are necessary to verify the nature and extent of the passage issues.

*Describe the types and locations of potential enhancement projects?*

- Based on the intrinsic potential information (valley width, stream gradient, active channel width, stream flow), many of the streams on ODF land are moderate to good candidates for enhancement activities. With the exception of the smallest tributaries and the headwaters areas, many streams are low to moderate gradient, in moderate to wide channels and valleys. Several streams could benefit from the addition of large woody debris, which would entrap substrate, scour deep pools, and provide cover for fish. Examples include portions of the Gnat Creek watershed, upper Little Wallooskee River, and upper Davis Creek.
- Enhancement activities can be more effective when a watershed approach is utilized. For example, rather than constructing one or two habitat structures in each of ten widely scattered locations, constructing these same structures in one watershed can enhance a longer continuous section of stream. With riparian plantings and the removal of a passage barrier, a whole stream could be improved.
- Priorities related to fish habitat are discussed above – improving habitat complexity, floodplain connectivity, scouring of pool habitat, and reduction of fine sediment, and retention of spawning gravel.
- Riparian plantings that increase the number, size, and species of conifer trees in the riparian zone would benefit floodplain connectivity and increase shade levels and long-term large



wood recruitment. Riparian enhancement for larger and greater mix of conifer species will again require site visits to identify appropriate floodplain and terrace sites within the Astoria North Project Area.

- The riparian surveys are a sample (not a census) of conditions along streams in the Astoria North Project Area, and hence only indicate the need for restoration.

*Describe confidence level in restoration analysis.*

- The aquatic surveys, between 1992 and 2004, described the overall conditions within each reach at the time of the survey. Restoration recommendations were based on existing habitat surveys (although selected attributes of the habitat data may be out of date for this use), channel and valley configuration, and digital elevation models. Because successful restoration depends on site-specific characteristics, we recommend: 1) site visits prior to final planning, 2) analysis of habitat data (available in GIS and database) at the habitat unit scale, 3) re-examination of gradient and valley form, 4) more comprehensive road and barrier information, and 5) more detailed description of riparian conditions.

## References

- Anlauf, K., K. Jones, C. Stein, and P. Kavanagh. 2006. Lower Columbia River Basin Coho Salmon Habitat Assessment: Status of Habitat and Production Potential and Capacity for Coho Salmon. Aquatic Inventories Project, Oregon Department of Fish and Wildlife, Corvallis.
- Barber, C., K. Moore, and J. Nicholas. 1995. Lower Columbia Tributaries Salmonid Habitat Restoration: Guide to Project Selection. Oregon Department of Fish and Wildlife.
- Everest, F., R. Beschta, J. Scrivener, K. Koski, J. Sedell, and C. Cedarholm. 1987. Fine sediment and salmonid production: A paradox. Pp. 98-142 in E.O. Salo and T.W. Cundy, eds. *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Seattle.
- Hupperts, K. 1998. Managing Oregon's aquatic resources: a dynamic segmentation application. Masters thesis. Portland State University, Portland, Oregon.
- Jones, K.K., R.L. Flitcroft, and B.A. Thom. 2001. Spatial patterns of aquatic habitat in Oregon. Pages 266–280 In *First International Symposium on GIS in Fisheries Science*. T. Nishida, Editor.
- Jones, K.K., Foster, S, and K.M.S. Moore. 1998. Preliminary assessment of 1996 flood impacts: Channel morphology and fish habitat. Oregon Department of Fish and Wildlife, Corvallis.
- Nickelson, T.E., Solazzi, M.F., Johnson, S.L., and Rodgers, J.D. 1992. An approach to determining stream carrying capacity and limiting habitat for Coho salmon (*Oncorhynchus kisutch*). p. 251-260 In *Proceedings of the Coho workshop*. Edited by L. Berg and P.W. Delaney. Nanaimo, B.C., May 26-28, 1992.
- Nickelson, T. E. 1998. A Habitat-Based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams. Oregon Dept. Fish and Wildlife, Fish Div., Fish. Info. Rep. 98-4 Portland, OR.
- Sedell, J. R. 1984. "Habitats and salmonid distribution in pristine, sediment-rich valley systems: S. Fork Hoh and Queets River, Olympic National Park," pp. 33-46 in Meehan, W. R., T. R. Merrell, and T. A. Hanley, eds., *Fish and Wildlife Relationships in Old-Growth Forests*, American Institute of Fishery Research Biologists, December, 1984.

## **Tables, Figures, and Maps**

Table 1. ODFW habitat surveyed streams within the ODF Astoria North project area.

ODFW surveyed stream	Survey Year
Big Creek	1992, 2004
Big Creek Tributary A	2004
Big Creek Tributary AA	2004
Big Creek Tributary B	2004
Big Creek Tributary C	2004
Big Creek Tributary C1	2004
Big Creek Tributary C2	2004
Big Creek Tributary D	2004
Big Noise Creek	1994
Gnat Creek	1994
Gnat Creek (6T-97)	1998
Hunt Creek	1994
Jack Creek	1997
Klaskanie River	1995
McNary Creek	2001
Middle Fork North Fork Klaskanie River	2001
Mill Creek	1996
North Fork Gnat Creek	1996
North Fork Gnat Creek Tributary A	1996
North Fork Klaskanie River	1995
Peterson Creek	1997
Plympton Creek	1994
Rock Creek	1994
Supply Creek	1994
West Creek	1996
West Creek (6T-149)	1998
West Fork Hunt Creek	1996
West Fork Plympton Creek	2001

Table 2. Habitat breakpoints based on reference streams within the distribution of coho salmon.

Parameter	Definition	Low break point	High break point
percent pools	percent primary channel area represented by pool habitat	<19%	>45%
deep pools/km	pools > 1m deep per kilometer of primary channel	=0	4
percent slackwater pools	percent primary channel area - slackwater pool habitat (beaver pond, backwater, alcoves, isolated pools).	=0%	>7%
percent secondary channels	percent total channel area represented by secondary channels	<0.8%	>5.3%
pieces lwd/100m	# pieces of wood > 0.15m diameter X 3m length per 100 meters primary stream length	<8	>21
volume lwd/100m	volume (m3) of wood > 0.15m diameter X 3m length per 100 meters primary stream length	<17	>58
key pieces lwd/100m	# pieces of wood > 60 cm diameter X > 12 meters long per 100 meters primary stream length	<0.5	>3
percent fines in riffles	visual estimate of substrate composed of <2mm diameter particles	<8%	>22%
percent gravel in riffles	visual estimate of substrate composed of 2-64mm diameter particles	<26%	>54%
percent bedrock in stream	visual estimate of substrate composed of solid bedrock	<1%	>11%
# conifers > 50 cm dbh	number of conifer trees larger than 50 cm dbh within 30m both sides of stream per 305m of primary stream length	<22	>153
# conifers > 90 cm dbh	number of conifer trees larger than 90 cm dbh within 30m both sides of stream per 305m of primary stream length	=0	>79
percent shade	percent of 180 degree sky; includes topographic and tree shade	<76%	>91%

Table 3. Comparison of reach length, active channel width, gradient, ownership, ecoregions, and geology between the reference surveys and ODF Lower Columbia Astoria North project area.

Attribute	Reference Reaches	Astoria North
Number of Reaches or Sites	124	75
Distance Surveyed - Total (km)	162km	99.3
Mean (median)	1306m (971m)	1324m (959m)
Range	174 - 6776m	99.4 - 6367m
Active Channel Width (meters):		
Mean (Median)	9.3m (7.3m)	8.1m (6.7m)
Range	1.5 – 31.5m	1.4 - 60m
Gradient (%):		
Mean (median)	2.8% (2.3%)	5.8% (5.1%)
Range	0.5 – 19.2%	0.5 - 31.7%
Ownership	Primarily federal	State
Ecoregions	Coastal 80% Cascades 20%	Coastal 100%
Geology	Sedimentary 72% Volcanic 21% Mixed 7%	Sedimentary 90% Volcanic 10%

Table 4. Habitat survey reach values and habitat parameter breakpoints relative to reference conditions in the Lower Columbia Astoria North project area.

Parameter	Habitat Breakpoints	ODF Astoria North project area 99.3km n=75	
		mean	median
percent pools	Low <19%		12.6
	Moderate	23.2	
	High >45%		
deep pools/km	Low 0		
	Moderate	2.0	0.4
	High >3		
% slackwater pools	Low 0		
	Moderate		0.5
	High >7%	9.9	
% secondary channel area	Low <0.8%		
	Moderate		
	High >5.3%	9.2	7.5
% fines in riffles	High >22%	37.4	37.0
	Moderate		
	Low <8%		
% gravel in riffles	Low <26%	25.5	
	Moderate		28.0
	High >54%		
% bedrock	High >11%		
	Moderate	4.2	1.4
	Low <1%		
pieces LWD/100m	Low <8		
	Moderate	20.4	18.6
	High >21		
volume LWD/100m	Low <17		
	Moderate	30.9	22.9
	High >58		
key pieces/100m	Low <0.5		
	Moderate	0.9	0.6
	High >3		
# conifers >50cm dbh	Low <22		
	Moderate	64.9	61.0
	High >153		
# conifers >90cm dbh	Low 0		0.0
	Moderate	6.2	
	High >79		
% shade	Low <76%		
	Moderate	87.3	
	High >91%		91.3

Table 5A. Summary of summer habitat reaches surveyed within the ODF Lower Columbia Astoria North project area.

ASTORIA NORTH PROJECT AREA  
REACH SUMMARY

STREAM	REACH	SURVEY DATE	REACH LENGTH (m)	% AREA		GRADIENT %	VWI	*VALLEY		*CHANNEL		*LAND USE		SHADE %	BEDROCK %	FINES IN RIFFLES** %	GRAVEL IN RIFFLES** %	LARGE BOULDERS #/100m
				IN SIDE CHANNELS	%			FORM	FORM	DOM	SUB-DOM							
BIG CREEK	1	6/1/2004	494.0	<b>13.5</b>	4.7	2.4	MV	CH	LT	ST	<b>100.0</b>	<b>0.0</b>	38.0	36.0	212.0			
BIG CREEK	2	6/2/2004	1444.0	<b>6.0</b>	6.1	2.6	CT	CA	LT	ST	<b>100.0</b>	4.0	62.0	22.0	726.0			
BIG CREEK	3	6/8/2004	500.0	<b>15.1</b>	3.1	2.0	MV	CH	LT	ST	<b>94.0</b>	<b>0.0</b>	92.0	3.0	0.0			
BIG CREEK	4	6/9/2004	1305.0	<b>8.3</b>	3.3	5.5	MT	US	LT	ST	<b>100.0</b>	1.0	37.0	29.0	696.0			
BIG CREEK	8	7/6/1992	2197.1	<b>7.1</b>	3.7	1.9	MV	CH	TH		<b>89.0</b>	4.5	38.4	27.5	997.0			
BIG CREEK	9	7/9/1992	841.1	<b>20.7</b>	2.9	4.5	MT	UA	ST		<b>100.0</b>	<b>0.1</b>	41.4	35.0	193.0			
BIG CREEK TRIBUTARY A	1	6/28/2004	1774.0	<b>14.6</b>	13.5	2.9	MT	CT	LT	ST	<b>93.0</b>	<b>0.0</b>	20.0	25.0	1211.0			
BIG CREEK TRIBUTARY A	2	6/28/2004	697.0	0.0	31.7	2.2	MV	CH	ST		<b>88.0</b>	5.0	15.0	30.0	134.0			
BIG CREEK TRIBUTARY AA	1	7/5/2004	378.0	<b>7.5</b>	14.4	6.9	CT	CT	LT	ST	<b>94.0</b>	<b>0.0</b>	82.0	6.0	69.0			
BIG CREEK TRIBUTARY B	1	6/16/2004	1042.0	1.1	10.7	2.8	MT	CT	LT	ST	<b>94.0</b>	4.0	60.0	30.0	289.0			
BIG CREEK TRIBUTARY C	1	7/7/2004	1253.0	<b>12.3</b>	3.6	3.9	CT	CA	LT	ST	<b>100.0</b>	5.0	35.0	36.0	105.0			
BIG CREEK TRIBUTARY C	2	7/15/2004	578.0	<b>6.7</b>	6.3	3.5	CT	CA	LT	PT	<b>98.0</b>	<b>0.0</b>	43.0	28.0	6.0			
BIG CREEK TRIBUTARY C1	1	7/22/2004	824.0	<b>5.7</b>	7.7	5.0	CT	CA	ST	LT	<b>100.0</b>	5.0	37.0	29.0	21.0			
BIG CREEK TRIBUTARY C2	1	7/14/2004	523.0	<b>6.5</b>	5.2	6.4	CT	CA	LT	ST	<b>94.0</b>	4.0	64.0	36.0	8.0			
BIG CREEK TRIBUTARY D	1	7/16/2004	707.0	3.9	15.4	4.7	CT	CA	ST	YT	<b>93.0</b>	1.0	63.0	9.0	30.0			
BIG NOISE CREEK	1	8/28/1994	4966.4	1.7	5.1	1.7	MV	CH	ST		83.5	15.3	51.9	17.7	199.0			
GNAT CREEK	1	6/23/1994	365.7	<b>24.2</b>	0.8	3.8	MT	US	MT	ST	84.8	<b>0.0</b>	40.8	41.4	30.0			
GNAT CREEK	2	6/28/1994	1117.6	<b>10.0</b>	1.4	1.8	MV	CH	MT	ST	87.8	8.3	27.4	32.5	108.0			
GNAT CREEK	3	6/29/1994	668.2	<b>17.4</b>	1.8	2.8	MV	CH	MT	ST	82.3	8.7	35.8	26.9	120.0			
GNAT CREEK	4	6/29/1994	260.7	4.3	1.6	2.5	MV	CH	MT	ST	82.9	1.1	0.0	0.0	91.0			
GNAT CREEK	5	6/30/1994	1454.3	<b>8.8</b>	2.8	5.5	MT	US	LT	YT	79.6	<b>0.0</b>	35.9	30.0	63.0			
GNAT CREEK	6	7/7/1994	3108.9	5.0	4.1	2.0	MV	CH	LT	YT	<b>91.3</b>	9.4	28.6	28.0	644.0			
GNAT (KNOTTS) CREEK	7	7/7/1994	4180.7	<b>13.5</b>	7.3	1.5	CH	MV	LT	YT	<b>95.4</b>	10.1	45.7	30.2	695.0			
GNAT (KNOTTS) CREEK	8	7/20/1994	518.7	<b>22.4</b>	5.3	3.7	MT	UA	LT	ST	<b>97.2</b>	<b>0.1</b>	32.3	39.8	103.0			
GNAT (KNOTTS) CREEK	9	7/26/1994	2503.5	<b>17.1</b>	6.6	1.9	MV	CH	LT	ST	<b>96.3</b>	1.0	51.6	39.2	360.0			
Gnat Creek (6T-97)	1	1998	1092.0	<b>11.7</b>	3.0	4.0	CT	CA	ST	LT	81.0	3.0	30.0	21.0	122.0			
HUNT CREEK	2	8/16/1994	2545.2	<b>7.6</b>	8.3	1.9	MV	CH	YT	MT	<b>95.7</b>	0.3	0.0	0.0	309.0			
HUNT CREEK	3	8/17/1994	1848.4	<b>7.3</b>	7.7	2.3	MV	CH	YT		<b>99.7</b>	1.3	0.0	0.0	71.0			
HUNT CREEK	4	8/18/1994	579.3	<b>13.5</b>	12.7	2.7	MT	US	PT		89.2	0.4	0.0	0.0	44.0			
JACK CREEK	1	7/10/1997	554.4	0.2	0.7	1.0	WF	UA	YT	MT	31.2	<b>0.0</b>	0.0	0.0	0.0			
JACK CREEK	2	7/15/1997	1235.9	5.4	5.5	2.5	MV	CH	ST		89.1	1.3	66.5	30.9	53.0			
M. FK. OF N. FK. KLASKANINE R.	1	8/24/1995	1584.5	<b>13.1</b>	3.6	5.6	CT	CA	ST	YT	<b>92.4</b>	3.8	21.2	47.4	259.0			
M. FK. OF N. FK. KLASKANINE R.	2	8/30/1995	2562.1	<b>7.9</b>	9.6	1.2	MV	CH	YT		90.7	3.5	26.8	52.4	335.0			
MCNARY (GNAT) CREEK	7	6/14/2001	604.8	<b>16.1</b>	9.5	1.6	MV	CH	ST	YT	87.3	<b>0.0</b>	10.0	15.0	985.0			
MCNARY (GNAT) CREEK	8	6/25/2001	740.2	<b>6.0</b>	9.3	2.2	SV	CH	ST	PT	<b>93.7</b>	<b>0.0</b>	15.0	15.0	1060.0			
MCNARY (GNAT) CREEK	9	6/26/2001	850.8	<b>19.1</b>	5.4	1.6	MV	CH	PT	YT	66.8	4.8	26.3	26.3	517.0			
MCNARY (GNAT) CREEK	10	6/28/2001	702.6	5.2	5.2	2.3	MV	CH	ST	PT	<b>98.4</b>	1.1	25.0	35.0	432.0			
MCNARY (GNAT) CREEK	11	7/2/2001	496.8	<b>30.5</b>	6.3	3.0	MT	UA	YT	PT	76.5	<b>0.0</b>	0.0	0.0	284.0			
MCNARY (GNAT) CREEK	12	7/3/2001	537.3	<b>13.4</b>	12.5	2.1	SV	CH	ST	LT	<b>96.2</b>	1.3	0.0	0.0	1649.0			
MCNARY (GNAT) CREEK	13	7/4/2001	2211.0	<b>20.7</b>	10.2	3.0	MT	UB	ST	PT	<b>99.7</b>	1.4	0.0	0.0	1993.0			



Table 5A. Summary of summer habitat reaches surveyed within the ODF Lower Columbia Astoria North project area.

ASTORIA NORTH PROJECT AREA  
REACH SUMMARY

STREAM	REACH	SURVEY DATE	REACH LENGTH (m)	% AREA IN SIDE CHANNELS	GRADIENT %	VWI	*VALLEY FORM	*CHANNEL FORM	*LAND USE DOM	SUB-DOM	SHADE %	BEDROCK %	FINES IN RIFFLES** %	GRAVEL IN RIFFLES** %	LARGE BOULDERS #/100m
MILL CREEK	1	7/12/2001	937.0	3.7	0.9	5.2	WF	UB	LT	ST	75.6	<b>0.0</b>	84.0	12.3	16.0
MILL CREEK	2	7/12/2001	1093.7	4.9	1.2	5.0	MT	US	LT	ST	74.9	1.0	69.8	24.4	30.0
MILL CREEK	3	7/16/2001	959.3	<b>10.8</b>	6.8	3.5	MT	CA	YT	ST	80.1	7.5	65.2	33.2	74.0
NORTH FORK GNAT CREEK	1	9/16/1996	1220.6	2.7	1.1	1.7	MV	CH	LT		84.7	12.2	69.5	11.4	5.0
NORTH FORK GNAT CREEK	2	9/18/1996	927.2	3.6	2.4	2.3	MT	CA	YT	LT	89.4	1.6	78.3	18.6	1.0
NORTH FORK GNAT CREEK TRIB A	1	9/17/1996	349.0	<b>7.6</b>	1.6	2.3	MV	CH	LT		<b>96.7</b>	16.9	55.1	23.5	0.0
NORTH FORK GNAT CREEK TRIB A	2	9/17/1996	346.5	0.0	1.4	2.6	CT	CA	YT	LT	<b>99.1</b>	10.4	43.7	27.0	0.0
NORTH FORK GNAT CREEK TRIB A	3	9/17/1996	661.1	0.0	3.6	1.9	MV	CH	YT		77.0	4.4	49.3	37.4	0.0
NORTH FORK KLASKANINE RIVER	2	9/13/1995	1674.6	<b>12.0</b>	2.0	2.6	CT	CA	YT		<b>91.1</b>	4.8	13.5	<b>57.7</b>	88.0
NORTH FORK KLASKANINE RIVER	3	9/14/1995	1803.1	<b>6.4</b>	4.5	1.7	MV	CH	MT		90.9	3.1	17.7	51.0	268.0
NORTH FORK KLASKANINE RIVER	4	10/9/1995	395.0	<b>6.8</b>	1.2	1.1	WF	US	ST		84.1	<b>0.0</b>	60.0	30.8	0.0
NORTH FORK KLASKANINE RIVER	5	10/9/1995	345.1	2.0	9.4	1.1	MV	CH	ST	YT	84.2	<b>0.0</b>	44.4	33.3	0.0
PETERSON CREEK	1	8/4/1997	645.7	1.7	0.5	20.0	CT	TC	HG		23.0	<b>0.0</b>	0.0	0.0	0.0
PETERSON CREEK	2	8/4/1997	348.3	2.4	1.1	17.5	CT	TC	ST		<b>91.7</b>	<b>0.0</b>	87.6	12.4	0.0
PETERSON CREEK	3	8/5/1997	96.8	2.7	0.0	1.0	WF	UB	ST		30.3	<b>0.0</b>	0.0	0.0	0.0
PETERSON CREEK	4	8/5/1997	1017.1	1.9	6.4	1.9	MV	CH	ST		<b>95.8</b>	3.8	51.3	32.8	285.0
PLYMPTON CREEK	1	8/30/1994	990.4	0.0	3.8	4.0	MT	US	ST		<b>98.7</b>	<b>0.2</b>	43.6	30.8	115.0
PLYMPTON CREEK	2	8/30/1994	1575.1	<b>9.7</b>	6.7	1.3	MV	CH	ST		<b>95.2</b>	25.0	27.5	<b>65.0</b>	173.0
PLYMPTON CREEK	3	8/31/1994	1013.2	<b>15.0</b>	2.9	3.4	MT	US	ST		<b>98.2</b>	1.2	30.8	<b>54.4</b>	47.0
PLYMPTON CREEK	4	9/1/1994	1838.7	<b>5.6</b>	5.1	1.4	MV	CH	ST		<b>94.5</b>	13.4	41.8	34.4	296.0
PLYMPTON CREEK	5	9/7/1994	3643.6	<b>9.9</b>	5.1	2.0	MV	CH	ST		<b>91.7</b>	5.0	51.3	29.4	394.0
PLYMPTON CREEK	6	9/12/1994	1777.8	0.2	2.5	4.2	MT	US	ST		71.8	<b>0.2</b>	94.4	4.3	10.0
ROCK CREEK	1	8/1/1994	6367.0	3.7	7.4	1.5	MV	CH	ST	LT	<b>93.1</b>	8.4	80.0	10.0	649.0
SUPPLY CREEK	1	8/10/1994	2298.9	1.6	4.2	1.3	MV	CH	ST		81.9	8.4	80.0	17.5	80.0
WEST CREEK	2	6/26/1996	4369.6	<b>12.5</b>	8.1	1.2	MV	CH	YT	ST	81.6	10.9	21.0	39.9	1770.0
WEST CREEK	3	7/15/1996	270.0	<b>22.9</b>	3.7	4.3	MT	CA	ST		81.3	0.5	37.1	52.9	12.0
WEST CREEK	4	7/15/1996	937.5	4.8	5.0	1.8	MV	CH	LT		87.3	17.7	27.7	33.7	129.0
West Creek (6T-149)	1	1998	589.0	<b>19.5</b>	9.0	2.0	MV	CH	YT	MT	80.0	1.0	12.0	11.0	265.0
WEST FORK HUNT CREEK	1	6/11/1996	1469.2	<b>19.0</b>	8.7	1.5	MV	CH	YT		63.4	1.0	14.0	38.2	985.0
WEST FORK HUNT CREEK	2	6/17/1996	960.5	<b>23.7</b>	7.4	1.4	OV	CH	YT		83.7	5.3	17.1	40.5	357.0
WEST FORK HUNT CREEK	3	6/19/1996	1332.7	<b>20.7</b>	10.4	1.6	OV	US	YT	ST	82.5	4.8	19.9	37.2	438.0
WEST FORK PLYMPTON CREEK	1	5/22/2001	513.6	4.1	7.3	2.1	SV	CH	LT	ST	<b>96.3</b>	23.0	47.9	14.7	597.0
WEST FORK PLYMPTON CREEK	2	5/23/2001	705.9	<b>9.6</b>	4.6	2.8	MT	US	LT	PT	<b>96.5</b>	9.3	25.5	24.2	716.0
WEST FORK PLYMPTON CREEK	3	5/29/2001	3064.8	<b>9.8</b>	4.5	2.5	MV	CH	LT	YT	<b>97.4</b>	5.1	37.5	31.1	1051.0
WEST FORK PLYMPTON CREEK	4	6/11/2001	936.1	<b>10.1</b>	3.7	3.2	MT	UB	PT	LT	<b>99.1</b>	1.2	37.0	27.0	115.0

\*see methods for an explanation of abbreviations

\*\* there are reaches without riffle units, therefore, a zero value (0.0) does not indicate a lack of fines or gravel substrate

**bold** indicates those reaches which met or exceeded the high reference value

Table 5B. Summary of summer habitat reaches surveyed within the ODF Lower Columbia Astoria North project area.

ASTORIA NORTH PROJECT AREA  
REACH SUMMARY

STREAM	REACH	SURVEY DATE	REACH LENGTH (m)	ACTIVE CHANNEL	CHANNEL WIDTHS/	PERCENT POOLS	PERCENT SLACKWATER	POOLS >1m DEEP/km	RESIDUAL POOL DEPTH (m)	PIECES # / 100m	WOOD DEBRIS VOLUME (m3)/100m	KEY PIECES # / 100m	CONIFER TREES TOTAL/1000ft	RIPARIAN CONIFERS #>50cm dbh /305m	#>90cm dbh /305m
				CHANNEL WIDTH (m)	POOL	POOLS	POOLS	POOLS	PIECES	KEY PIECES	TREES	#>50cm dbh	#>90cm dbh		
BIG CREEK	1	6/1/2004	494.0	9.7	4.1	20.9	0.6	1.5	0.4	40.1	44.5	0.6	274.0	61.0	0.0
BIG CREEK	2	6/2/2004	1444.0	5.3	6.6	20.1	2.9	0.0	0.3	42.3	57.5	0.6	351.0	15.0	0.0
BIG CREEK	3	6/8/2004	500.0	13.3	2.6	78.3	76.0	0.0	0.4	33.0	45.8	0.2	305.0	30.0	0.0
BIG CREEK	4	6/9/2004	1305.0	2.4	84.5	7.0	5.1	0.0	0.3	14.7	21.4	0.2	305.0	30.0	0.0
BIG CREEK	8	7/6/1992	2197.1	7.1	5.1	28.5	1.1	0.4	0.4	63.5	105.0	3.1	0.0	0.0	0.0
BIG CREEK	9	7/9/1992	841.1	4.2	4.3	57.8	8.2	0.0	0.4	57.8	135.0	4.5	0.0	0.0	0.0
BIG CREEK TRIBUTARY A	1	6/28/2004	1774.0	5.5	14.7	3.4	0.1	0.0	0.4	30.9	71.4	3.3	914.0	61.0	0.0
BIG CREEK TRIBUTARY A	2	6/28/2004	697.0	3.7	0.0	0.0	0.0	0.0	0.0	15.1	69.2	2.6	1158.0	0.0	0.0
BIG CREEK TRIBUTARY AA	1	7/5/2004	378.0	4.4	46.9	4.1	2.3	0.0	0.2	14.8	57.8	3.2	1219.0	61.0	0.0
BIG CREEK TRIBUTARY B	1	6/16/2004	1042.0	1.9	187.1	1.6	0.6	0.0	0.3	33.6	28.0	0.3	457.0	61.0	0.0
BIG CREEK TRIBUTARY C	1	7/7/2004	1253.0	4.9	6.1	39.8	8.1	0.7	0.4	23.2	36.0	0.5	274.0	15.0	0.0
BIG CREEK TRIBUTARY C	2	7/15/2004	578.0	2.2	57.0	1.6	0.1	0.0	0.2	23.7	37.2	1.2	305.0	0.0	0.0
BIG CREEK TRIBUTARY C1	1	7/22/2004	824.0	2.4	28.9	6.8	2.1	0.0	0.3	31.9	40.3	0.2	549.0	91.0	0.0
BIG CREEK TRIBUTARY C2	1	7/14/2004	523.0	1.4	39.4	12.1	0.7	0.0	0.3	17.0	38.7	1.1	488.0	122.0	0.0
BIG CREEK TRIBUTARY D	1	7/16/2004	707.0	1.8	137.3	1.9	1.5	0.0	0.2	20.9	59.1	2.1	610.0	122.0	0.0
BIG NOISE CREEK	1	8/28/1994	4966.4	6.1	20.4	31.6	30.8	1.6	0.4	25.9	34.2	1.4	1120.0	168.9	36.2
GNAT CREEK	1	6/23/1994	365.7	13.5	3.4	43.3	0.0	6.2	0.4	11.5	7.4	0.0	163.0	36.2	0.0
GNAT CREEK	2	6/28/1994	1117.6	15.9	2.8	37.7	3.6	12.0	0.9	15.5	19.8	0.8	406.0	54.3	18.1
GNAT CREEK	3	6/29/1994	668.2	19.9	2.4	39.0	0.0	7.0	0.8	20.7	22.4	1.3	244.0	0.0	0.0
GNAT CREEK	4	6/29/1994	260.7	15.2	3.4	26.2	0.4	12.9	0.8	14.9	9.0	0.0	427.0	120.7	0.0
GNAT CREEK	5	6/30/1994	1454.3	12.3	5.8	16.0	0.4	4.7	0.7	19.0	13.8	0.2	91.0	0.0	0.0
GNAT CREEK	6	7/7/1994	3108.9	12.5	9.5	8.7	1.2	2.5	0.7	14.1	12.7	0.4	274.0	36.2	6.0
GNAT (KNOTTS) CREEK	7	7/7/1994	4180.7	10.4	10.0	6.7	0.7	2.7	0.8	26.0	46.6	2.2	357.0	52.0	9.0
GNAT (KNOTTS) CREEK	8	7/20/1994	518.7	7.8	4.2	11.0	0.3	0.0	0.4	24.9	51.3	2.2	213.0	60.3	0.0
GNAT (KNOTTS) CREEK	9	7/26/1994	2503.5	5.2	10.2	11.5	2.7	0.3	0.4	24.7	37.2	0.8	1315.0	72.4	6.0
Gnat Creek (6T-97)	1	1998	1092.0	11.0	7.0	24.0	0.0	3.0	1.0	18.0	21.0	1.0	549.0	163.0	41.0
HUNT CREEK	2	8/16/1994	2545.2	7.8	131.1	0.6	0.0	0.3	0.0	17.9	14.9	0.3	955.0	138.8	18.1
HUNT CREEK	3	8/17/1994	1848.4	4.9	111.3	1.3	0.7	0.5	0.0	17.3	22.8	0.9	1057.0	0.0	0.0
HUNT CREEK	4	8/18/1994	579.3	3.2	0.0	0.0	0.0	0.0	0.0	47.9	17.3	0.0	610.0	181.0	60.3
JACK CREEK	1	7/10/1997	554.4	60.0	0.0	0.0	0.0	0.0	0.0	3.2	0.8	0.0	2073.0	0.0	0.0
JACK CREEK	2	7/15/1997	1235.9	1.8	94.7	15.0	0.0	0.0	0.3	11.1	18.5	0.4	833.0	20.0	0.0
M. FK. OF N. FK. KLASKANINE R.	1	8/24/1995	1584.5	6.3	6.1	18.0	0.4	0.0	0.3	20.2	33.0	1.0	284.0	81.0	10.0
M. FK. OF N. FK. KLASKANINE R.	2	8/30/1995	2562.1	7.6	11.2	13.9	7.5	0.0	0.3	24.7	45.5	2.1	732.0	88.0	0.0
MCNARY (GNAT) CREEK	7	6/14/2001	604.8	7.5	10.5	9.9	0.5	1.2	0.5	21.3	22.9	0.2	792.0	61.0	0.0
MCNARY (GNAT) CREEK	8	6/25/2001	740.2	7.5	5.4	11.8	0.3	3.4	0.5	11.8	20.7	0.0	914.0	0.0	0.0
MCNARY (GNAT) CREEK	9	6/26/2001	850.8	8.9	8.4	13.9	4.6	0.8	0.5	23.5	21.4	0.3	488.0	61.0	0.0
MCNARY (GNAT) CREEK	10	6/28/2001	702.6	6.8	14.8	8.9	0.0	0.0	0.4	11.6	8.8	0.0	1524.0	61.0	0.0
MCNARY (GNAT) CREEK	11	7/2/2001	496.8	8.2	6.7	38.3	36.1	2.4	0.6	28.8	23.4	1.6	1829.0	30.0	0.0
MCNARY (GNAT) CREEK	12	7/3/2001	537.3	6.8	40.4	1.5	0.0	0.0	0.4	12.2	10.7	0.1	945.0	61.0	30.0
MCNARY (GNAT) CREEK	13	7/4/2001	2211.0	5.9	28.9	2.8	0.1	0.0	0.3	5.3	4.2	0.0	1189.0	229.0	0.0
MILL CREEK	1	7/12/2001	937.0	5.3	21.6	69.2	58.7	6.8	1.1	2.4	8.4	0.6	0.0	0.0	0.0
MILL CREEK	2	7/12/2001	1093.7	3.4	9.0	74.4	65.0	2.3	0.5	5.3	11.0	0.5	752.0	102.0	20.0

Table 5B. Summary of summer habitat reaches surveyed within the ODF Lower Columbia Astoria North project area.

ASTORIA NORTH PROJECT AREA  
REACH SUMMARY

STREAM	REACH	SURVEY DATE	REACH LENGTH (m)	ACTIVE CHANNEL	CHANNEL	PERCENT POOLS	PERCENT	POOLS >1m DEEP/km	RESIDUAL	PIECES # / 100m	WOOD DEBRIS	KEY PIECES # / 100m	CONIFER	RIPARIAN CONIFERS	
				CHANNEL WIDTHS/ POOL	SLACKWATER POOLS		POOL DEPTH (m)		VOLUME (m3)/100m		TOTAL/1000ft		#>50cm dbh /305m	#>90cm dbh /305m	
MILL CREEK	3	7/16/2001	959.3	1.9	84.1	3.9	0.0	0.0	0.2	7.2	25.2	1.5	1189.0	<b>183.0</b>	0.0
NORTH FORK GNAT CREEK	1	9/16/1996	1220.6	8.1	4.7	<b>65.1</b>	<b>44.2</b>	2.3	0.3	<b>29.6</b>	36.6	0.9	305.0	0.0	0.0
NORTH FORK GNAT CREEK	2	9/18/1996	927.2	3.6	10.5	<b>70.9</b>	<b>65.0</b>	<b>10.2</b>	0.3	<b>27.5</b>	30.3	0.6	884.0	30.0	0.0
NORTH FORK GNAT CREEK TRIB A	1	9/17/1996	349.0	2.4	16.3	<b>60.0</b>	0.0	0.0	0.4	15.9	17.4	0.0	244.0	0.0	0.0
NORTH FORK GNAT CREEK TRIB A	2	9/17/1996	346.5	2.5	9.2	<b>77.7</b>	0.0	0.0	0.4	8.4	18.5	0.3	244.0	61.0	0.0
NORTH FORK GNAT CREEK TRIB A	3	9/17/1996	661.1	5.0	13.1	<b>62.9</b>	<b>54.9</b>	3.0	0.4	<b>21.5</b>	25.4	0.6	579.0	0.0	0.0
NORTH FORK KLASKANINE RIVER	2	9/13/1995	1674.6	10.1	4.4	39.3	0.3	<b>4.8</b>	0.7	11.7	12.4	0.4	290.0	15.0	15.0
NORTH FORK KLASKANINE RIVER	3	9/14/1995	1803.1	5.9	9.7	26.4	3.7	2.9	0.5	16.1	32.4	0.8	329.0	24.0	12.0
NORTH FORK KLASKANINE RIVER	4	10/9/1995	395.0	2.3	48.0	<b>54.3</b>	0.0	0.0	0.3	8.8	14.2	0.0	0.0	0.0	0.0
NORTH FORK KLASKANINE RIVER	5	10/9/1995	345.1	1.7	0.0	0.0	0.0	0.0	0.0	<b>23.1</b>	81.9	0.8	671.0	<b>244.0</b>	0.0
PETERSON CREEK	1	8/4/1997	645.7	3.1	219.4	11.8	0.0	1.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0
PETERSON CREEK	2	8/4/1997	348.3	3.0	20.6	<b>47.5</b>	16.7	2.7	0.4	4.4	8.5	0.5	610.0	<b>244.0</b>	61.0
PETERSON CREEK	3	8/5/1997	96.8	50.0	1.1	<b>97.3</b>	<b>18.6</b>	<b>18.6</b>	1.4	0.9	0.5	0.0	488.0	0.0	0.0
PETERSON CREEK	4	8/5/1997	1017.1	2.0	37.5	13.4	4.4	0.0	0.3	8.6	18.7	0.7	732.0	137.0	0.0
PLYMPTON CREEK	1	8/30/1994	990.4	10.7	10.3	7.7	0.0	3.0	0.0	7.3	9.9	0.5	61.0	0.0	0.0
PLYMPTON CREEK	2	8/30/1994	1575.1	13.5	16.0	5.7	0.0	3.6	0.0	<b>26.0</b>	48.5	2.7	183.0	90.5	30.2
PLYMPTON CREEK	3	8/31/1994	1013.2	11.2	19.1	7.9	0.0	2.7	0.0	13.3	12.4	0.1	0.0	0.0	0.0
PLYMPTON CREEK	4	9/1/1994	1838.7	11.5	26.5	3.4	0.7	2.8	0.0	<b>36.8</b>	91.7	<b>5.5</b>	335.0	90.5	30.2
PLYMPTON CREEK	5	9/7/1994	3643.6	7.5	86.1	7.8	7.6	0.9	0.0	<b>26.0</b>	35.2	0.8	1341.0	<b>205.1</b>	24.1
PLYMPTON CREEK	6	9/12/1994	1777.8	3.1	83.3	<b>56.0</b>	<b>56.0</b>	1.1	0.0	<b>34.0</b>	49.8	1.4	518.0	91.0	0.0
ROCK CREEK	1	8/1/1994	6367.0	6.7	29.4	4.7	0.5	0.7	0.6	<b>23.1</b>	32.4	1.0	739.0	144.8	6.0
SUPPLY CREEK	1	8/10/1994	2298.9	10.5	11.0	<b>64.4</b>	<b>64.1</b>	0.4	0.6	17.1	23.0	0.6	467.0	0.0	0.0
WEST CREEK	2	6/26/1996	4369.6	9.7	5.0	15.1	0.3	1.5	0.0	<b>36.7</b>	78.3	2.1	788.0	61.0	0.0
WEST CREEK	3	7/15/1996	270.0	2.7	33.9	16.9	0.0	2.7	0.0	9.3	8.9	0.0	975.0	0.0	0.0
WEST CREEK	4	7/15/1996	937.5	3.1	107.0	6.8	0.0	0.0	0.0	12.2	11.8	0.3	1128.0	91.0	0.0
West Creek (6T-149)	1	1998	589.0	8.0	11.0	6.0	0.0	0.0	0.0	<b>32.0</b>	48.0	1.0	488.0	102.0	0.0
WEST FORK HUNT CREEK	1	6/11/1996	1469.2	10.9	7.2	7.9	0.0	0.0	0.0	<b>25.1</b>	33.6	0.5	1483.0	41.0	0.0
WEST FORK HUNT CREEK	2	6/17/1996	960.5	9.1	8.8	8.5	0.7	0.0	0.0	<b>29.3</b>	28.7	0.8	1905.0	107.0	15.0
WEST FORK HUNT CREEK	3	6/19/1996	1332.7	4.9	27.2	3.7	0.3	0.0	0.0	18.6	16.2	0.3	1804.0	110.0	0.0
WEST FORK PLYMPTON CREEK	1	5/22/2001	513.6	7.9	6.5	14.7	0.2	<b>3.5</b>	0.6	<b>23.9</b>	16.1	0.0	305.0	0.0	0.0
WEST FORK PLYMPTON CREEK	2	5/23/2001	705.9	10.3	6.2	16.5	0.3	<b>4.2</b>	0.4	13.3	9.6	0.0	213.0	61.0	0.0
WEST FORK PLYMPTON CREEK	3	5/29/2001	3064.8	8.2	8.7	12.6	0.2	0.2	0.4	12.1	14.9	0.2	533.0	84.0	15.0
WEST FORK PLYMPTON CREEK	4	6/11/2001	936.1	5.2	14.4	10.0	0.9	0.0	0.3	7.0	19.3	0.6	386.0	102.0	0.0

\*see methods for an explanation of abbreviations

**bold** indicates those reaches which met or exceeded the high reference value

Table 6. Comparison of reach attributes between small streams (upstream of coho distribution) in the Astoria North project area and the project area as a whole.

Attribute	Astoria North small streams	Astoria North project area
Number of Reaches or Sites	46	76
Distance Surveyed - Total (km)	66.4km	103km
Mean (median)	1444.3m (987m)	1358m (960m)
Range	96.8 - 6367m	96.8 - 6367m
Active Channel Width (meters):		
Mean (Median)	6.6m (5.2m)	8.2m (6.8m)
Range	1.4 - 50m	1.4 - 60m
Gradient (%):		
Mean (median)	6.9% (6.3%)	5.8% (5.0%)
Range	0.5 - 31.7%	0.5 - 31.7%

Table 7. Habitat survey reach values and habitat parameter breakpoints relative to reference conditions in small streams in the Lower Columbia Astoria North project area.

Parameter	Habitat Breakpoints	ODF Astoria North small streams 66.46km n=46		ODF Astoria North project area 99.3km n=75	
		mean	median	mean	median
percent pools	Low <19%		9.6		12.6
	Moderate	23.2		23.2	
	High >45%				
deep pools/km	Low 0		0.0		
	Moderate	1.6		2.0	0.4
	High >3				
% slackwater pools	Low 0				
	Moderate		0.7		0.5
	High >7%	12.1		9.9	
% secondary channel area	Low <0.8%				
	Moderate				
	High >5.3%	9.2	7.4	9.2	7.5
% fines in riffles	High >22%	40.5	43.3	37.4	37.0
	Moderate				
	Low <8%				
% gravel in riffles	Low <26%	25.1		25.5	
	Moderate		29.0		28.0
	High >54%				
% bedrock	High >11%				
	Moderate	4.1	2.3	4.2	1.4
	Low <1%				
pieces LWD/100m	Low <8				
	Moderate	20.1		20.4	18.6
	High >21		22.3		
volume LWD/100m	Low <17				
	Moderate	33.0	29.5	30.9	22.9
	High >58				
key pieces/100m	Low <0.5				
	Moderate	1.0	0.6	0.9	0.6
	High >3				
# conifers >50cm dbh	Low <22				
	Moderate	75.8	61.0	64.9	61.0
	High >153				
# conifers >90cm dbh	Low 0		0.0		0.0
	Moderate	7.5		6.2	
	High >79				
% shade	Low <76%				
	Moderate	89.4		87.3	
	High >91%		93.1		91.3

Table 8. Potential barriers to fish distribution and associated features (as identified by Streamnet) within the Astoria North project area.

Stream LLID	Stream name	Record Id	Barrier type	*Passage	**Adult fish passage	Comments
1236738460591	North Fork Klaskanie tributary	1131	Unnamed culvert	99	fish use not mapped	Not on straight-line chart. Juvenile salmonids above. Lots of gravel. Gradient increases upstream.
1235360461829	Gnat Creek tributary	1366	Unnamed culvert	1	fish use not mapped	Pipe is too small, steep to allow fish passage. 0.5 miles from E end of Rd. There is another creek of similar caliber (ie Cutthroat habitat) 0.1 miles E of this one with a culvert too small.
1235315461979	Gnat Creek	50407	Gnat Creek Hatchery Barrier	2	fish use extends beyond	Fishway and height data provided by the North Coast District offices. According to Ref. 50088, it is assumed that a natural falls developed blocking anadromous fish. This is actually a dam w/ ladder. Not in Co Rd log.
1233766461371	Plympton Creek	51366	Westport Water Supply Diversion Dam	2	fish use ends at or below	Documented in 1950-Ref 50122 reported that "the dam is difficult for fish to pass during low water periods".
1233766461371	Plympton Creek	51367	Unnamed Falls (2)	99	only steelhead beyond	Documented in 1950-Ref 50122 reported that there are 2 waterfalls at this location, 6 and 8 feet high.
1235315461979	Gnat Creek	51513	Unnamed Falls	99	fish use extends beyond	
1233766461371	Plympton Creek	51672	Unnamed Falls	99	fish use ends at or below	Two other falls listed in this reach, but as 6' and 8' respectively, also at RM 1.5, barrier # 51367.
1235315461979	Gnat Creek	53042	Gnat Creek Concrete Intake Dam	99	fish use extends beyond	All anadromous fish are stopped. D.B. questioned whether the area above is large enough to support a self sustaining population of any anadromous species. A good population of cutthroat now exists. Fish production extends 5 m
1233766461371	Plympton Creek	55045	Unnamed Falls	99	fish use ends at or below	Dam in same location (already in DB).
1235293461940	Davis Creek	55369	Unnamed Culvert	99	fish use ends at or below	
1235076461805	Gnat Creek tributary	55377	Unnamed Falls	99	fish use not mapped	
1234890461481	Knotts Creek	55384	Unnamed Falls	99	fish use ends at or below	
1234890461481	Knotts Creek	55385	Unnamed Falls	99	fish use ends at or below	
1233766461371	Plympton Creek	55387	Unnamed Falls	99	only steelhead beyond	
1233602461259	West Creek	55388	Unnamed	99	fish use ends at or below	
1233766461371	Plympton Creek	55411	Unnamed Falls	99	fish use extends beyond	
1233602461259	West Creek	60123	Unnamed dam	99	fish use ends at or below	

\*Passage 1=complete, 2=partial, 4=non-blocking, 99=unknown

\*\*Migratory fish passage (coho, Chinook, steelhead) as mapped by Streamnet.

Table 9. OWEB funded instream restoration projects on ODF land in the Astoria North project area, highlighting some actions and goals and the species benefiting from the restoration project.

Stream name	Year	Project description	Project goals	Targeted species			
				coho	steelhead	chinook	cutthroat
Big Noise Cr	1997	anchored structures, weirs riparian tree planting culvert removed & not replaced	large wood recruitment increase complexity improve fish passage	x			x
North Fork Gnat Cr	1997	instream large wood placement	increase complexity increase pools	x	x	x	x
Klatskanine R	1996	culvert replaced with bridge	improve fish passage	x	x		x
Gnat Cr	1995	culvert replaced with bridge	improve fish passage	x	x	x	x
Plympton Cr	1997	culvert replaced with bridge	improve fish passage	x	x	x	x
Big Noise Cr	1998	1 culvert retrofitted, 3 fish ladders installed	improve fish passage increase pools				x
Mill Cr tributary	1998	culvert removed & not replaced	improve fish passage				
Sludge Cr	1998	1 culvert replaced 1 culvert with weirs installed below outlet	improve fish passage				
Gnat Cr tributary	1998	peak flow passage improvements surface drainage improvements 2 culverts replaced weirs installed below outlet	improve fish passage reduce erosion and runoff improve drainage improve upslope stability				
Gnat Cr tributary	1999	road vacated 3 culverts removed and not replaced	improve fish passage reduce erosion and runoff reduce road density and washout				
Nic Nack Cr	1999	instream large wood placement	improve complexity recruit gravel				
Sludge Cr	1999	instream large wood placement	increase complexity recruit gravel increase bank stability reconnect with floodplain				
Gnat Cr tributary	1999	peak flow passage improvements 3 culverts replaced weir installed below 1 culvert outlet	improve fish passage				
Jack Cr tributary	1999	peak flow passage improvements sidecast pulled back, road vacated culvert removed and not replaced	improve fish passage reduce erosion and runoff reduce road density and washout improve drainage	x			x
Plympton Cr	2001	1 culvert replaced with bridge	improve fish passage				x
North Fork Klaskanine R tributary	2002	1 culvert replaced	improve fish passage				x
Hunt Cr	2002	road survey peak flow passage improvements surface drainage improvements road vacated 1 culvert removed and not replaced	reduce erosion and runoff reduce road density and washout improve drainage improve fish passage				x
North Fork Gnat Cr tributary	2002	peak flow passage improvements surface drainage improvements road vacated 1 culvert removed and not replaced	improve drainage reduce erosion and runoff reduce road density and washout improve fish passage				x
West Fork Plympton Cr	2002	1 culvert replaced	improve fish passage				x
Big Noise Cr, East Rock Cr, West Rock Cr and several unnamed tribs	2003	road survey peak flow passage improvements surface drainage improvements 1 culvert replaced with culvert	improve fish passage reduce erosion and runoff improve drainage large wood recruitment increase shade				x
North Fork Klaskanine R tributary	2003	peak flow passage improvements road vacated 1 culvert removed and not replaced	reduce washout reduce erosion improve fish passage		x		x
South Fork Klaskanine R tributary	2004	2 culverts replaced peak flow passage improvements surface drainage improvements	improve fish passage improve drainage reduce washout reduce runoff	x	x		x

Table 10. Potential instream enhancement sites for Astoria North area located on ODF land.  
 From Lower Columbia Tributaries Salmonid Habitat Restoration: Guide to Project Selection 1995.

Stream name	Gradient %	Channel width (m)	Location	Potential project extent		Treated Since 1997?
				From	To	
MF of NF Klaskanine River	2	7	T7N-R8W-S28	Hwy 202	approx 3/4 mile to old logging bridge	n
Gnat Creek	1.9	19.9	T8N-R7W-S14	800 meters downstream of Hwy 30	Hwy 30 bridge	n
Big Noise Creek	5.1	6.1	T8N-R7W-S14	.25 miles downstream of Gnat Cree	Several hundred meters above Gnat Cree	n
Plympton Creek	2.5-4.0	10.7	T8N-R6W-S36	Hwy 30 bridge	0.3 miles upstream where valley narrows	n

Note: Land ownership based on 1995 information.



Table 11. Criteria for selecting restoration sites

<b>Best stream reaches for restoration</b>	<b>Poor stream reaches for restoration</b>	<b>Rational</b>	<b>Solution</b>
low gradient (<5%)	high gradient (>5%)	Structures placed in steep reaches will probably get washed down stream.	Although the overall gradient may be steep, it may be possible to locate flats or benches of low gradient. Instream work should be limited to such areas.
moderate channel size (<12m)	large channel size (>12m)	Structures placed in wide channels will probably get washed down stream.	Large channel restoration should use very large pieces of wood that partially extend into the channel.
moderate valley type	steep valley shape	Streams in steep valleys are constrained by the valley walls. During high flow events, there is limited over-wintering habitat potential.	Instream structures should be limited to sections of wider valley where stream energy can be dissipated.
water temperature cool enough for juvenile salmon summer survival	water too warm for juvenile salmon summer survival	Fish have water temperature tolerances.	Efforts to restore or improve streamside shading may result in water temperature suitable to salmonids.
water supply adequate to support young salmon summer survival	inadequate water supply to support young salmon summer survival	Fish need adequate water supply for survival	Although inadequate water supply during the summer, these reaches may provide over-wintering opportunities. However, if the stream is too steep, has inadequate water parameters, or not adjacent to summer rearing areas, there is little restoration potential. Restoration efforts in such streams should carefully assess winter rearing potential.
unobstructed access by juvenile and adult salmon during migration	restricted access to juvenile and adult migration	Salmon need access to the stream system	Streams blocked by culverts or other physical properties make them desirable for restoration.

Oregon Department of Forestry: Lower Columbia Astoria North project area

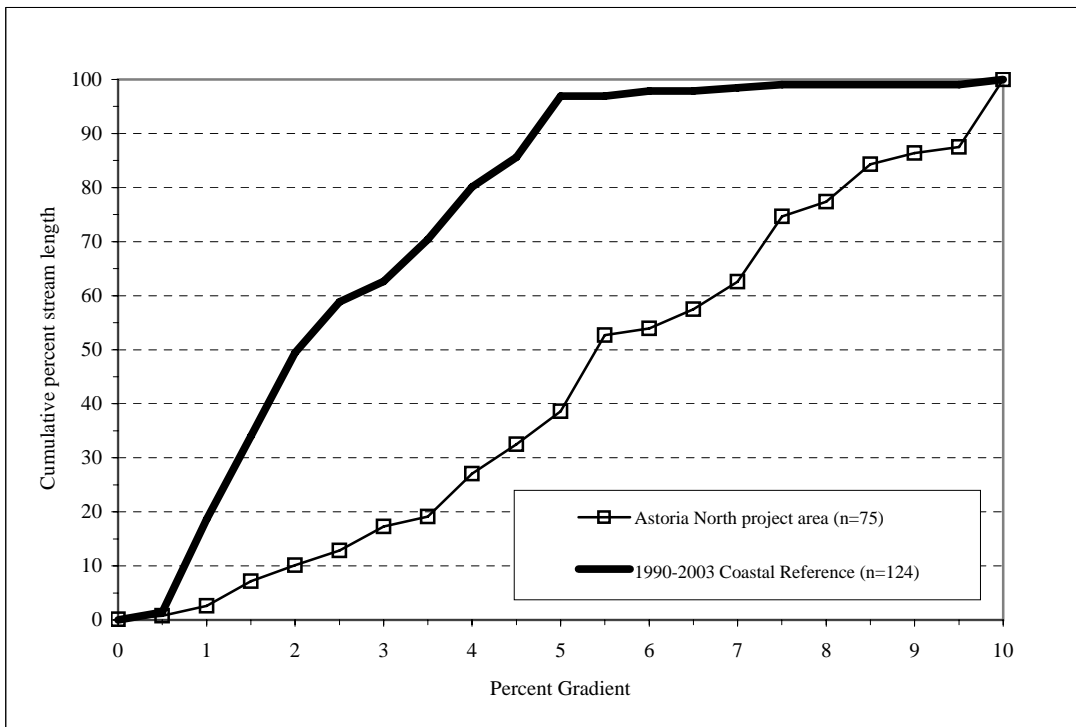
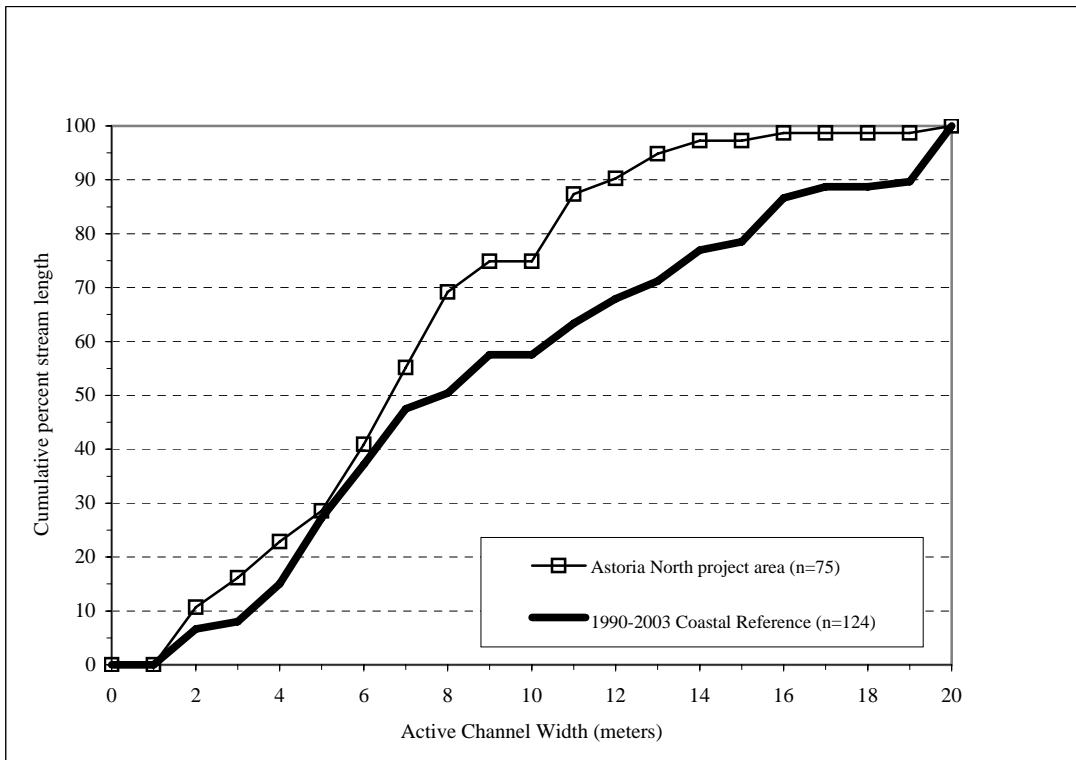


Figure 1. Cumulative frequency distribution comparing active channel width and gradient to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

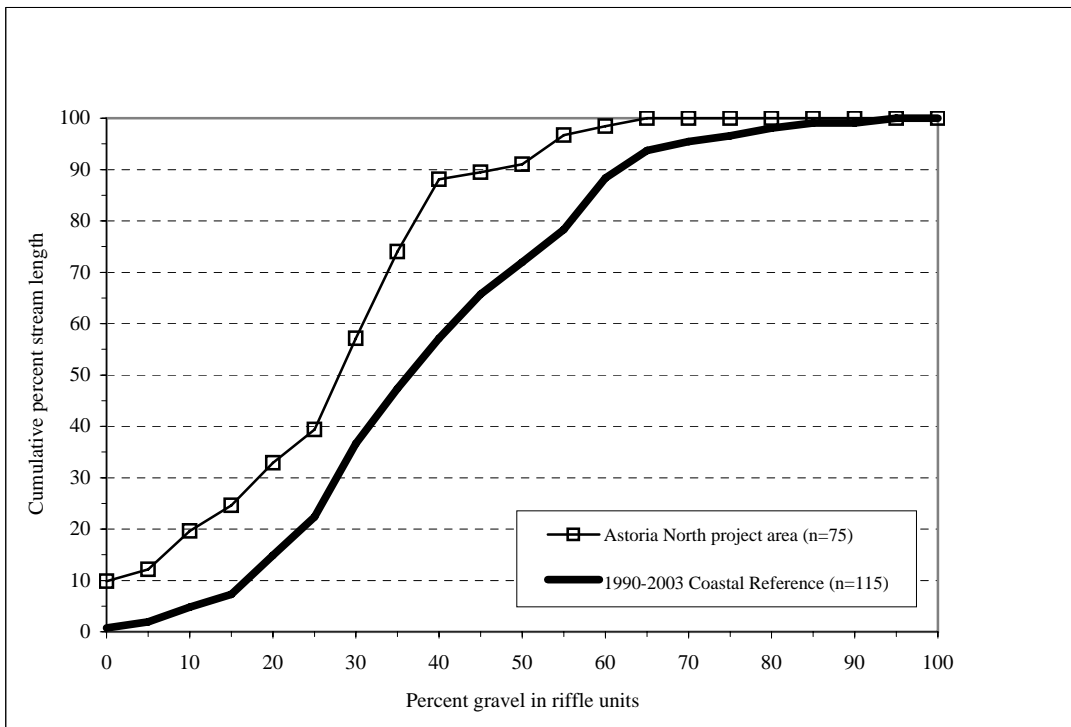
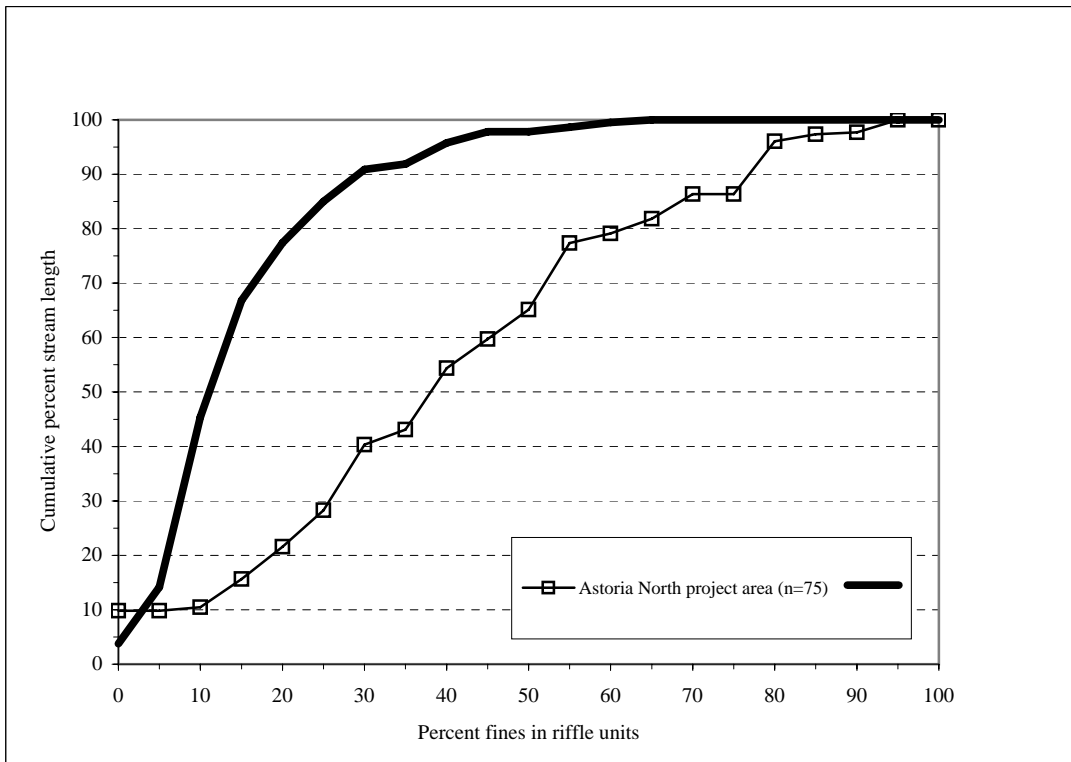


Figure 2. Cumulative frequency distribution comparing fines and gravel in riffle units to reference conditions within the project area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

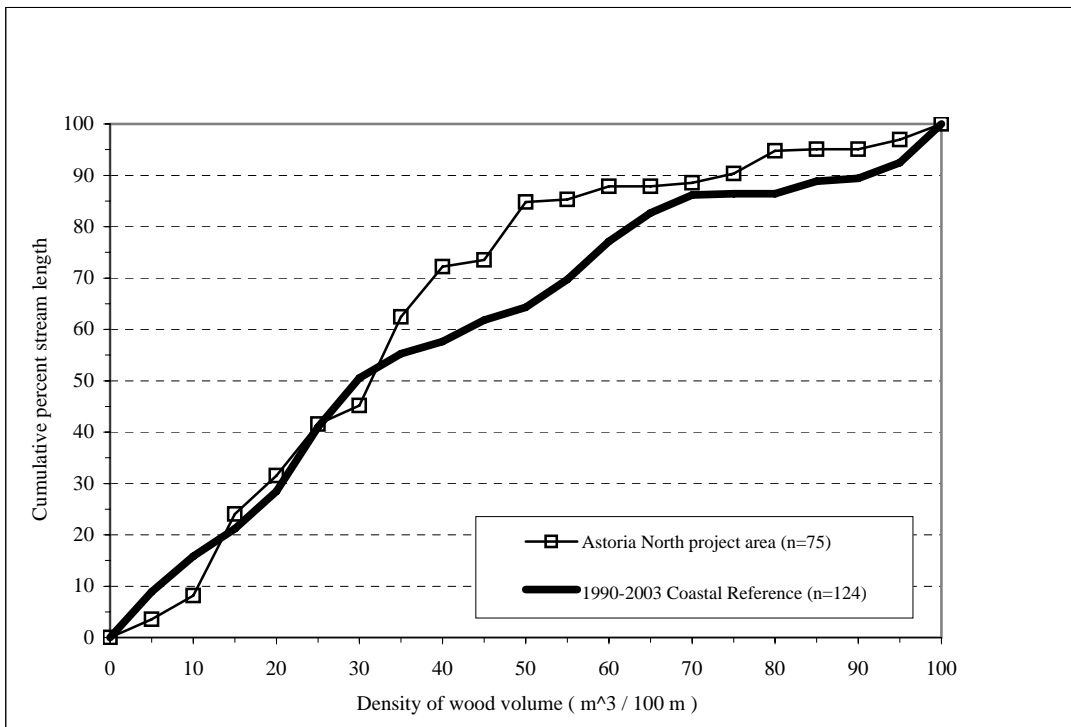
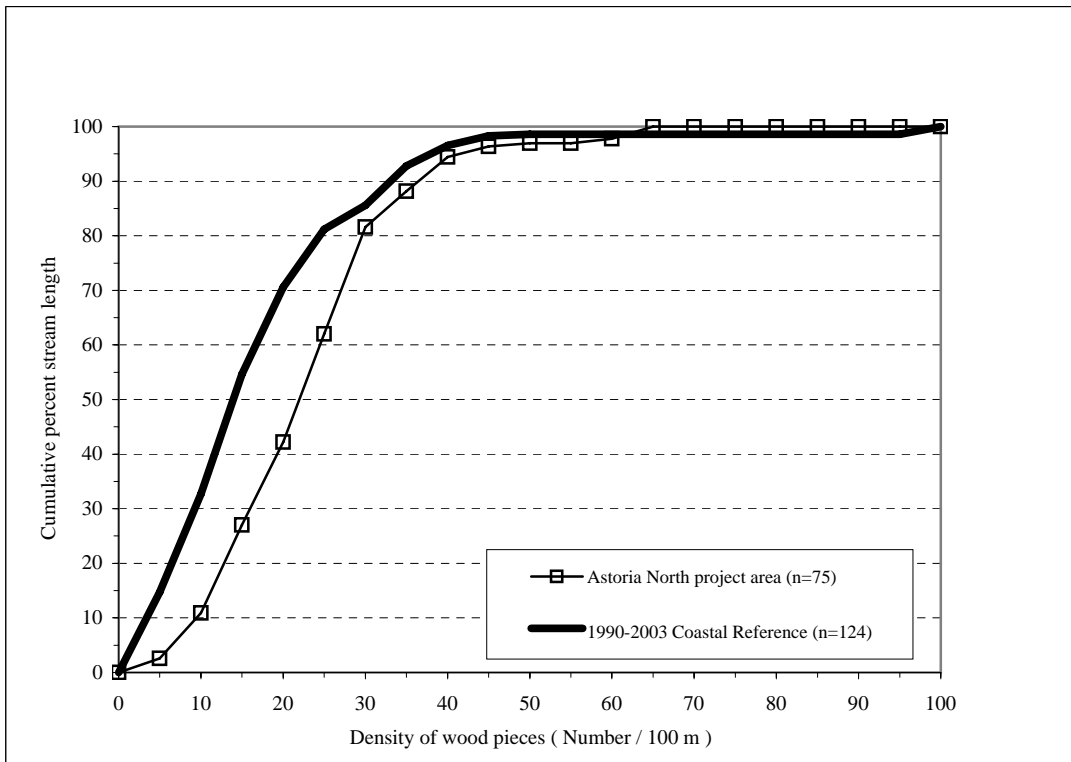


Figure 3. Cumulative frequency distribution comparing wood pieces and volume to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

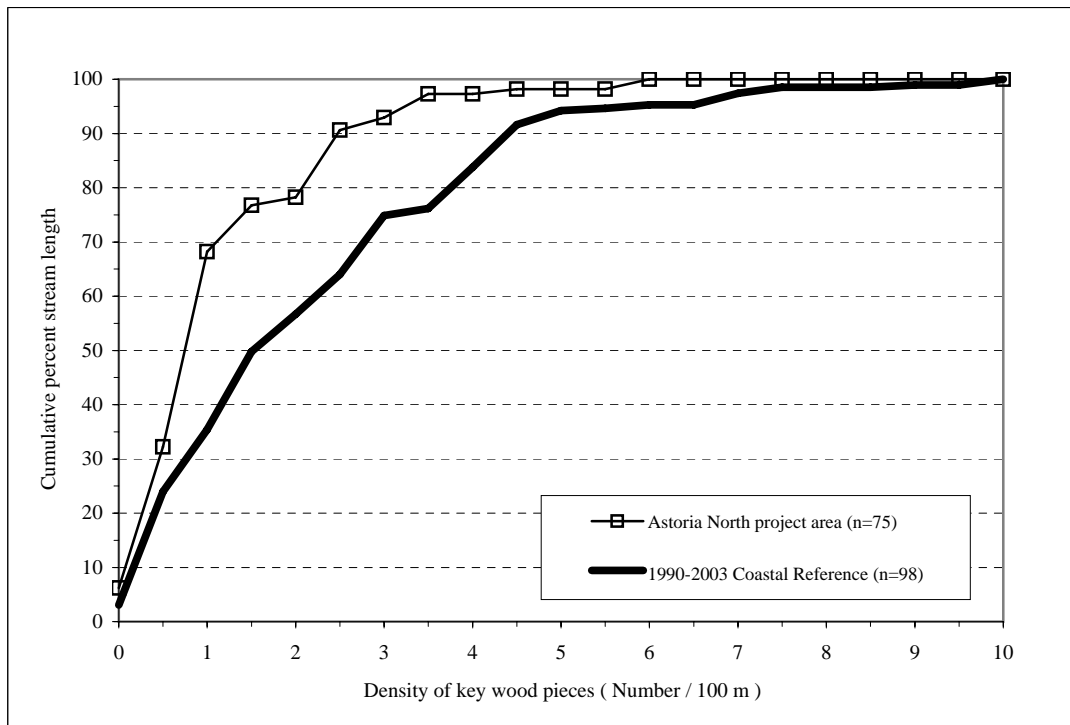
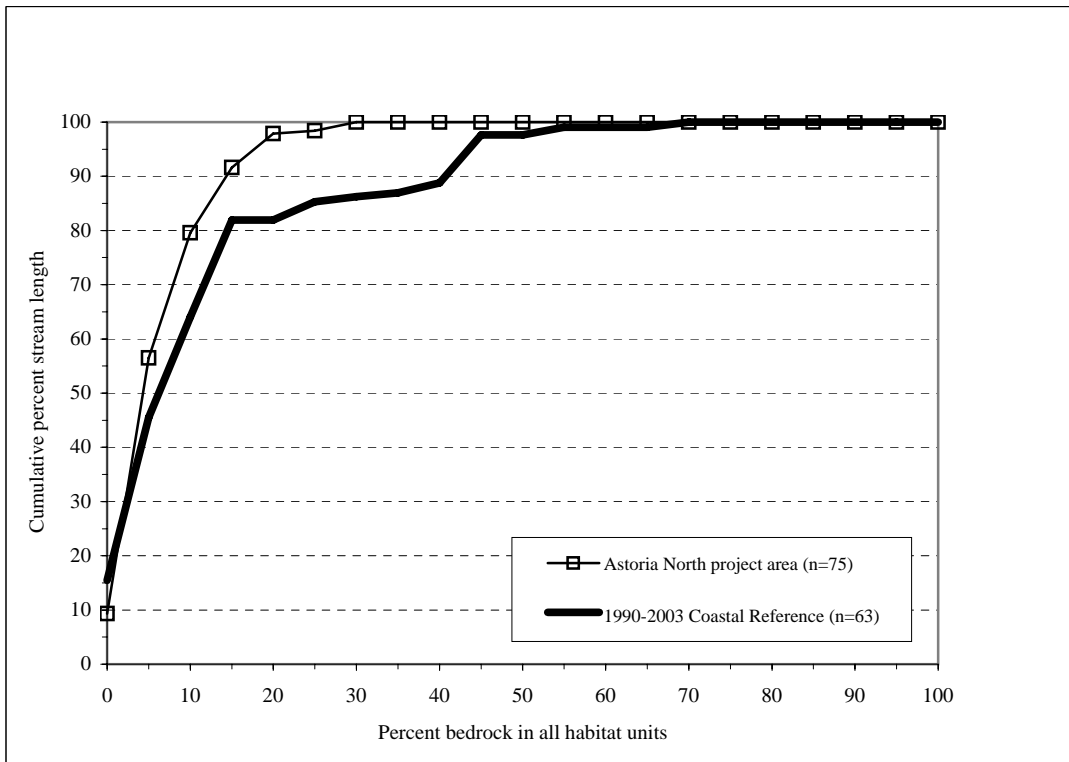


Figure 4. Cumulative frequency distribution comparing LWD keypieces and bedrock to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

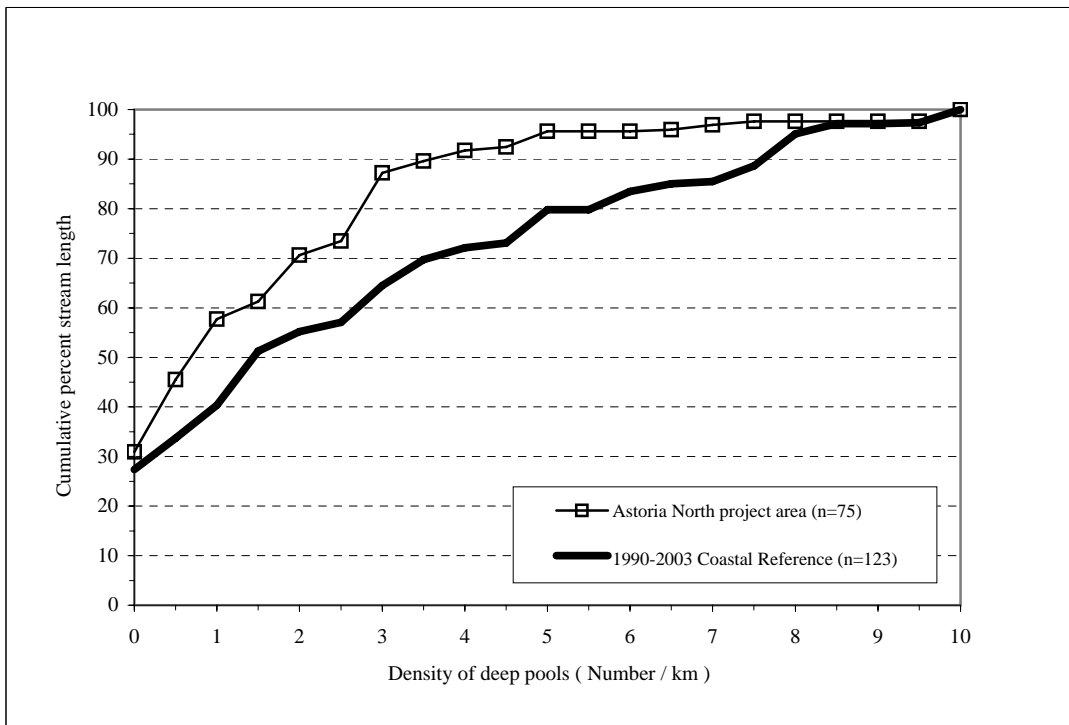
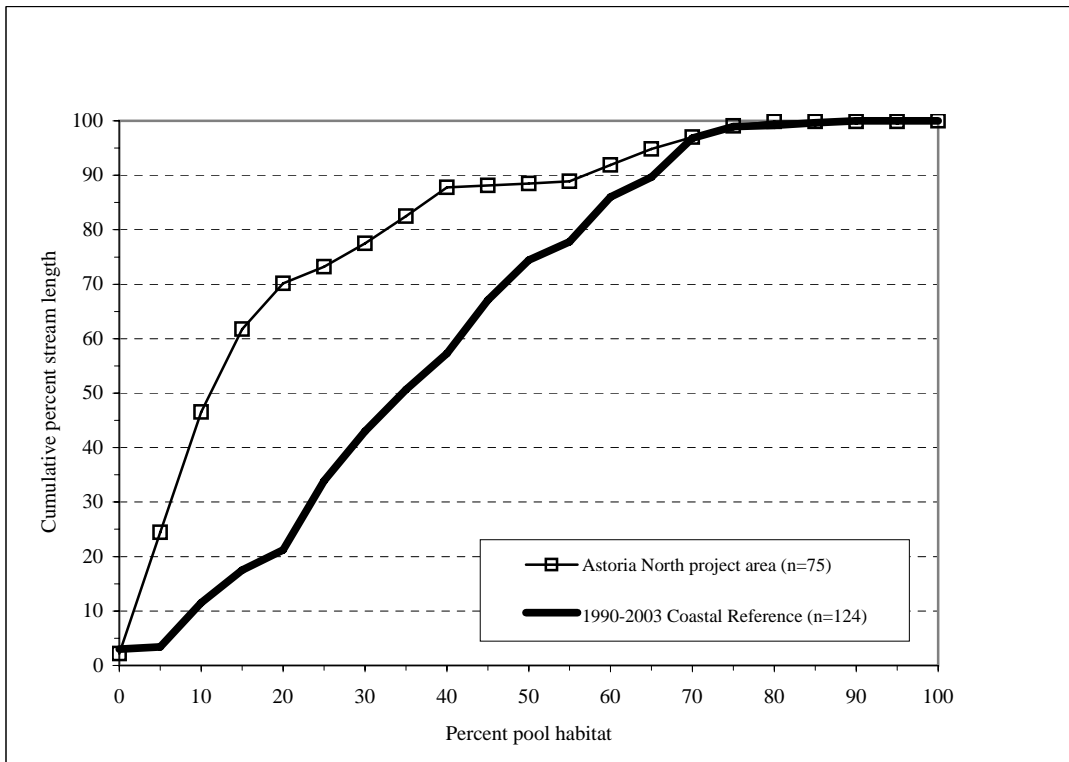


Figure 5. Cumulative frequency distribution comparing pools to the reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

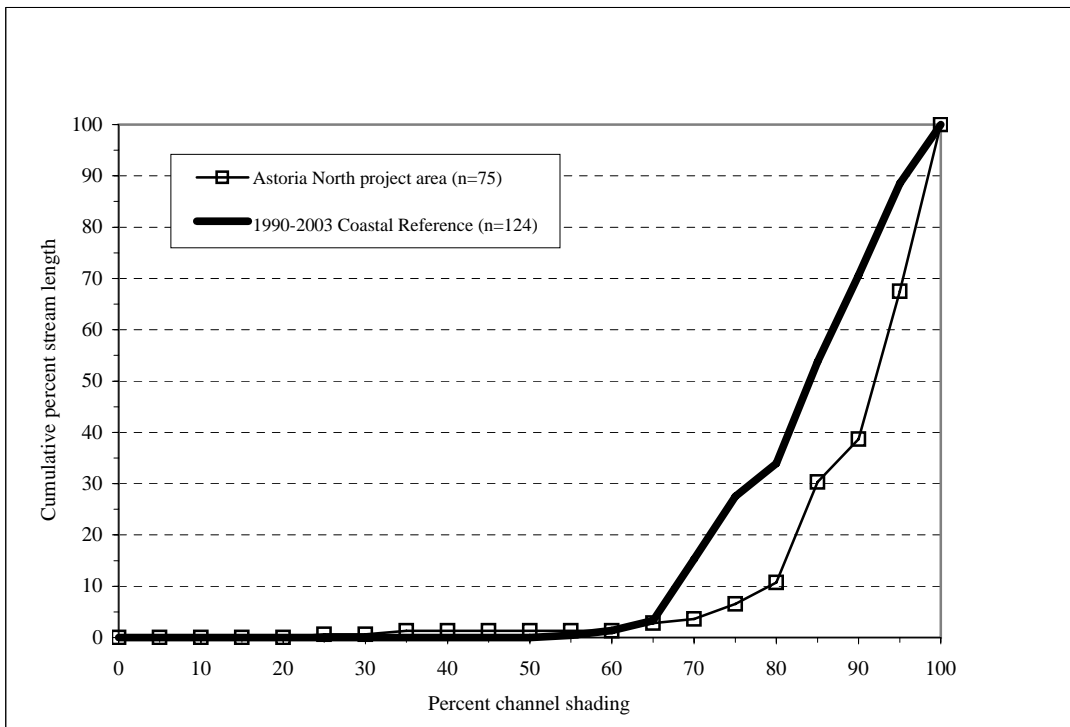
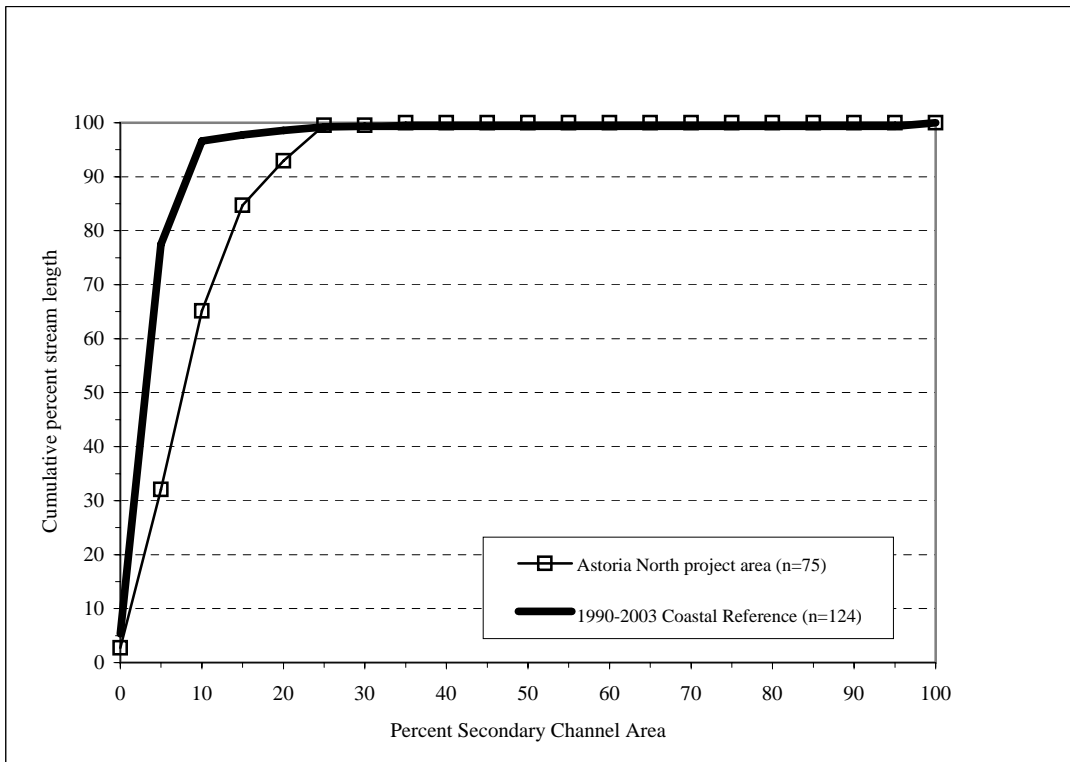


Figure 6. Cumulative frequency distribution comparing secondary channel area and shade to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

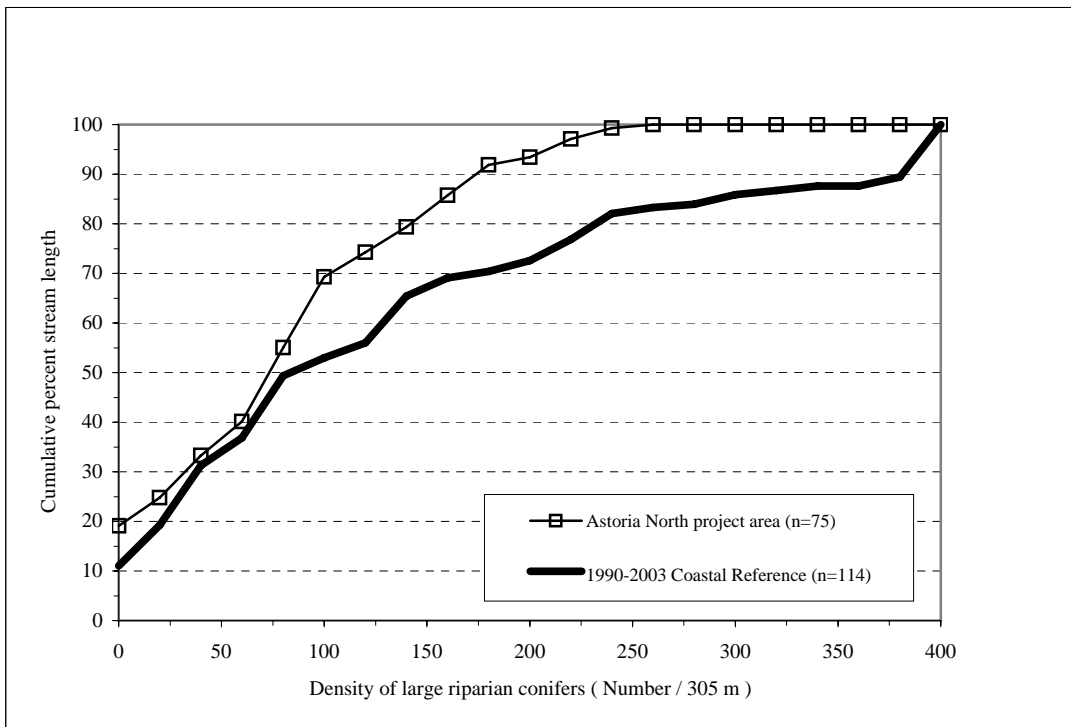
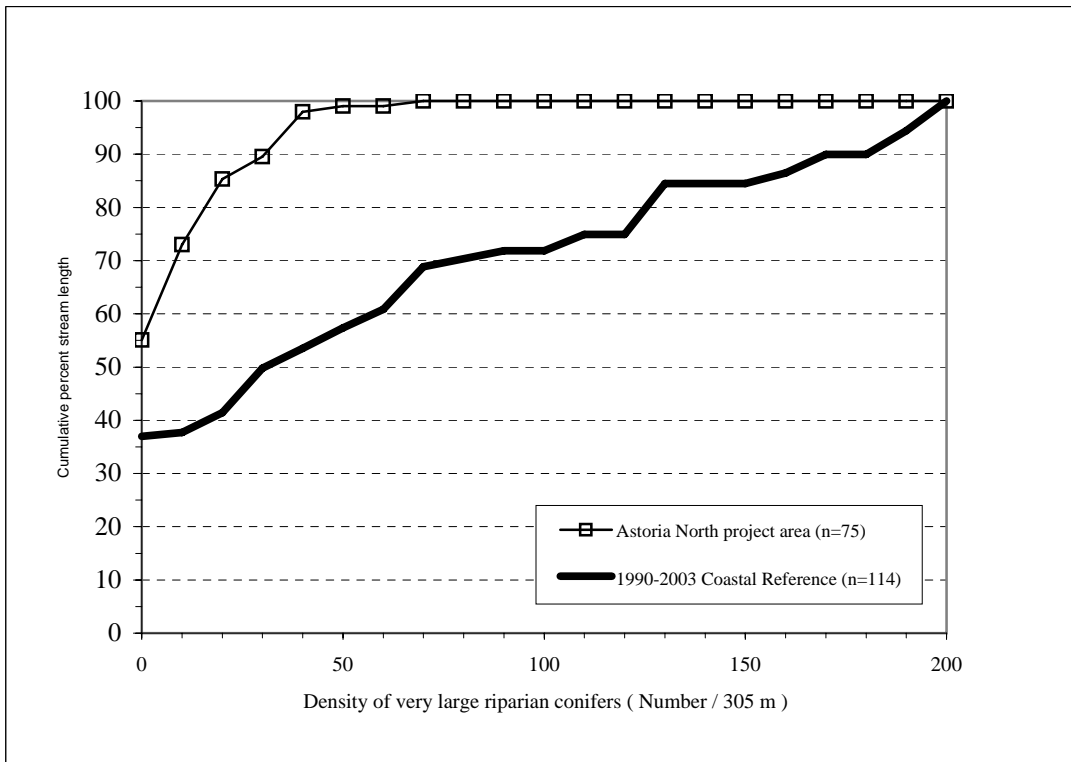


Figure 7. Cumulative frequency distribution comparing riparian conifers to reference conditions within the study area.



Oregon Department of Forestry: Lower Columbia Astoria North project area

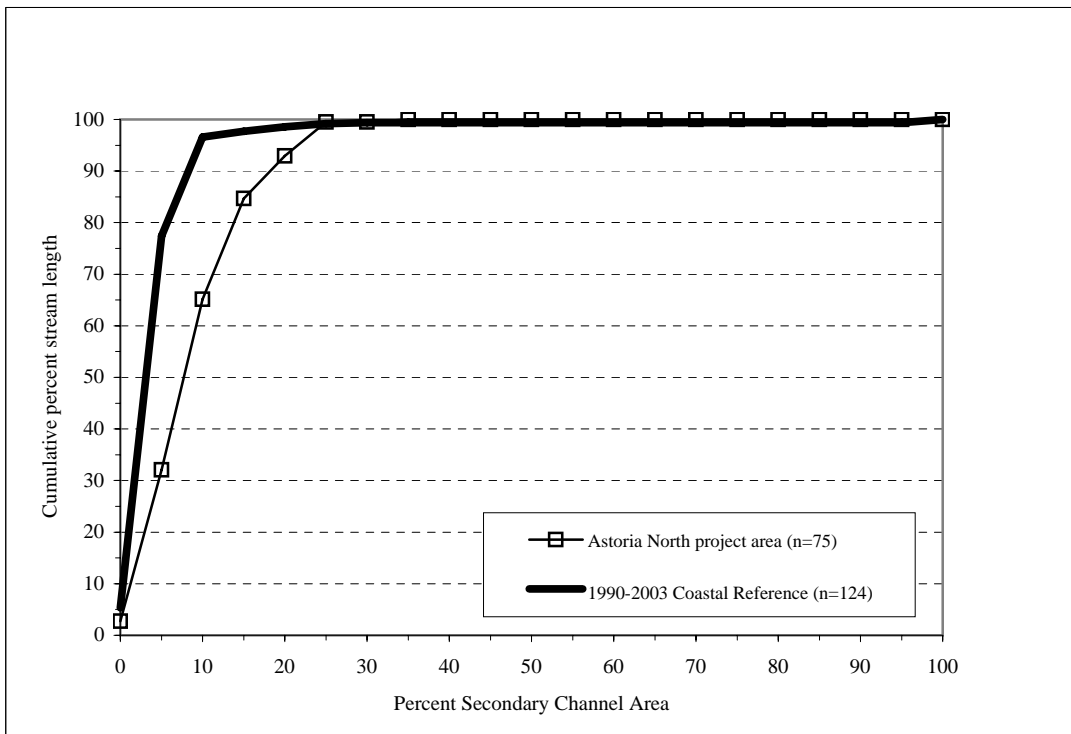
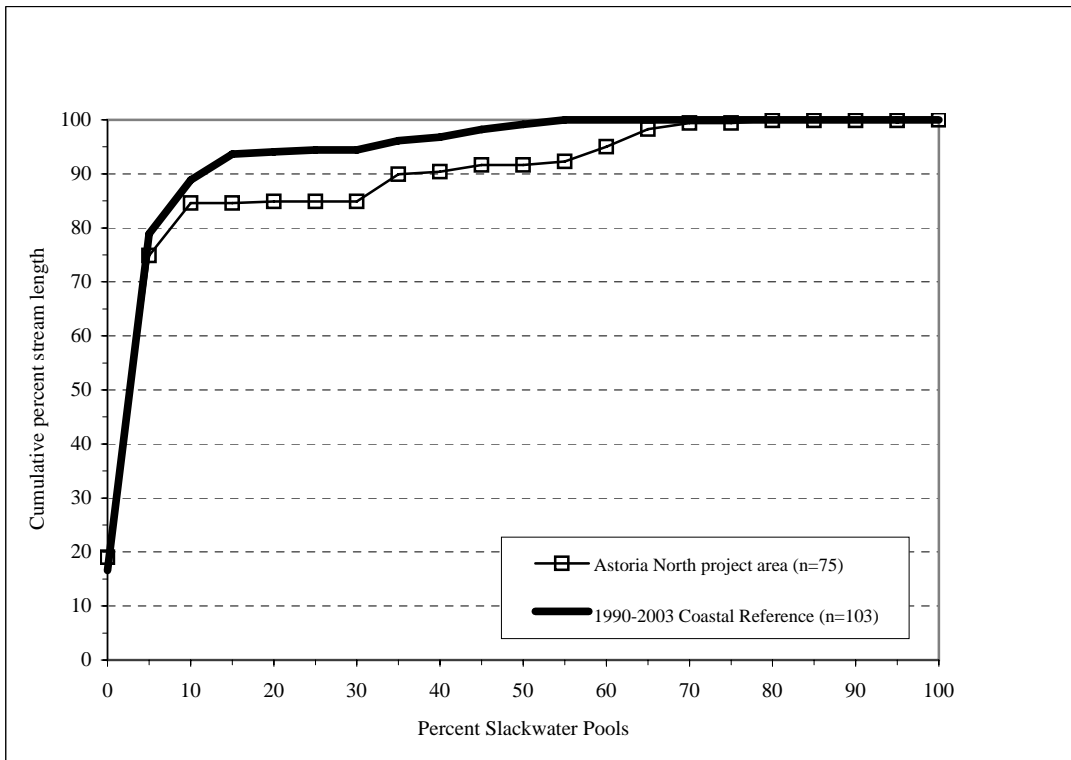


Figure 8. Cumulative frequency distribution comparing percent slackwater and secondary channel to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

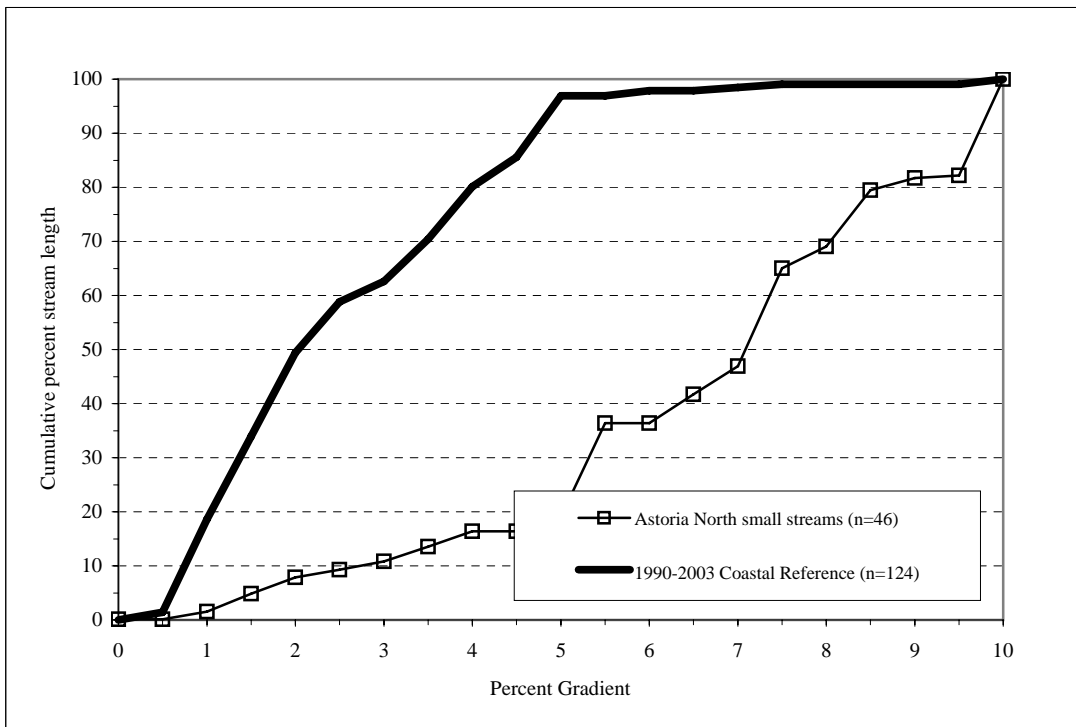
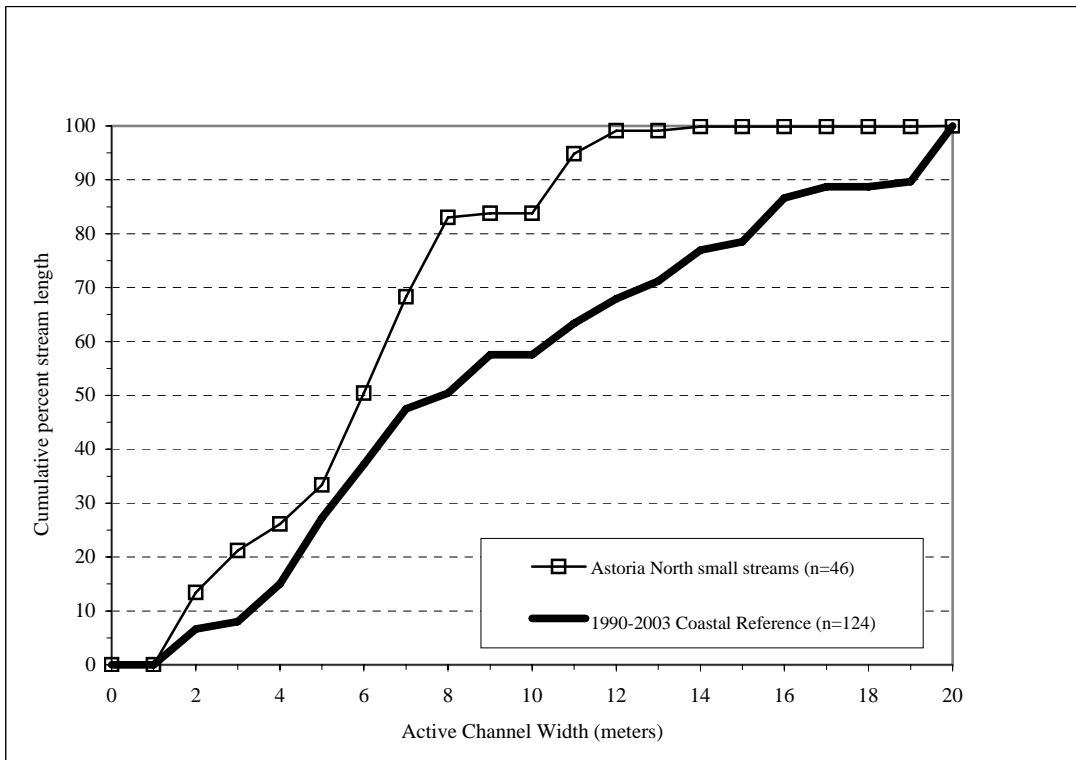


Figure 9. Cumulative frequency distribution comparing active channel width and gradient in small streams to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

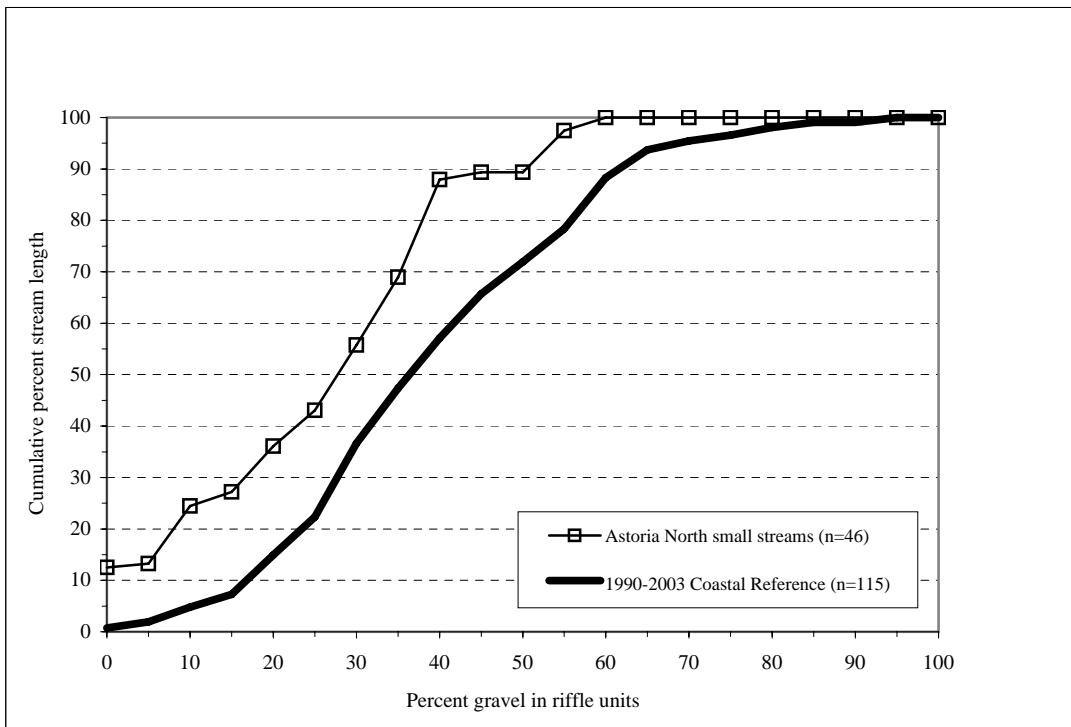
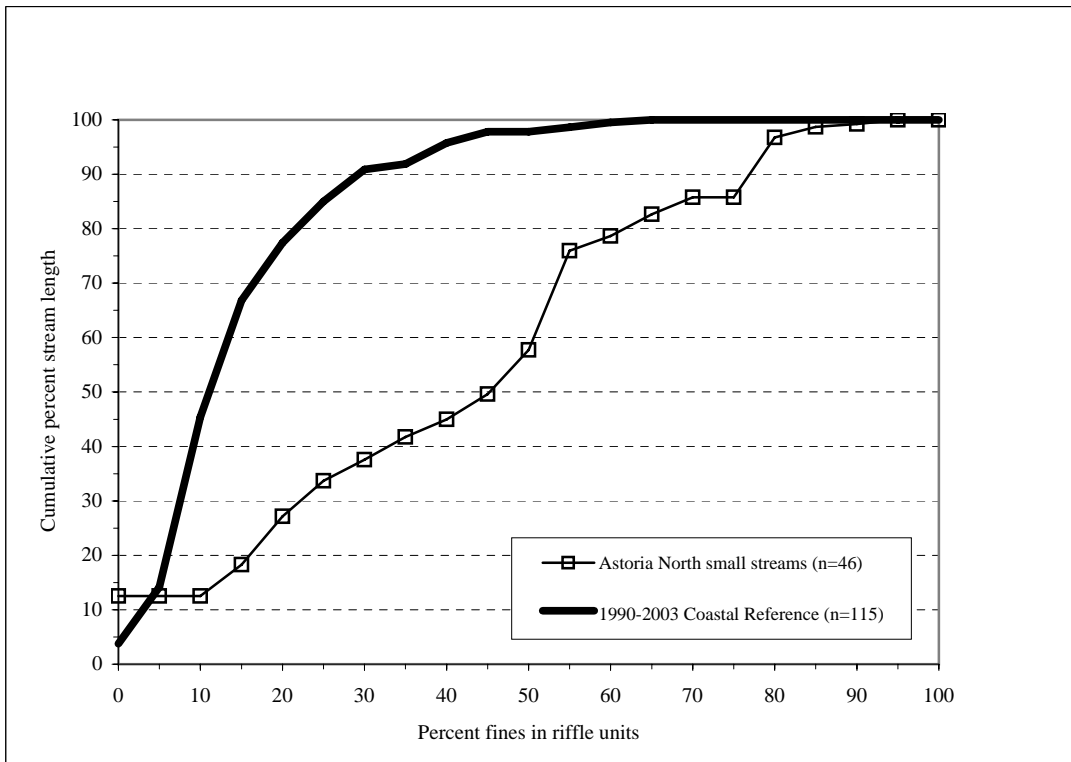


Figure 10. Cumulative frequency distribution comparing fines and gravel in small stream riffle units to reference conditions within the project area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

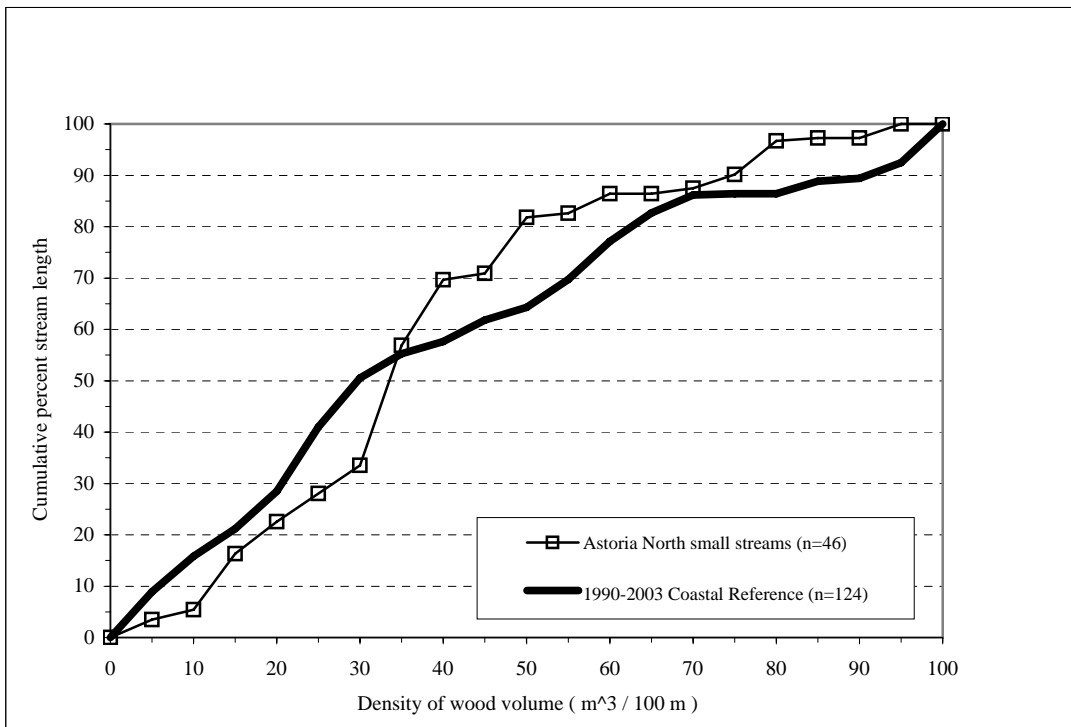
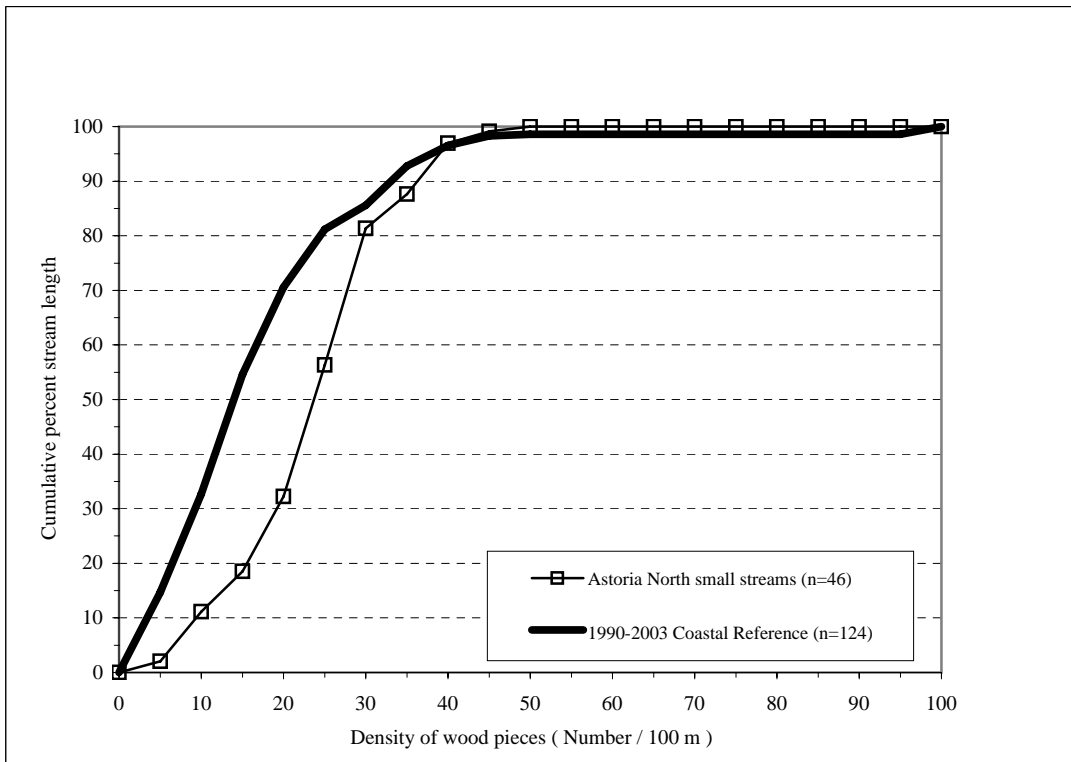


Figure 11. Cumulative frequency distribution comparing wood pieces and volume in small streams to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

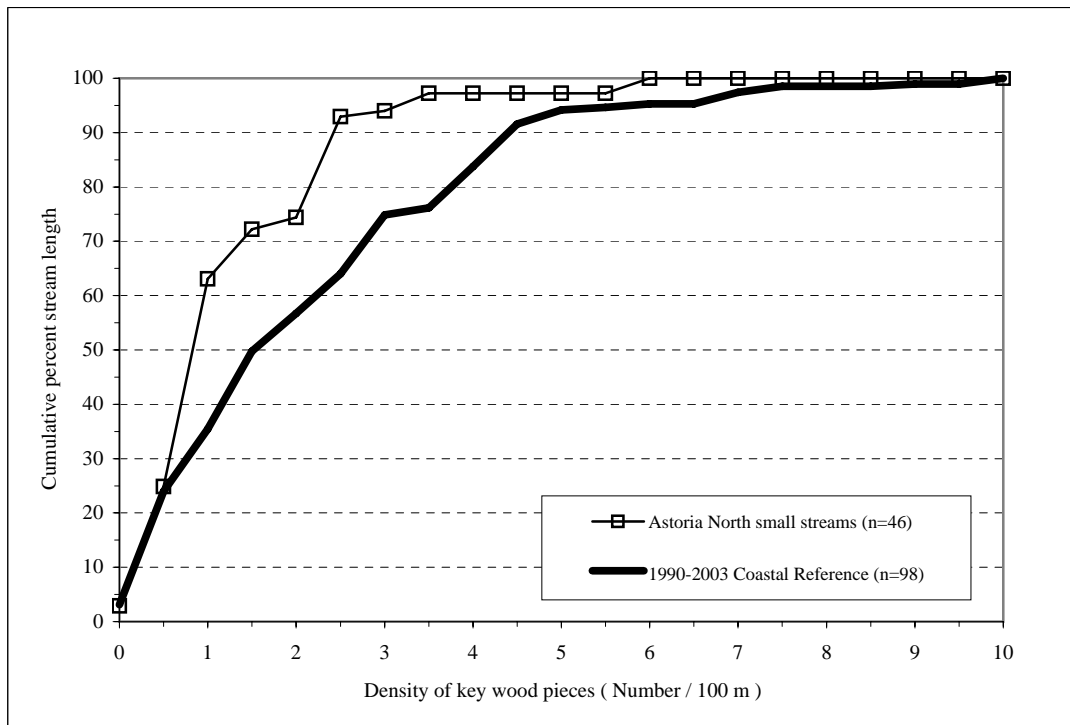
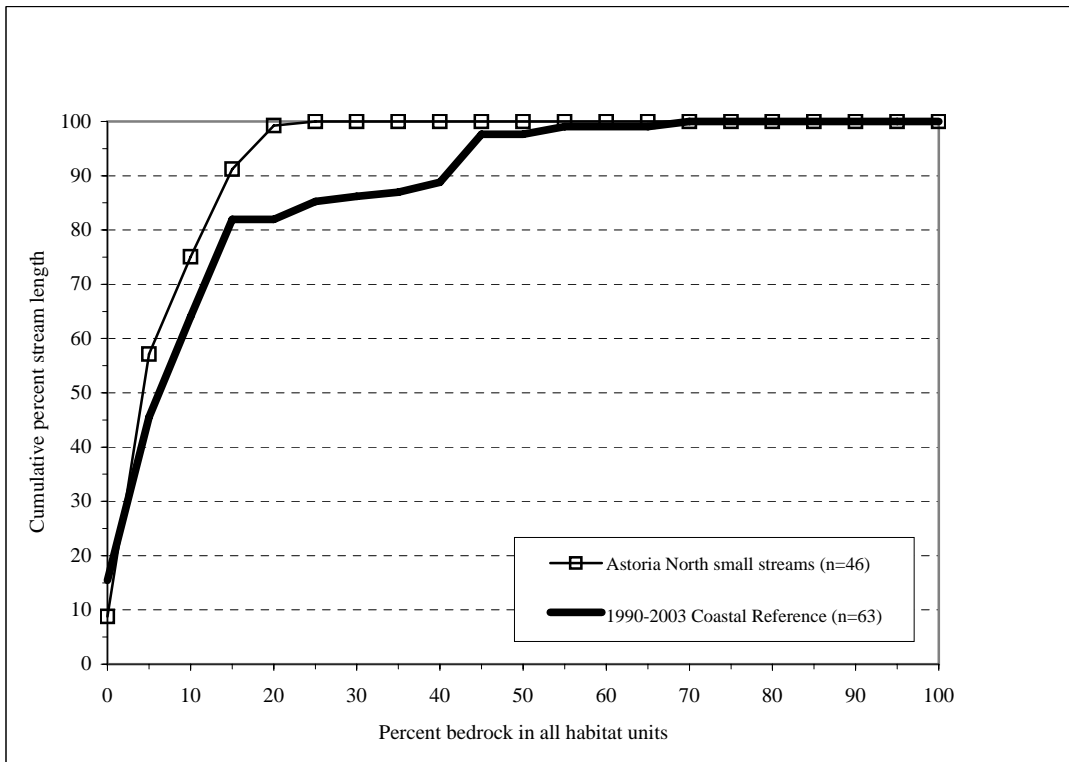


Figure 12. Cumulative frequency distribution comparing LWD keypieces and bedrock in small streams to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

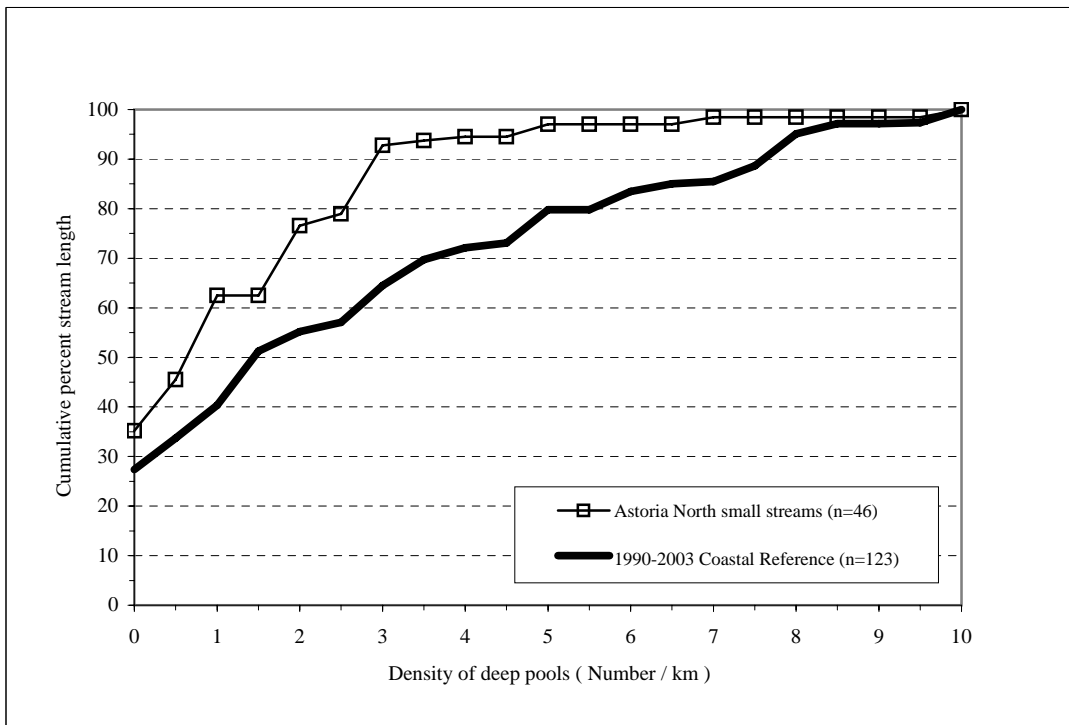
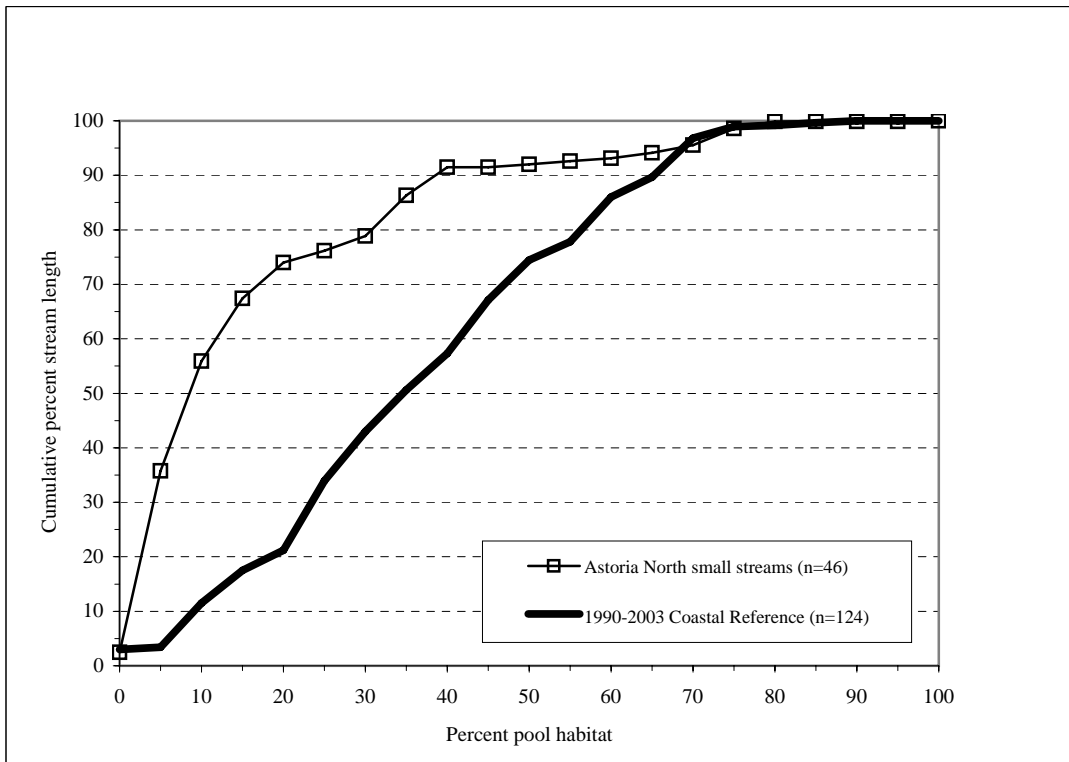


Figure 13. Cumulative frequency distribution comparing pools in small streams to the reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

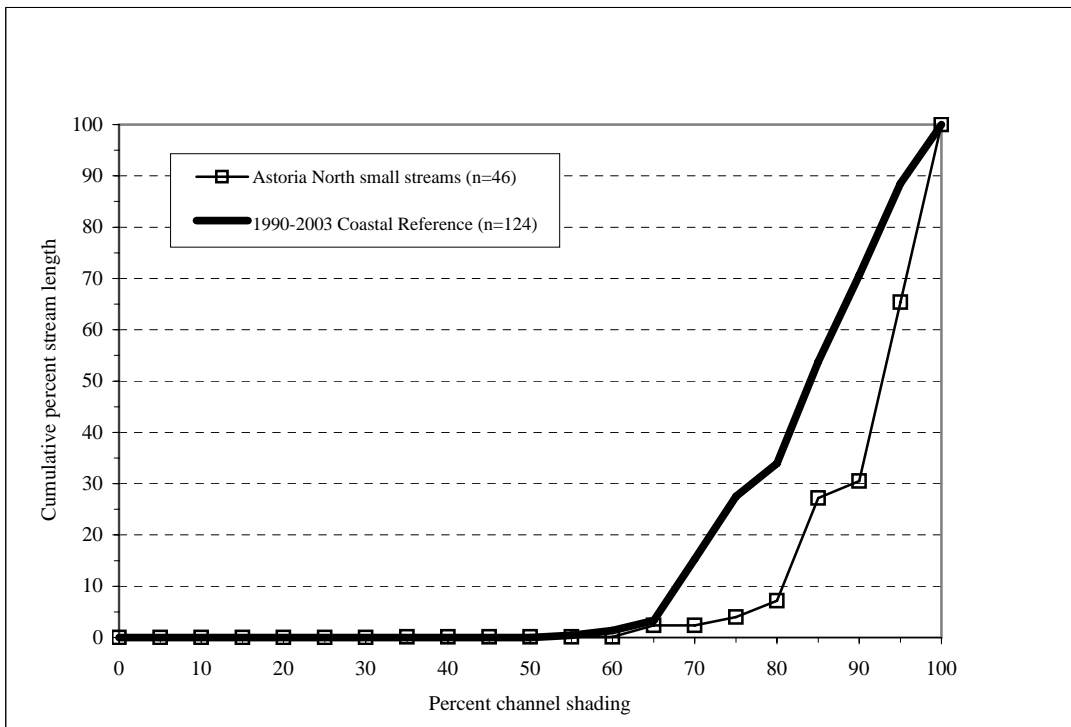
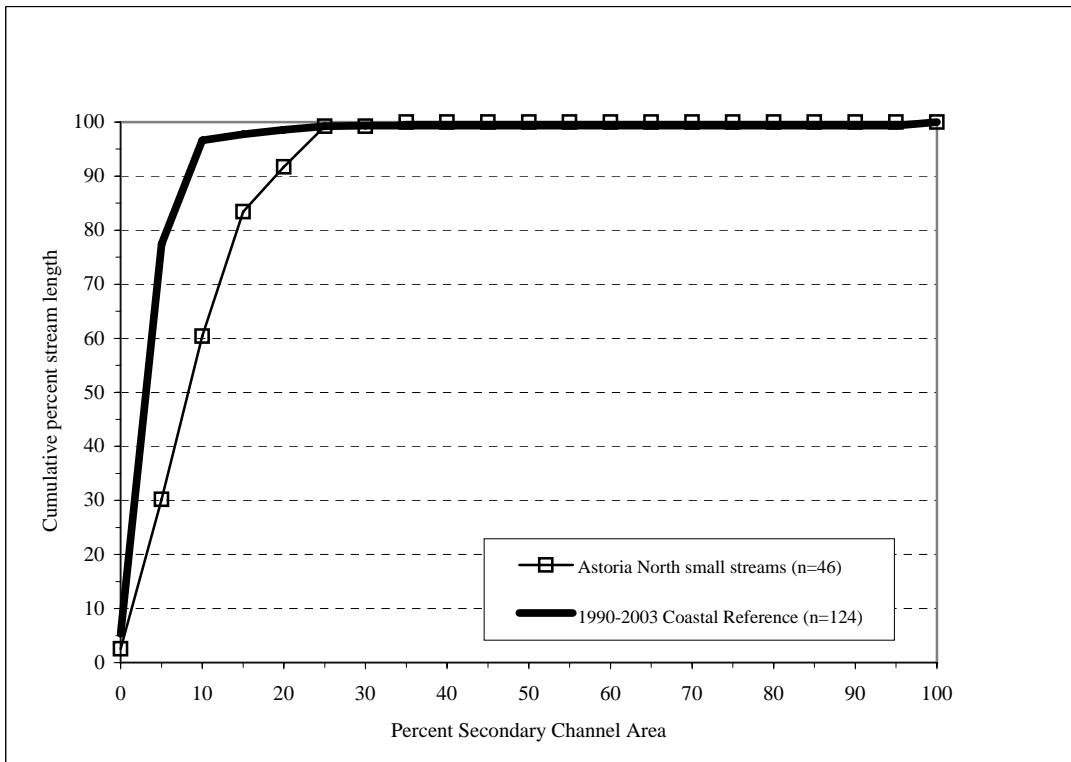


Figure 14. Cumulative frequency distribution comparing secondary channel area and shade in small streams to reference conditions within the study area.

Oregon Department of Forestry: Lower Columbia Astoria North project area

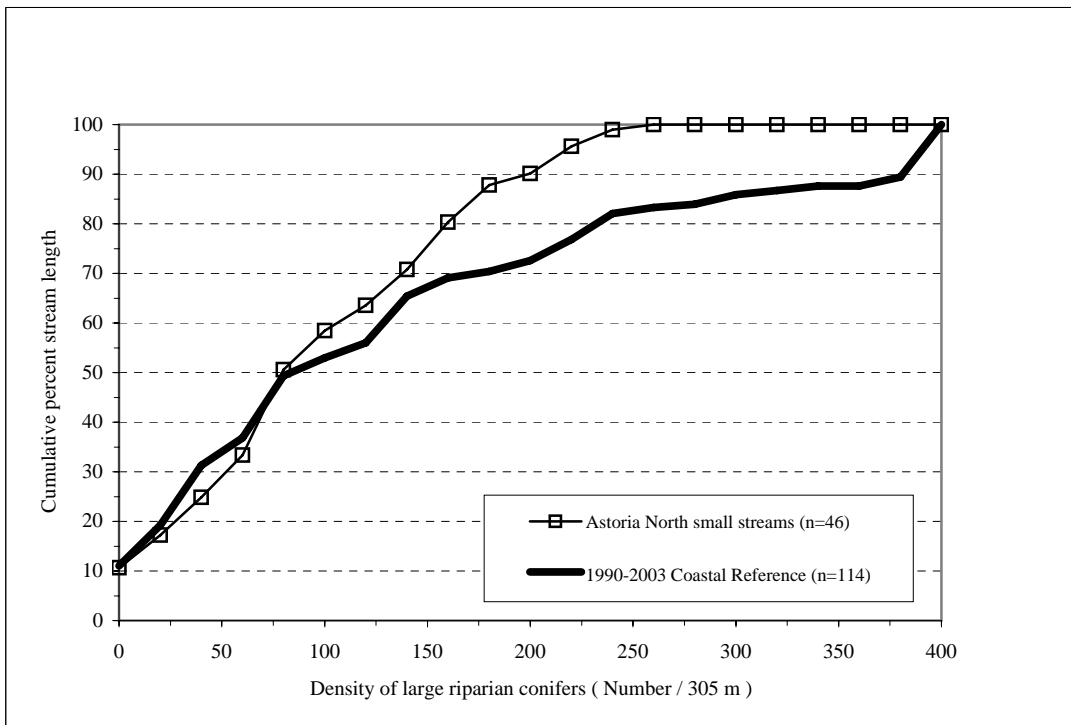
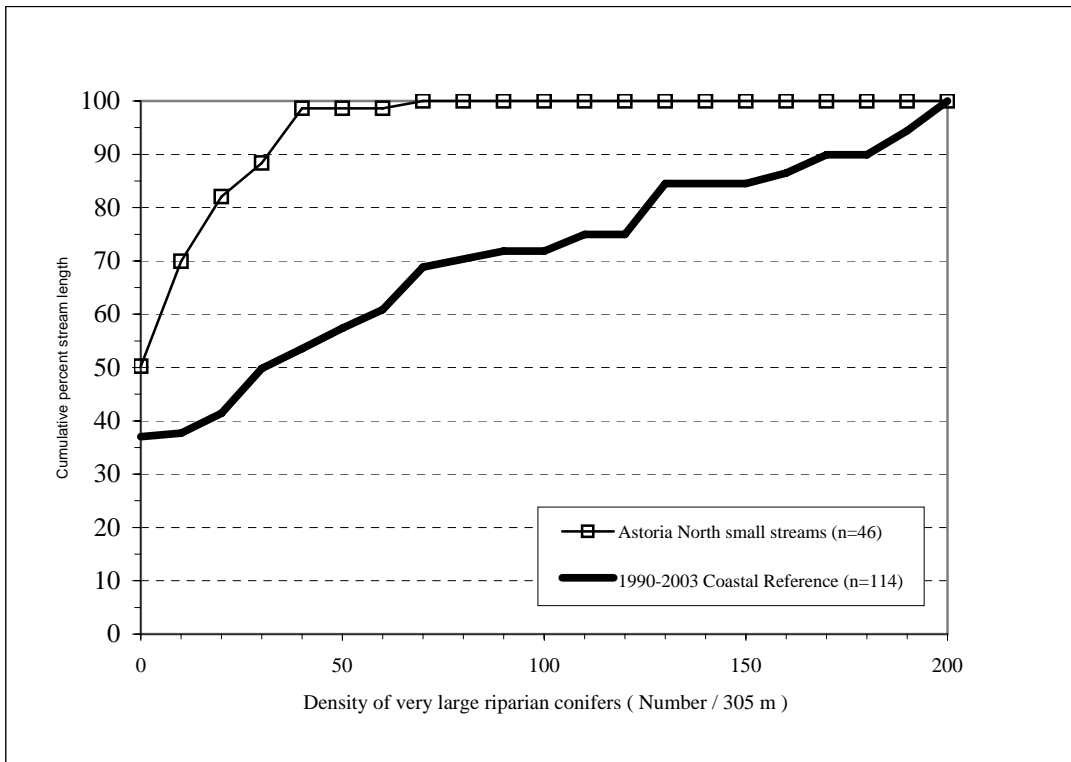


Figure 15. Cumulative frequency distribution comparing riparian conifers in small streams to reference conditions within the study area.



Oregon Department of Forestry: Lower Columbia Astoria North project area

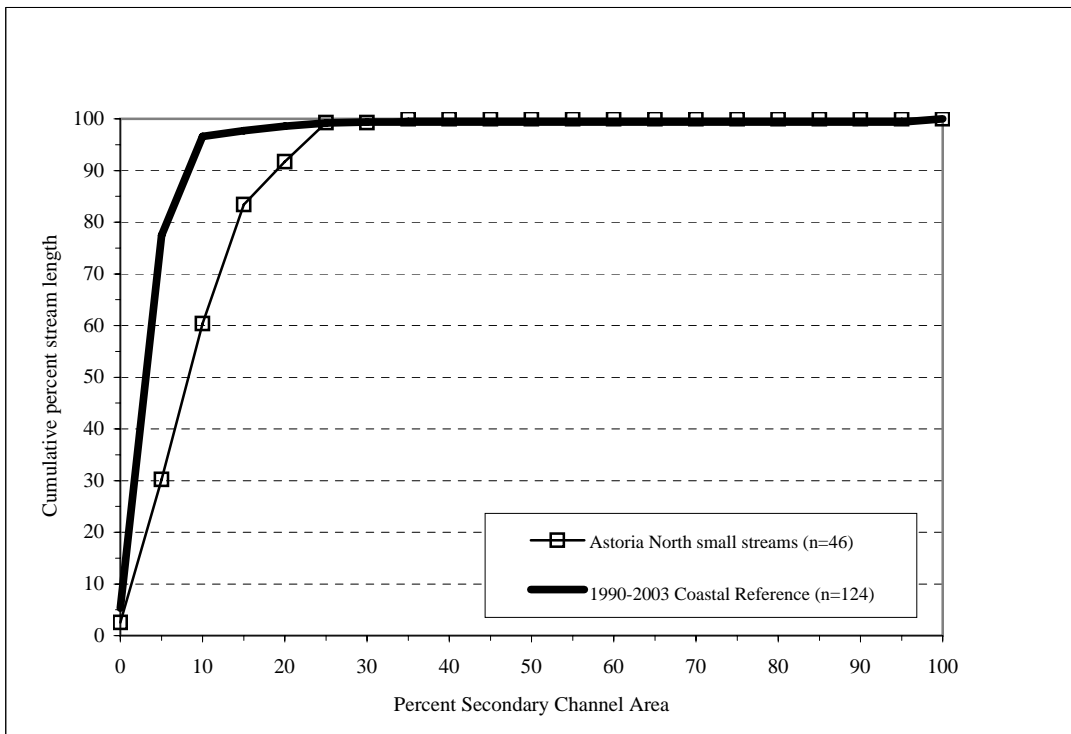
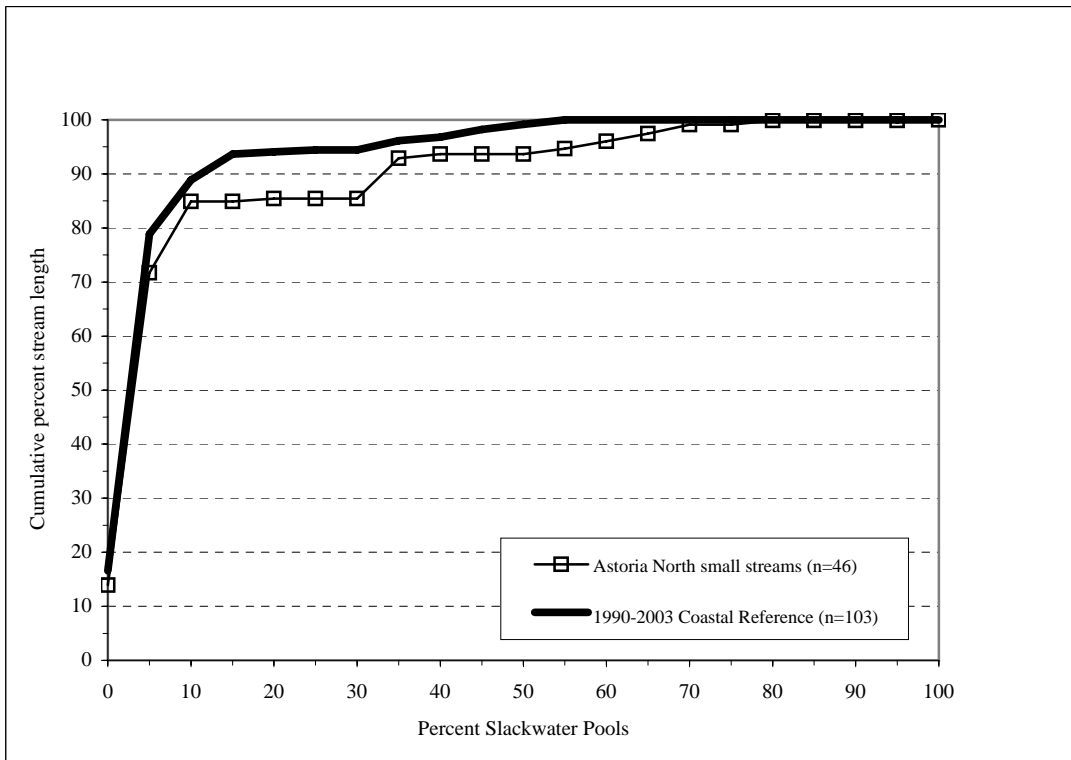
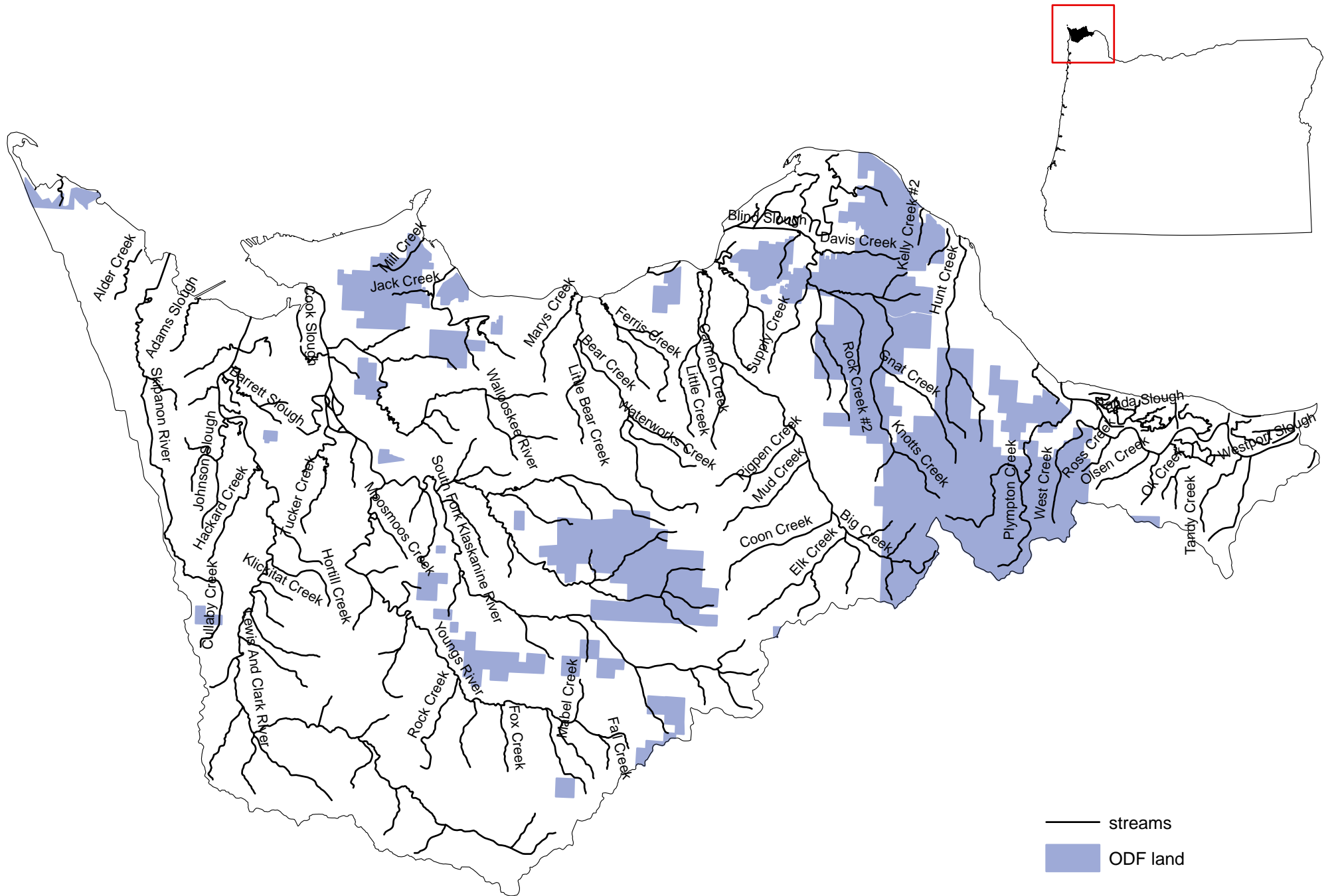
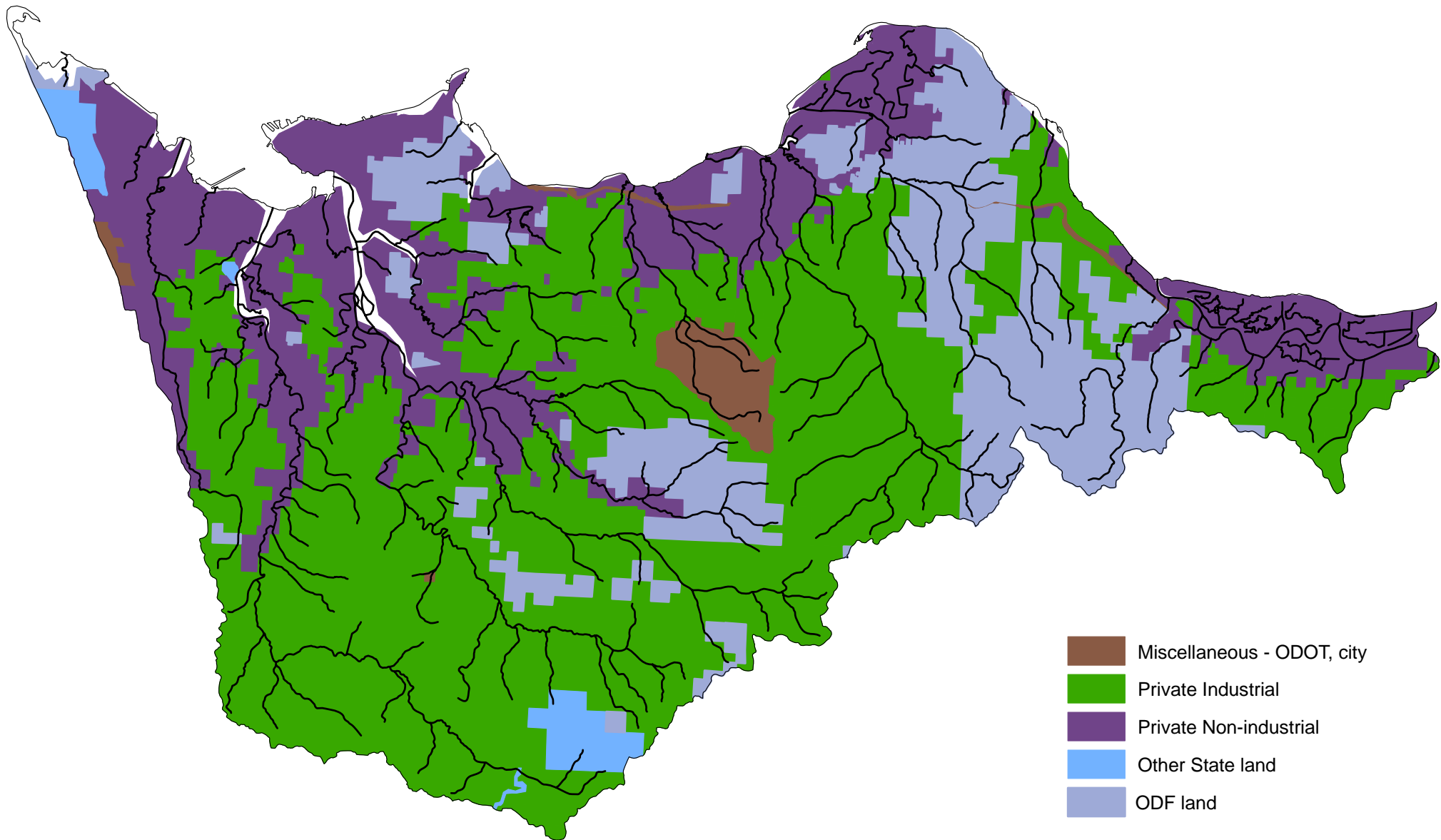


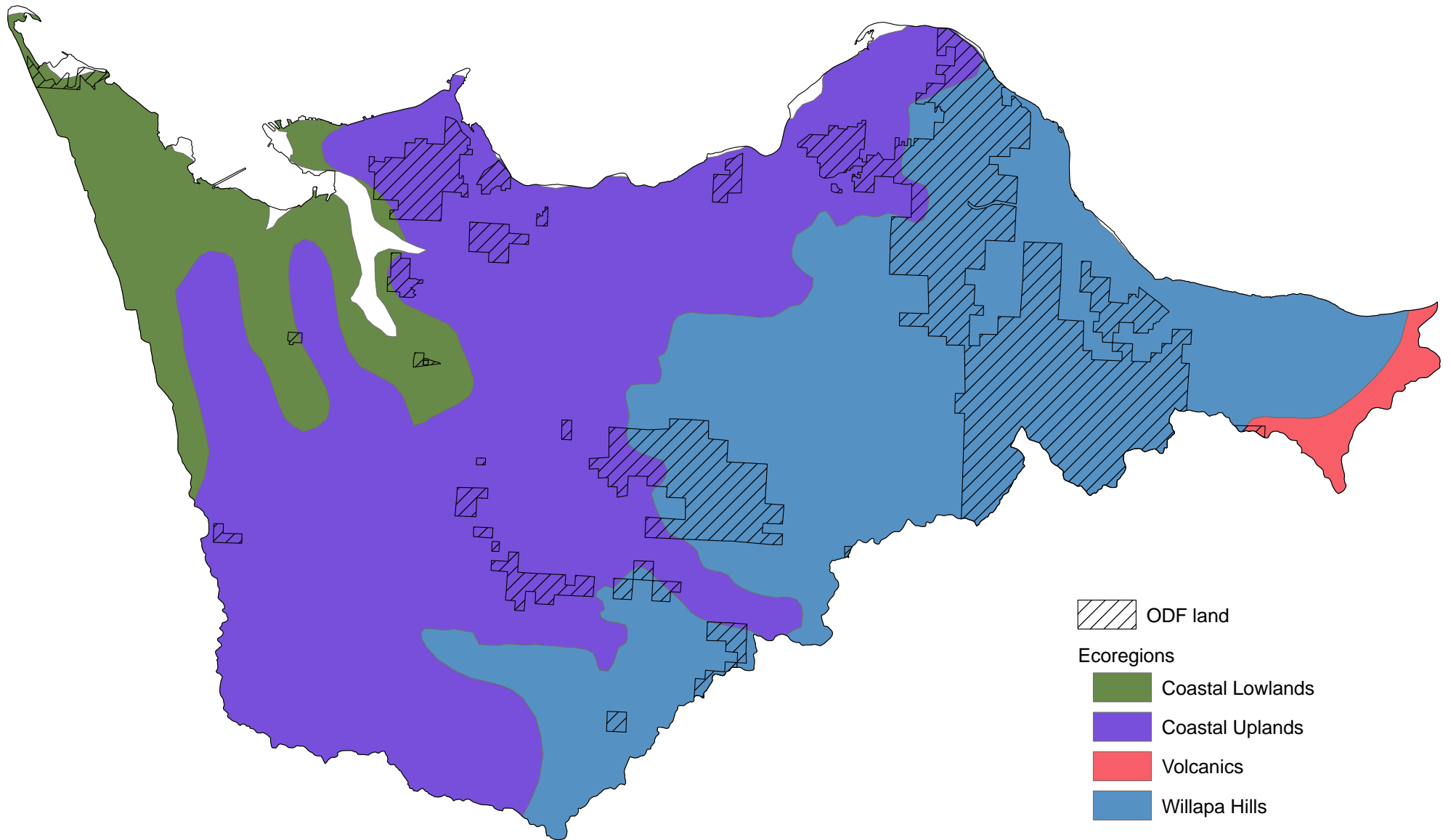
Figure 16. Cumulative frequency distribution comparing percent slackwater and secondary channel area in small streams to reference conditions within the study area.



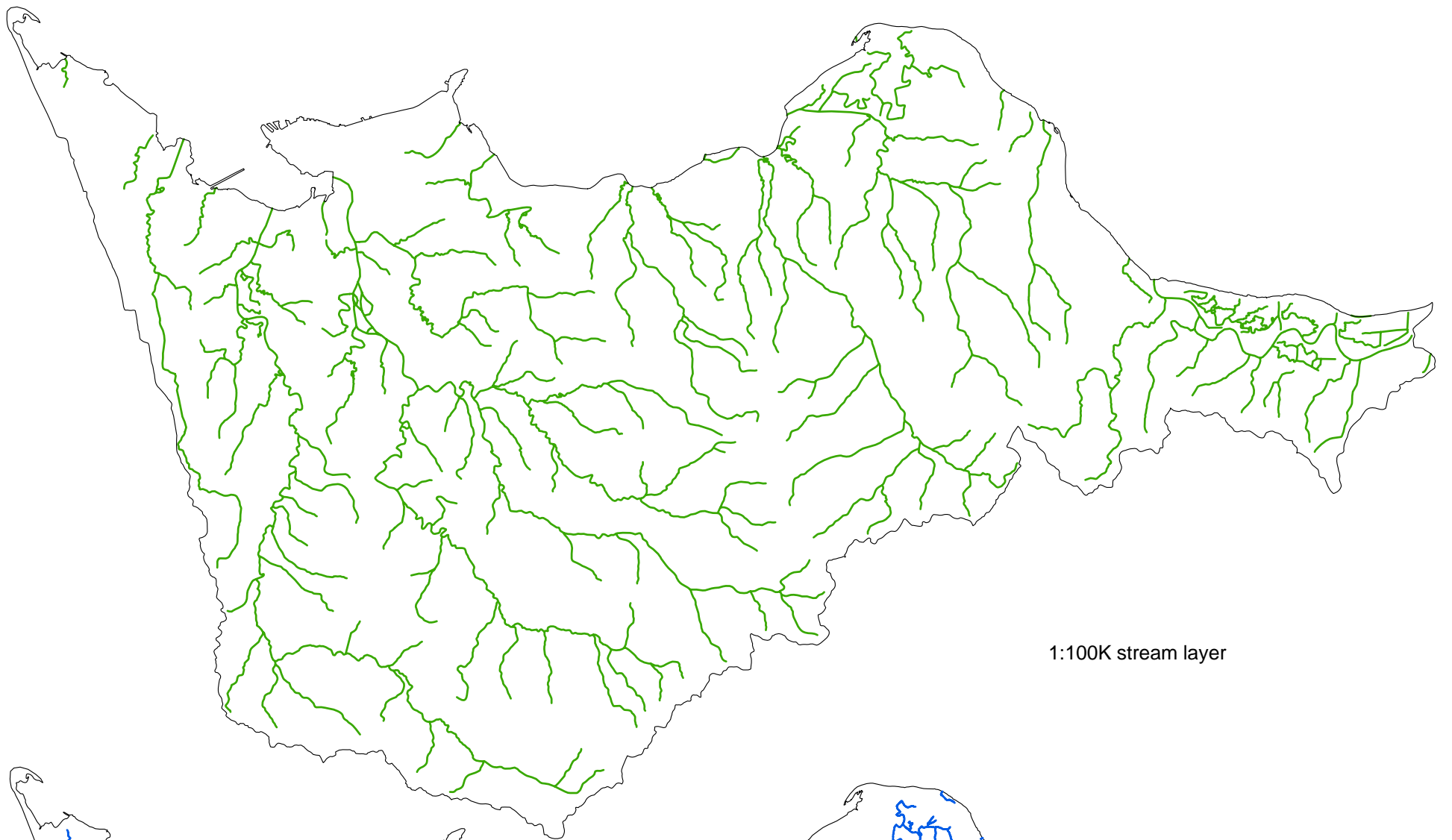
Map 1. Streams in the Lower Columbia Astoria North study area in the state of Oregon.



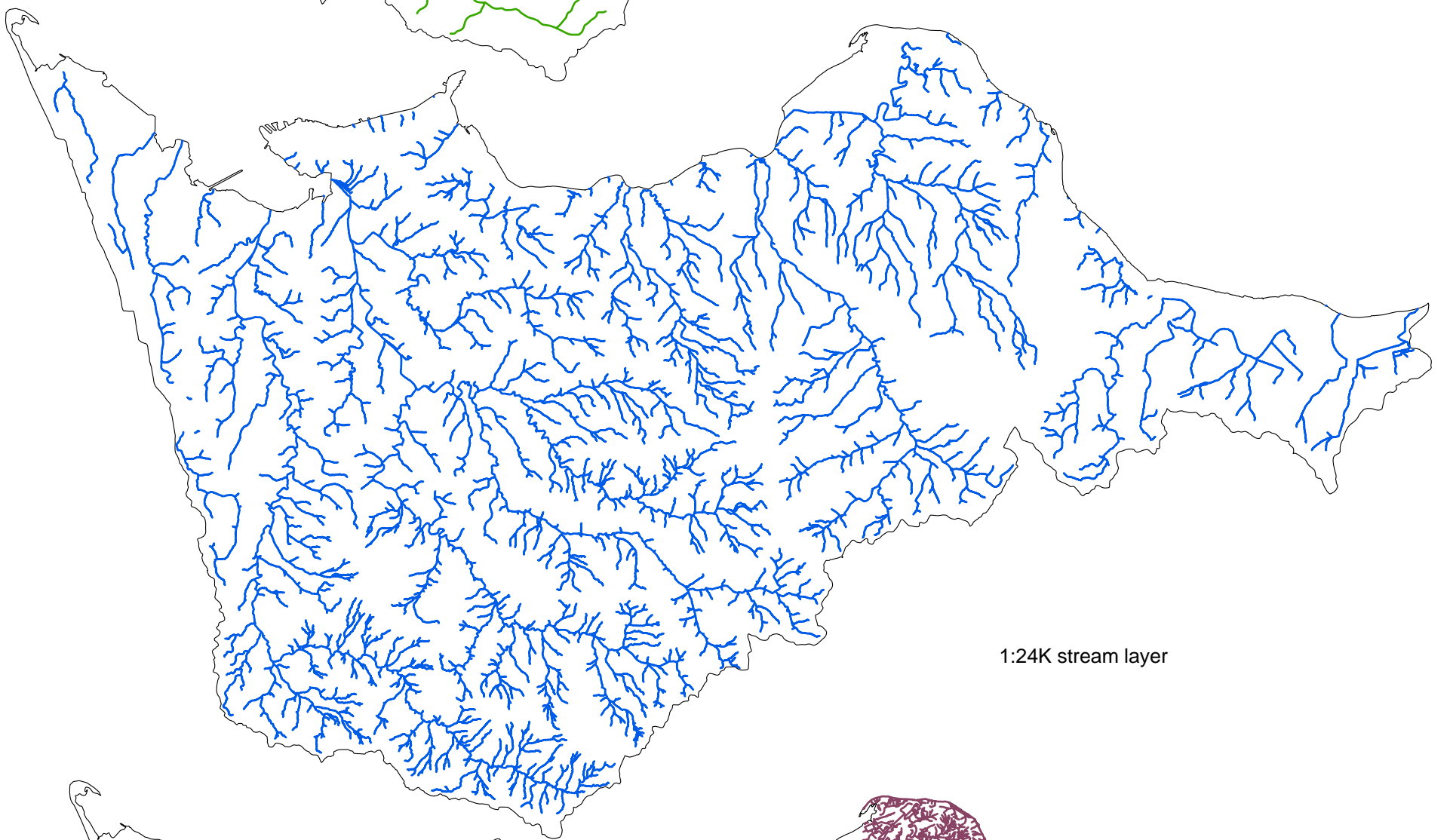
Map 2. Land ownership in the Astoria North study area.



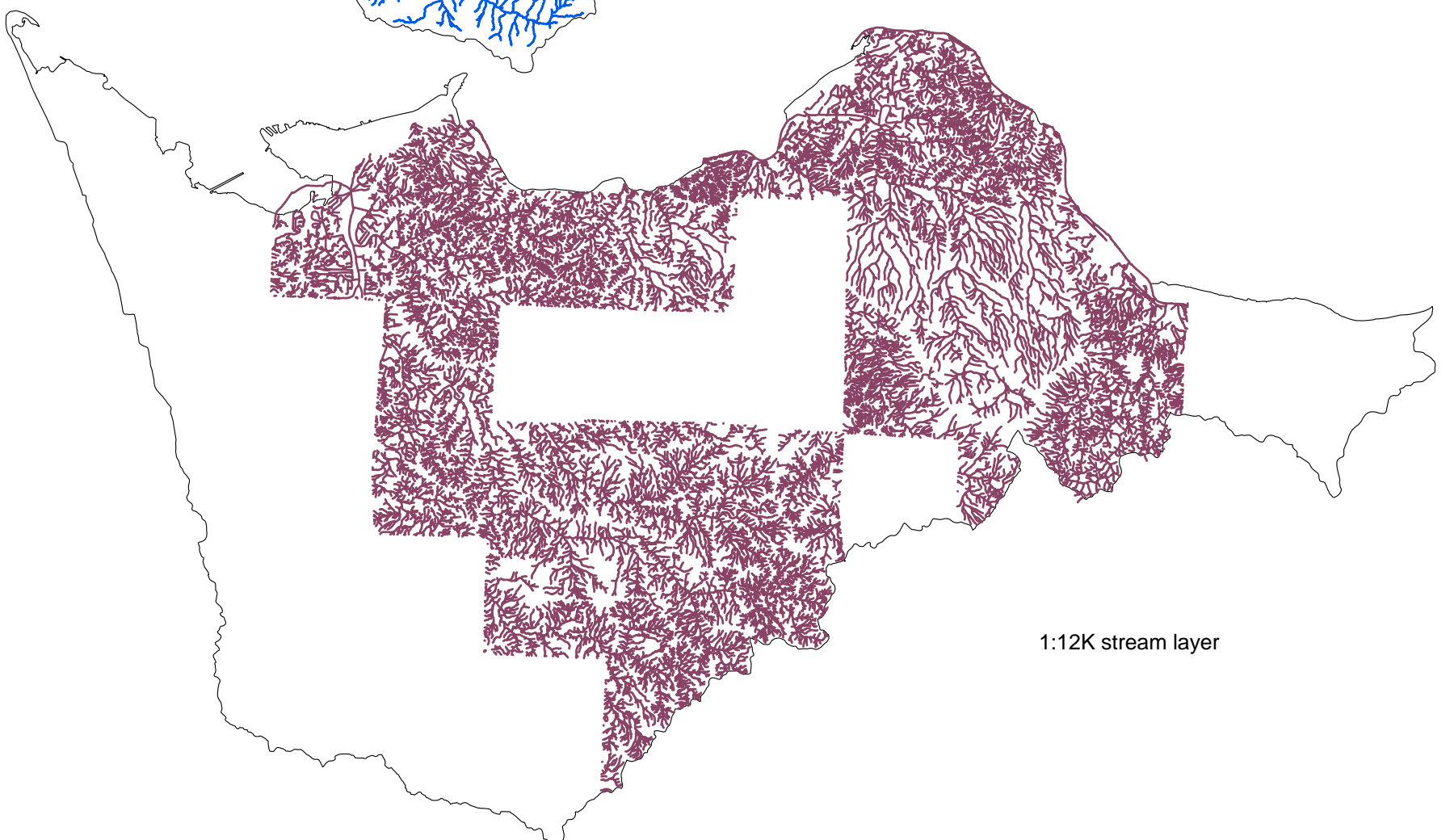
Map 3. Level IV ecoregions in the Astoria North study area (Thorson et al. 2003).



1:100K stream layer

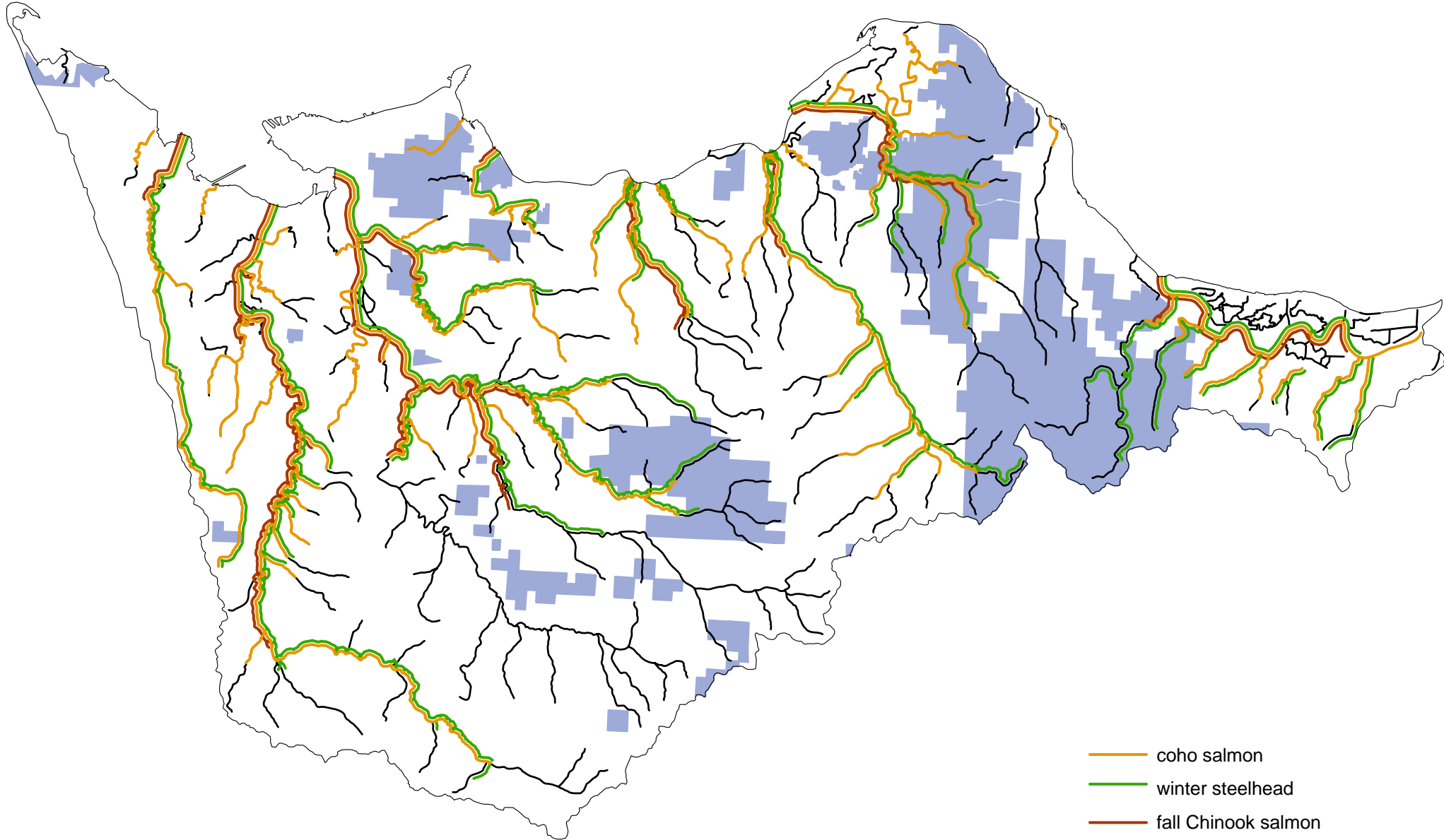


1:24K stream layer

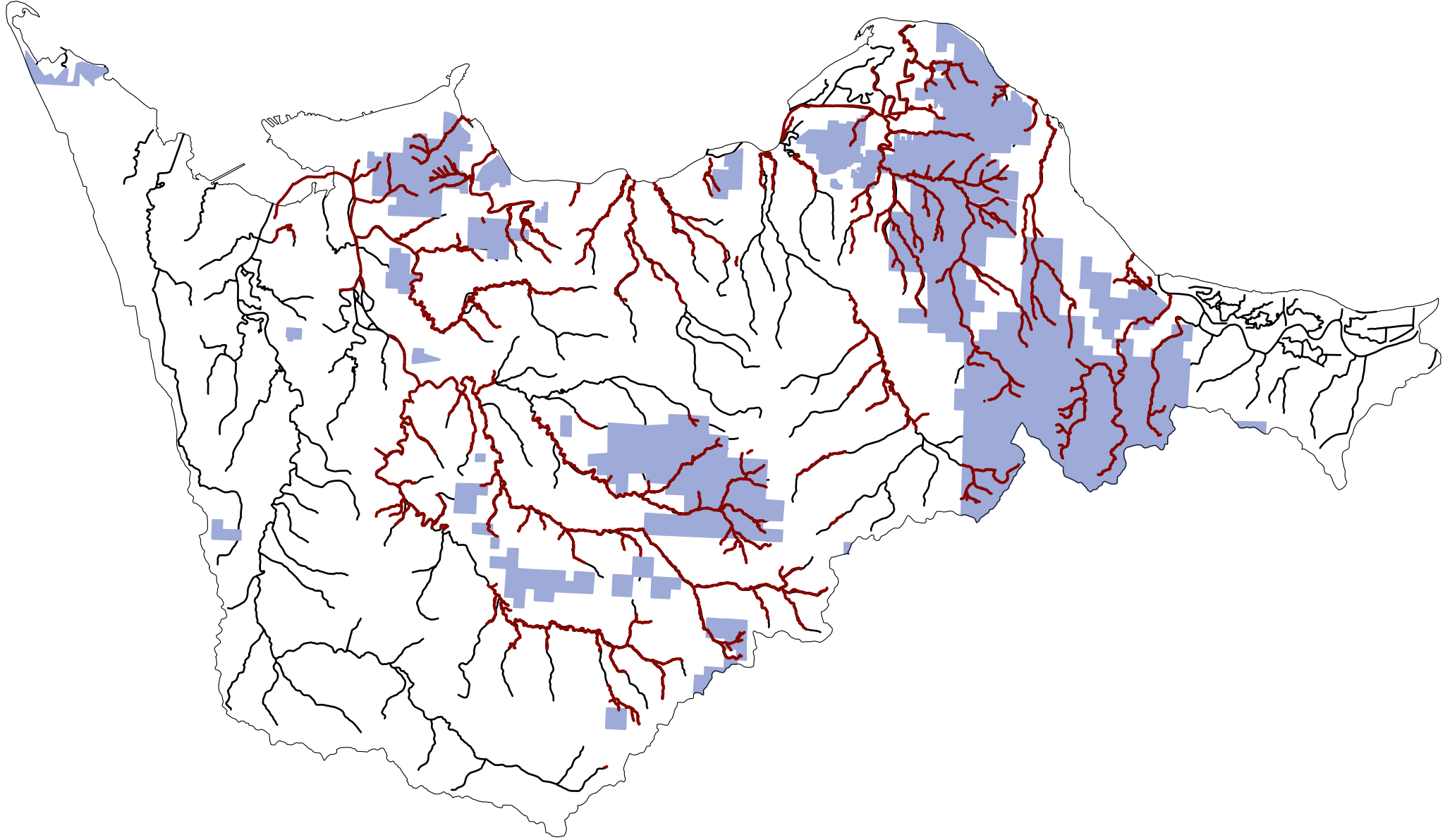


1:12K stream layer

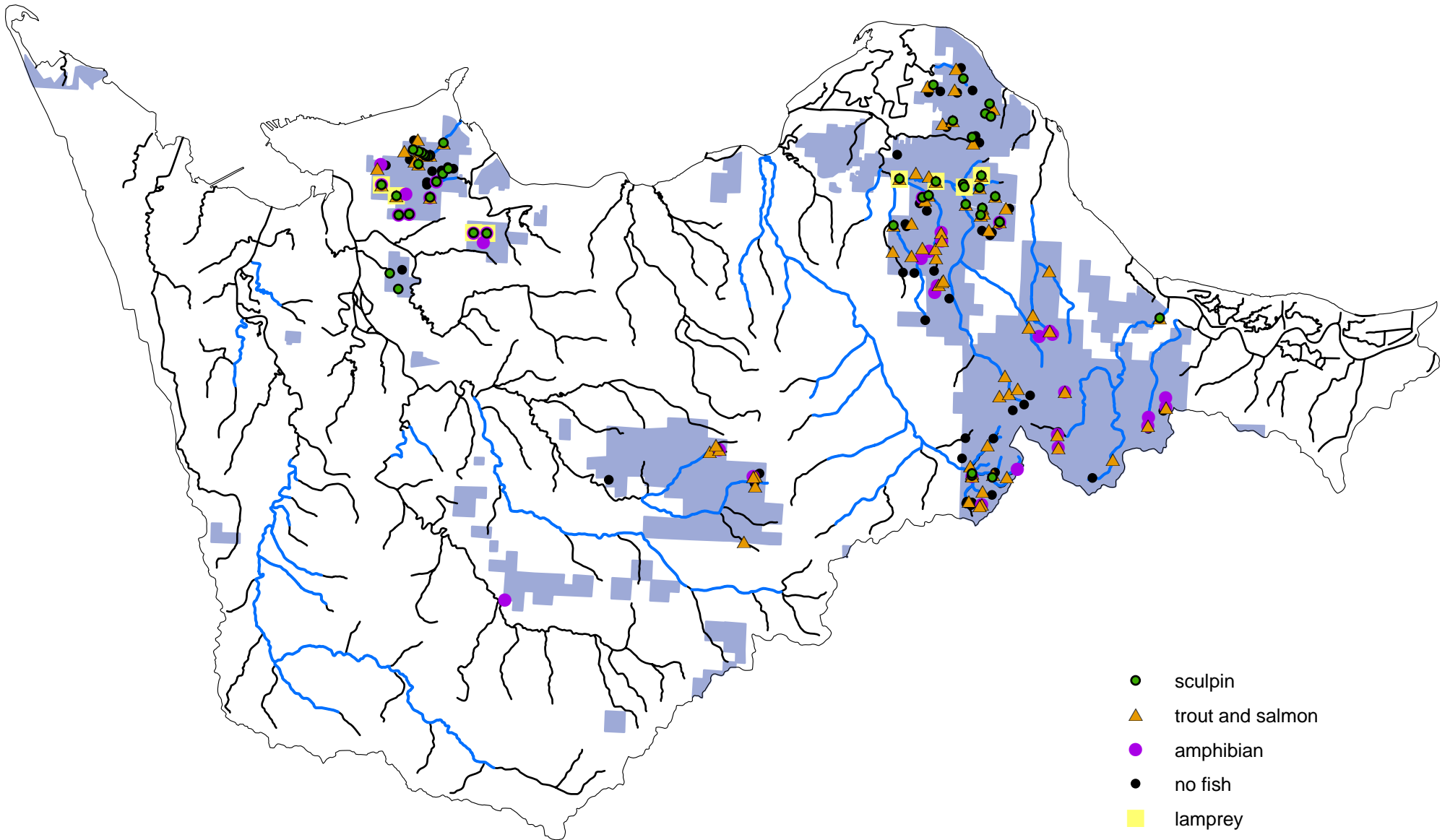
Map 4. Stream layers - 1:100k (ODFW), 1:24k (CLAMS), and 1:12k (ODF) - in the Astoria North study area.



Map 5. Anadromous fish distribution in the Astoria North study area.

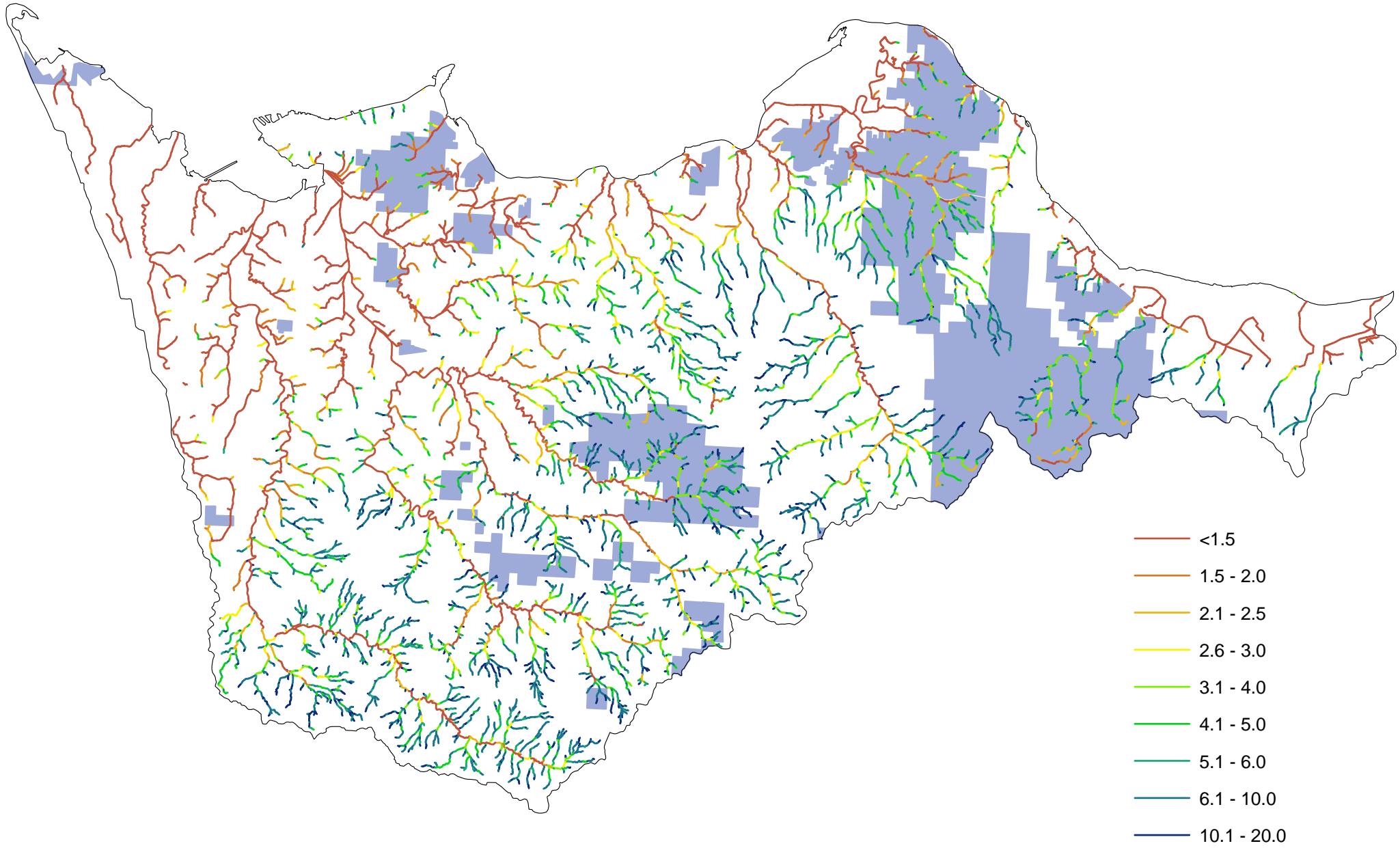


Map 6. Cutthroat trout distribution (red) in the majority of the Astoria North study area (source: ODF).

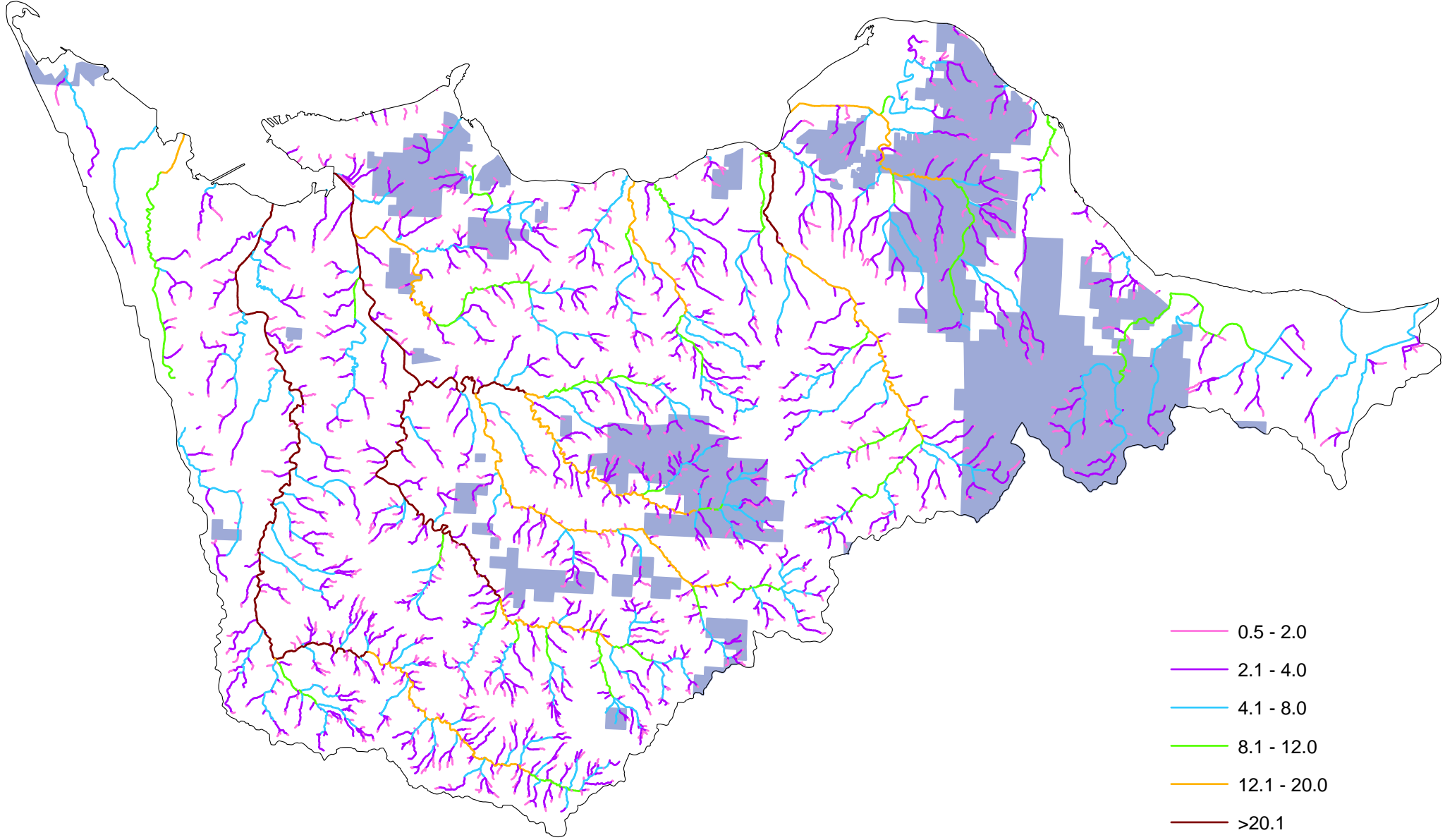


Map 7. ODFW Aquatic Inventories fish presence/absence survey sites within the Astoria North project area. The trout and salmon grouping includes coho salmon, Chinook salmon, rainbow and cutthroat trout, and unidentified salmon and trout.

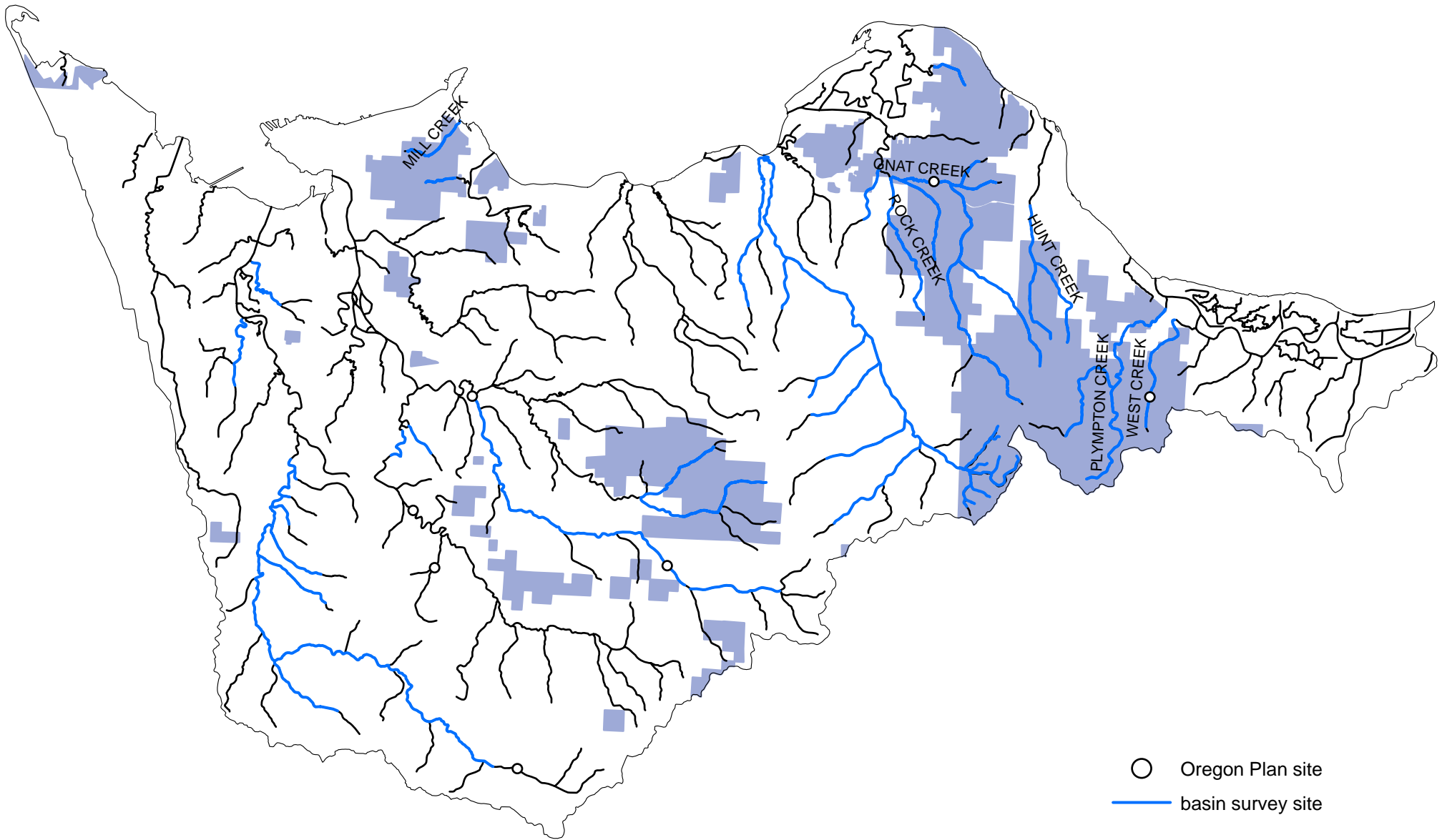




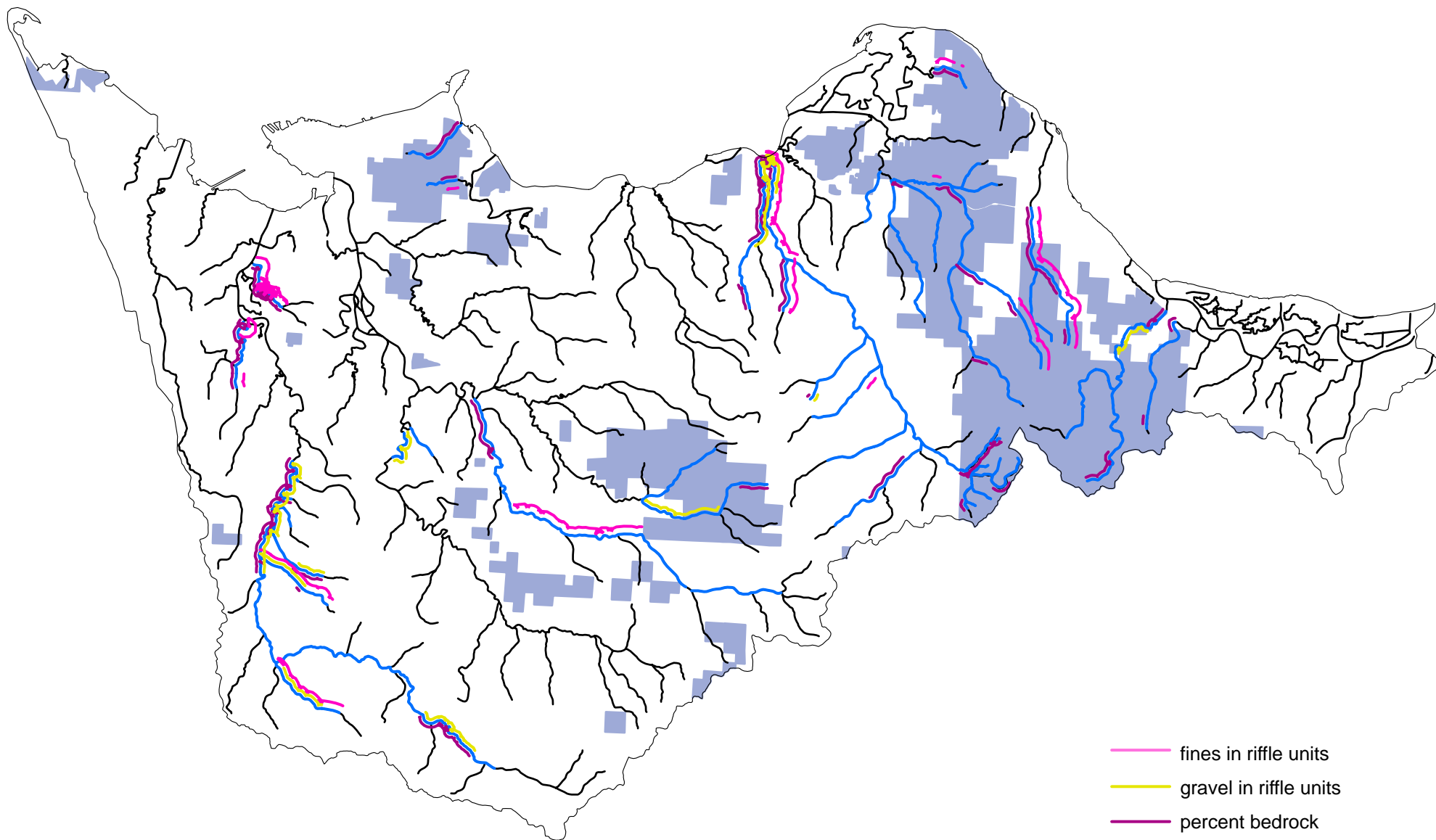
Map 8. Gradient (percent) of streams in the Astoria North study area (source: CLAMS).



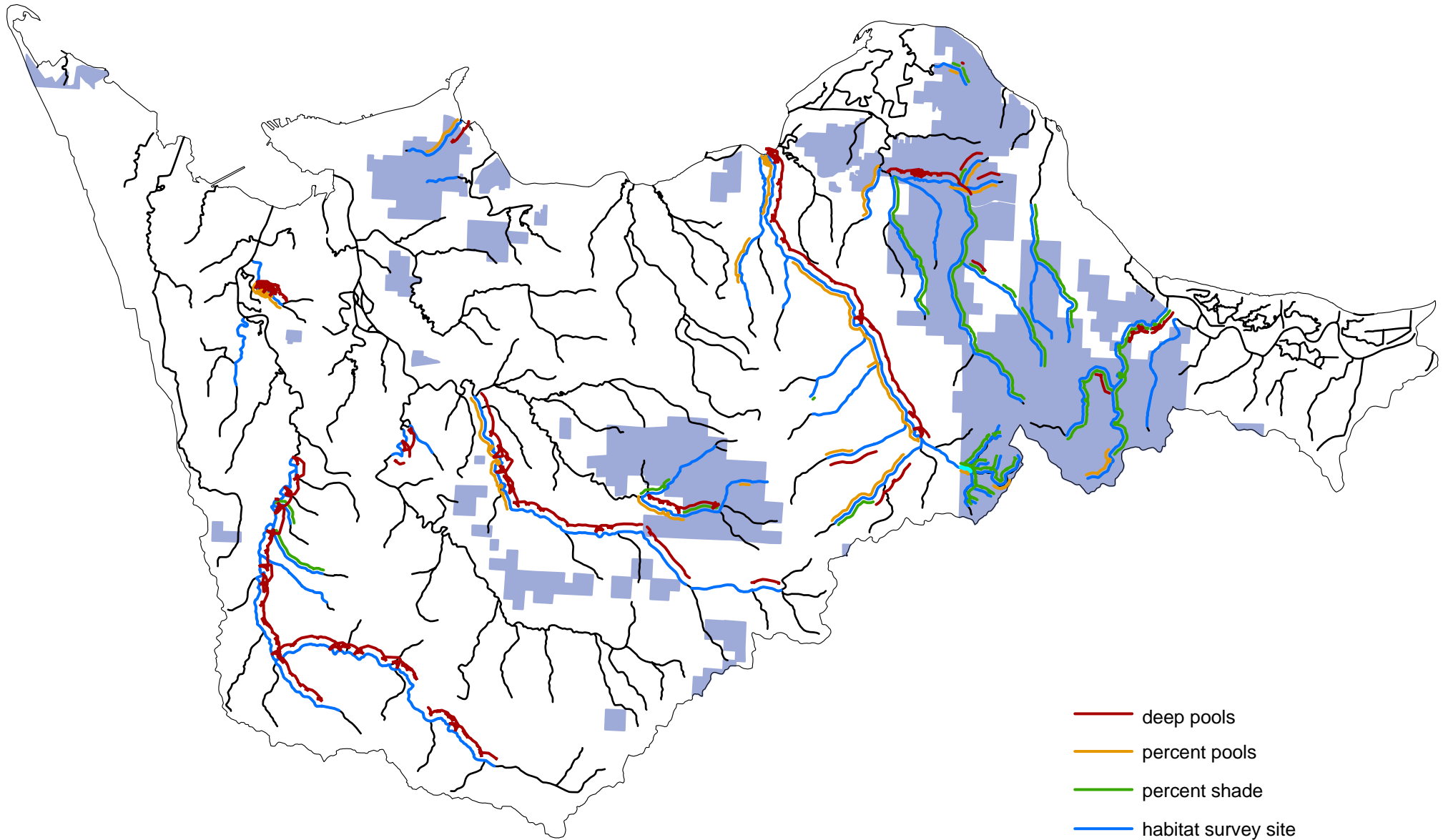
Map 9. Active channel width (meters) of streams in the Astoria North study area (source: CLAMS).



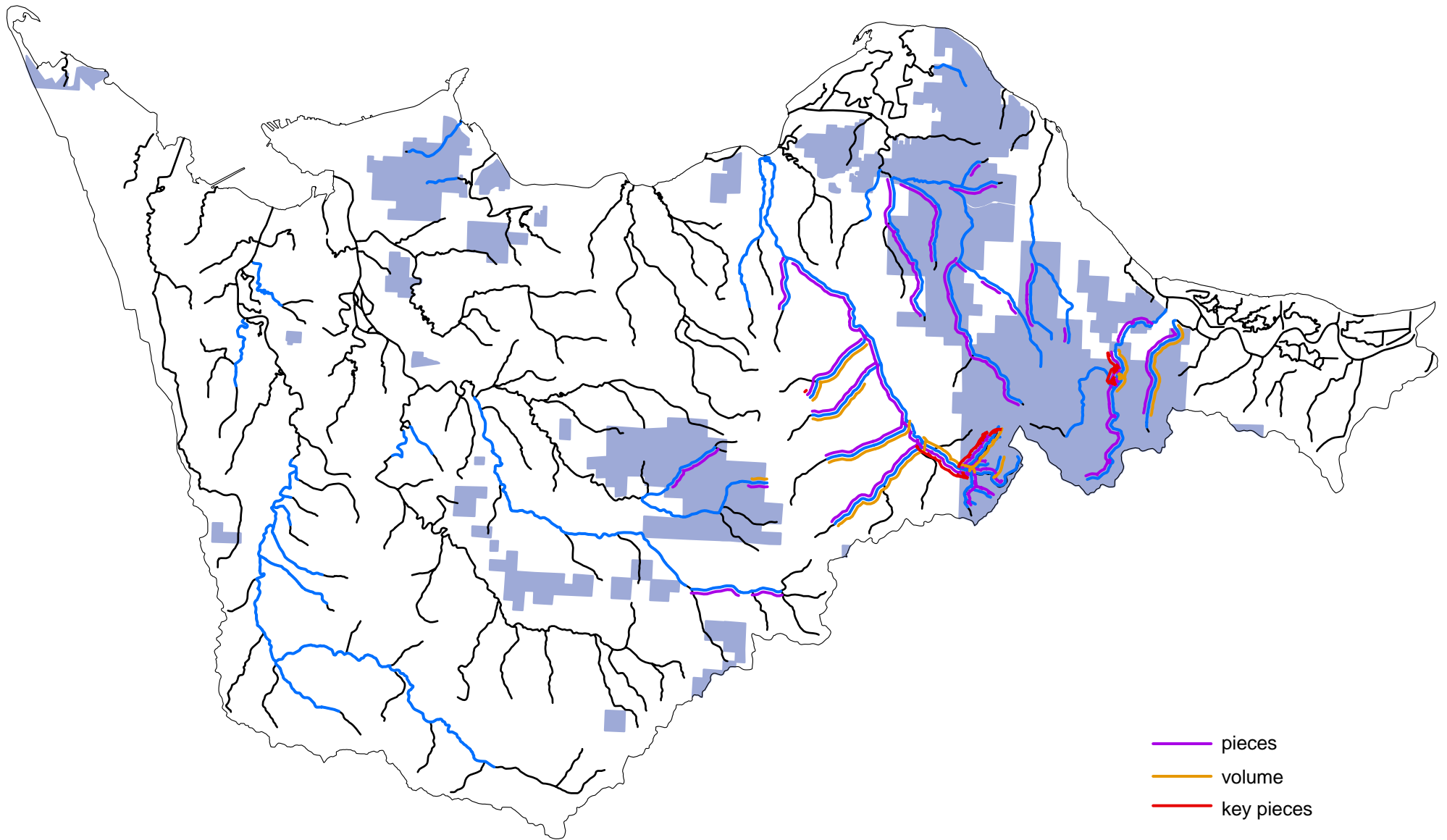
Map 10. ODFW Aquatic Inventories Project summer habitat survey site location in the Astoria North study area.



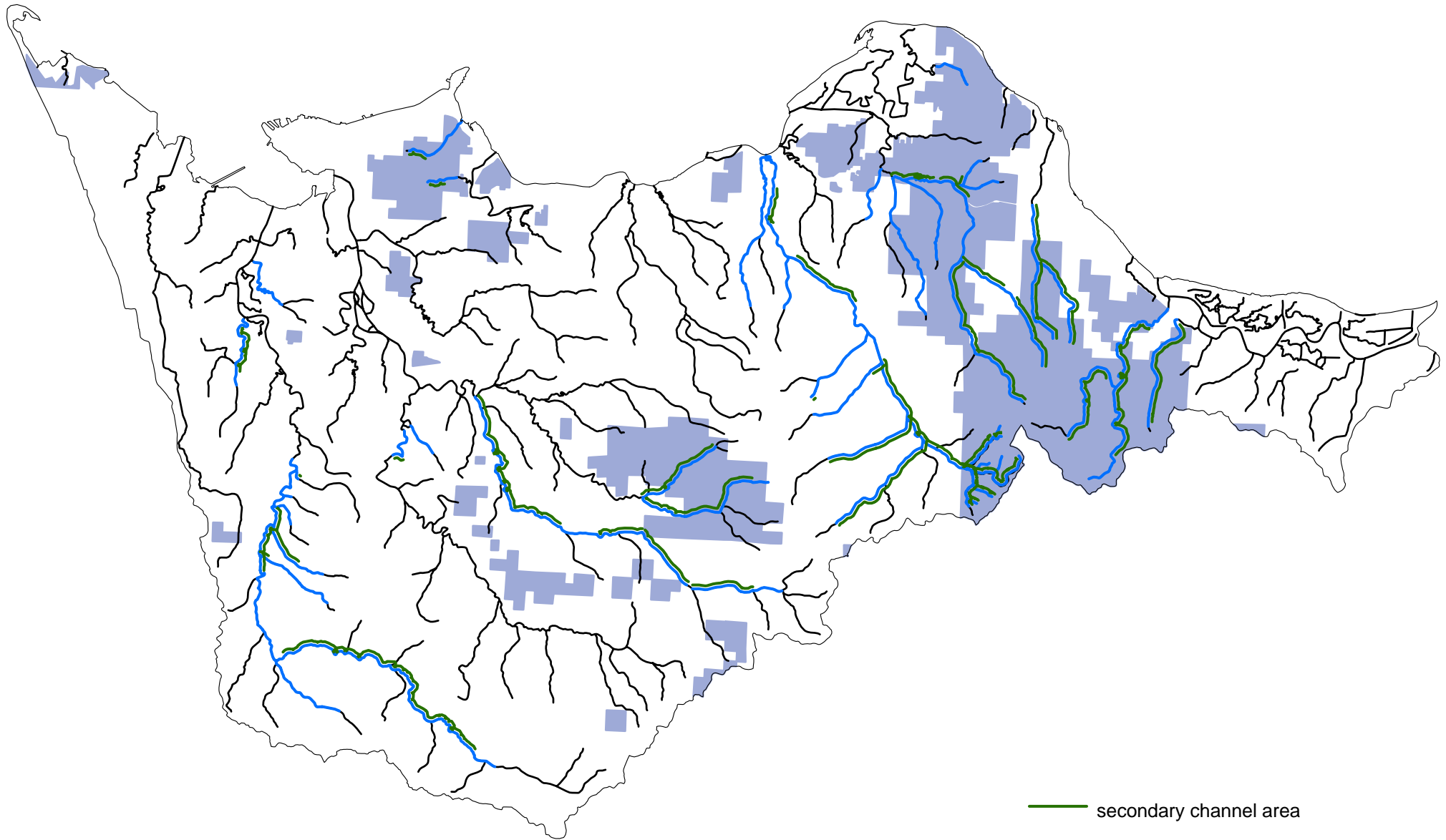
Map 11. Reaches which met or exceeded the high reference value for key habitat characteristics - percent fine and gravel substrates in riffle units and percent bedrock - in the Astoria North study area.



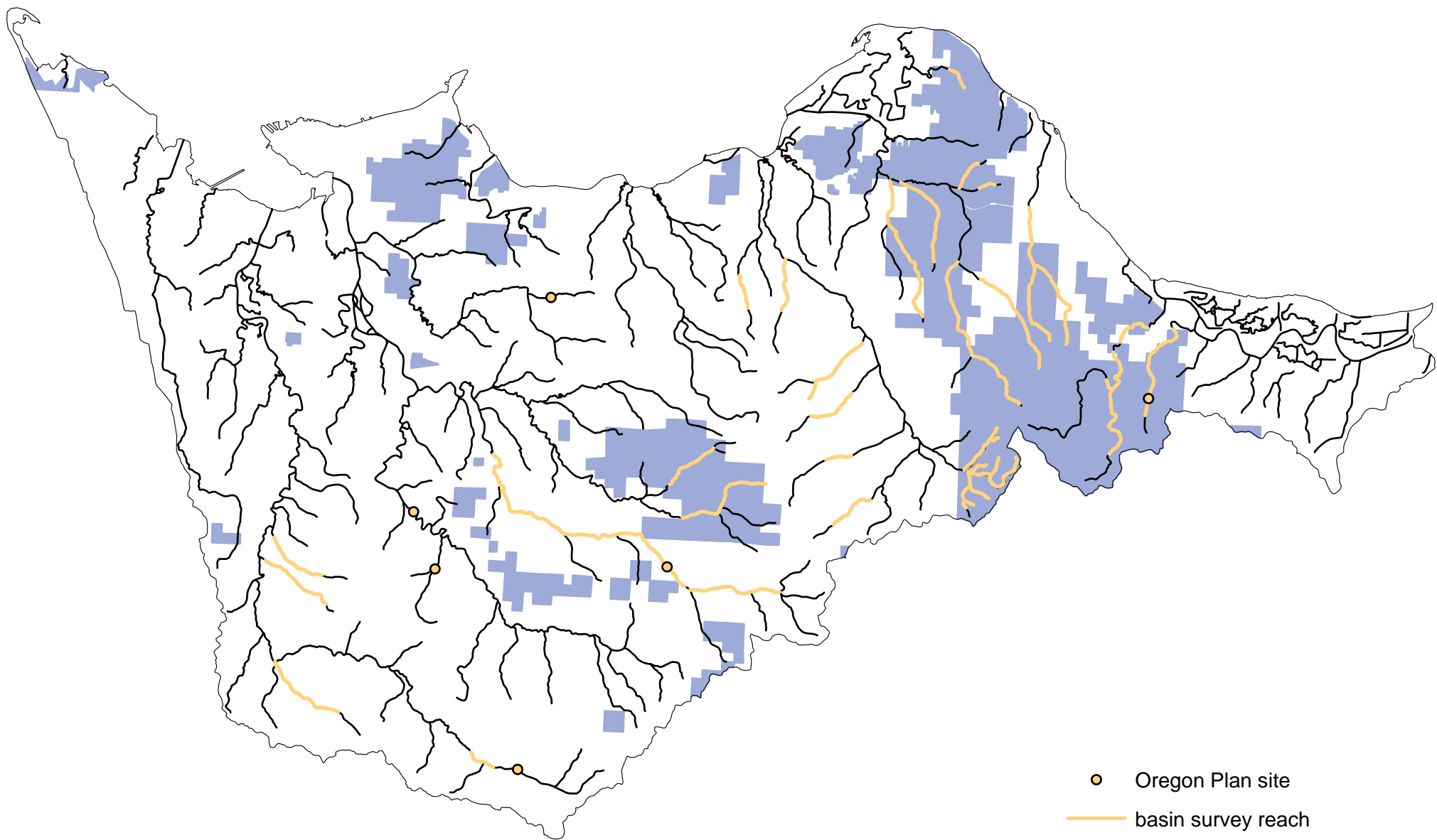
Map 12. Reaches which met or exceeded the high reference value for key habitat characteristics - percent pools, deep pools (>1m deep/km), and percent shade - in the Astoria North study area.



Map 13. Reaches which met or exceeded the high reference value for key habitat characteristics - number of pieces, volume, and key pieces of large wood - in the Astoria North study area.

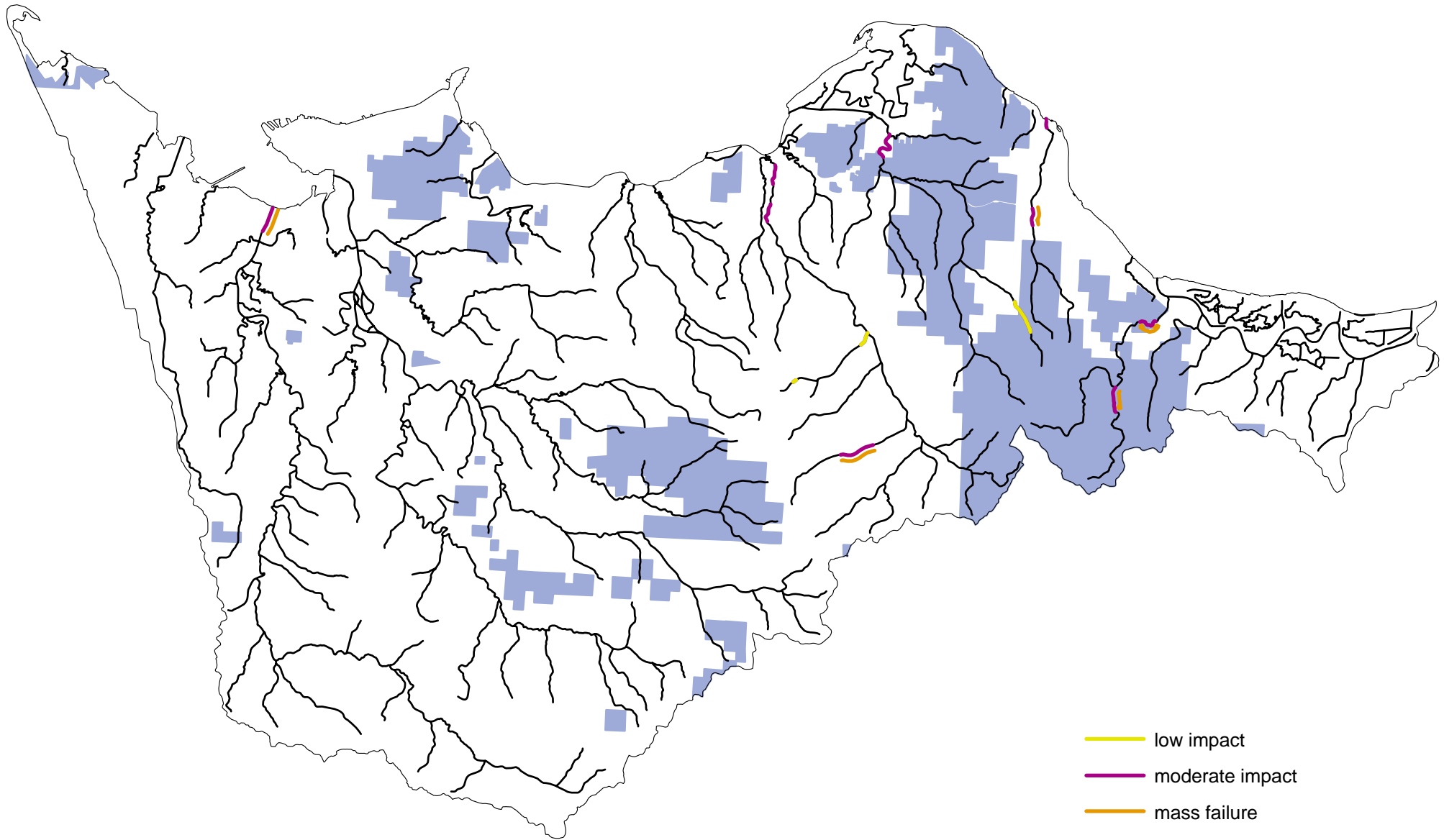


Map 14. Reaches which met or exceeded the high reference value for key habitat characteristics - percent secondary channel area - in the Astoria North study area.

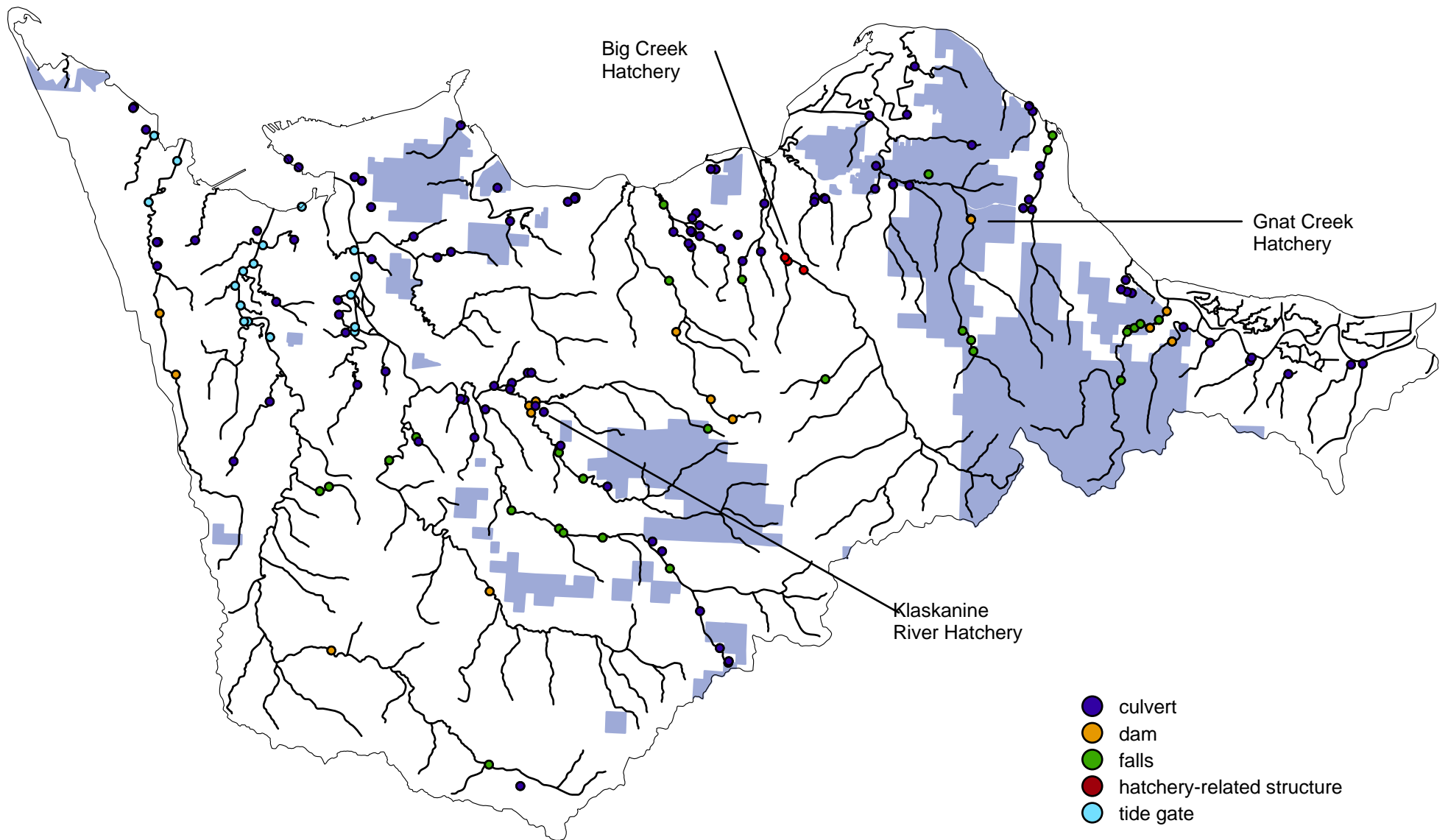


Map 15. Small streams (defined here as habitat upstream of coho distribution) survey sites in the Astoria North study area.

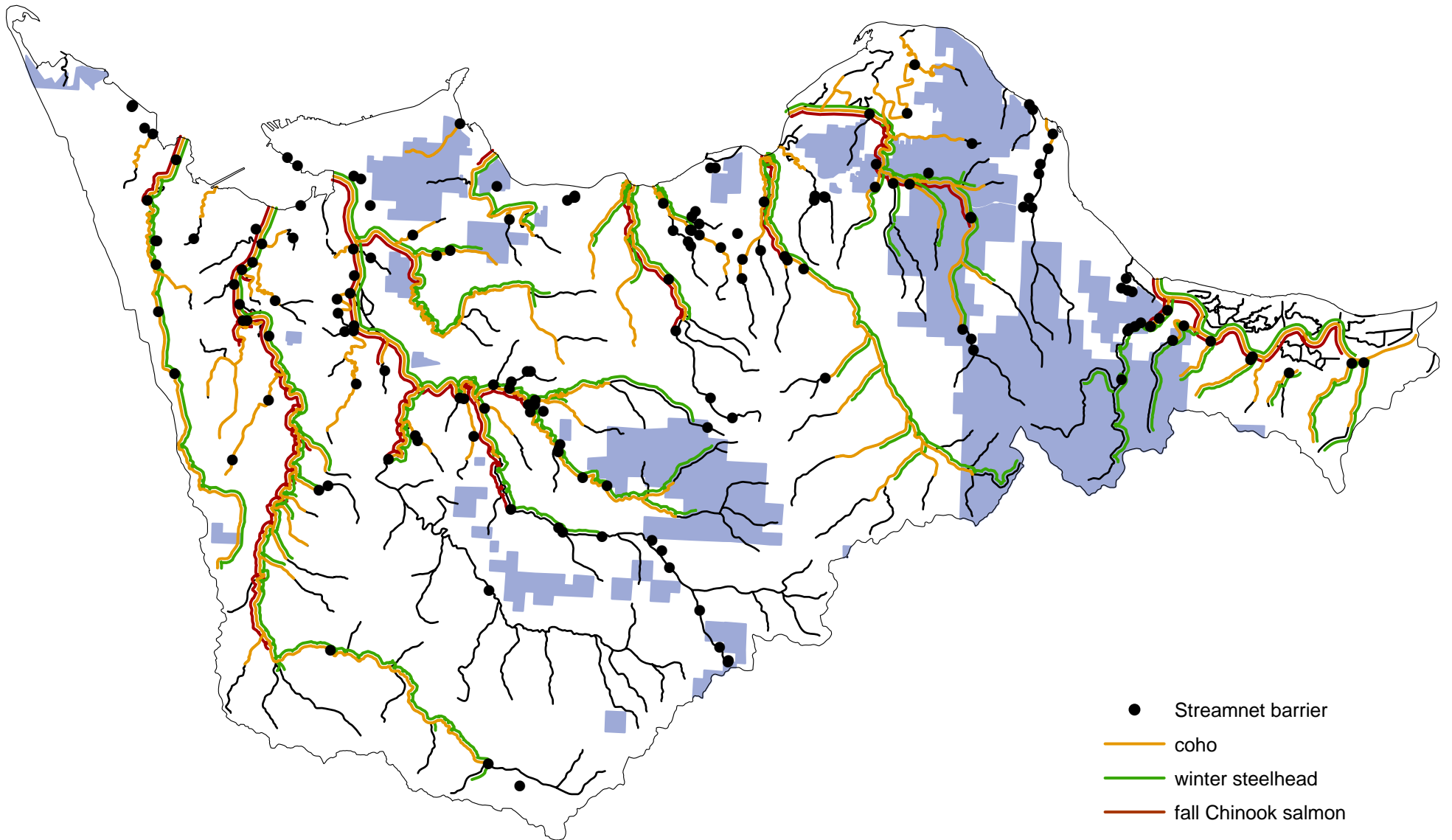




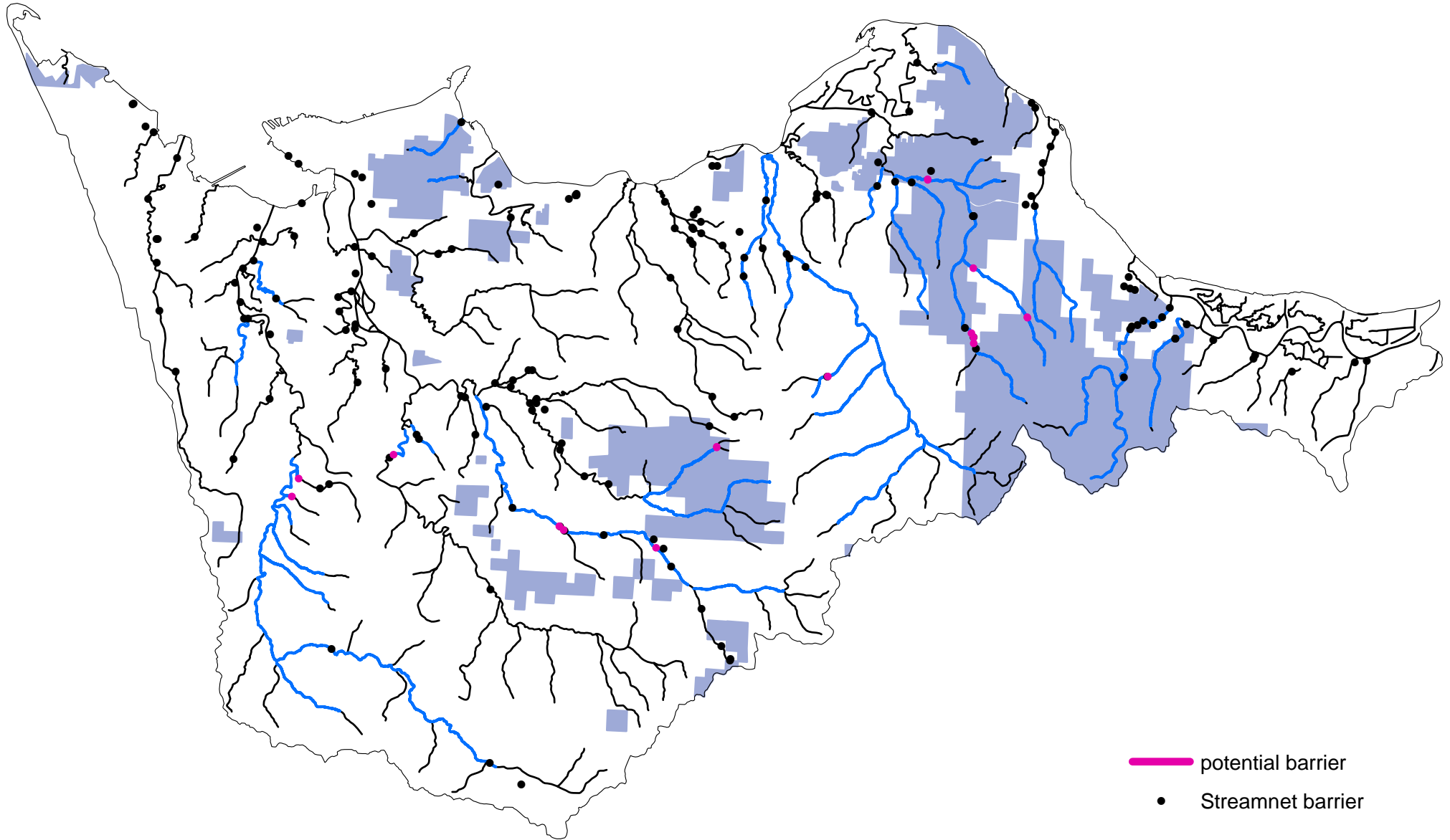
Map 16. 1996 Flood impact levels at randomly chosen survey sites in the Astoria North study area. No areas of high impact were observed at the survey sites.



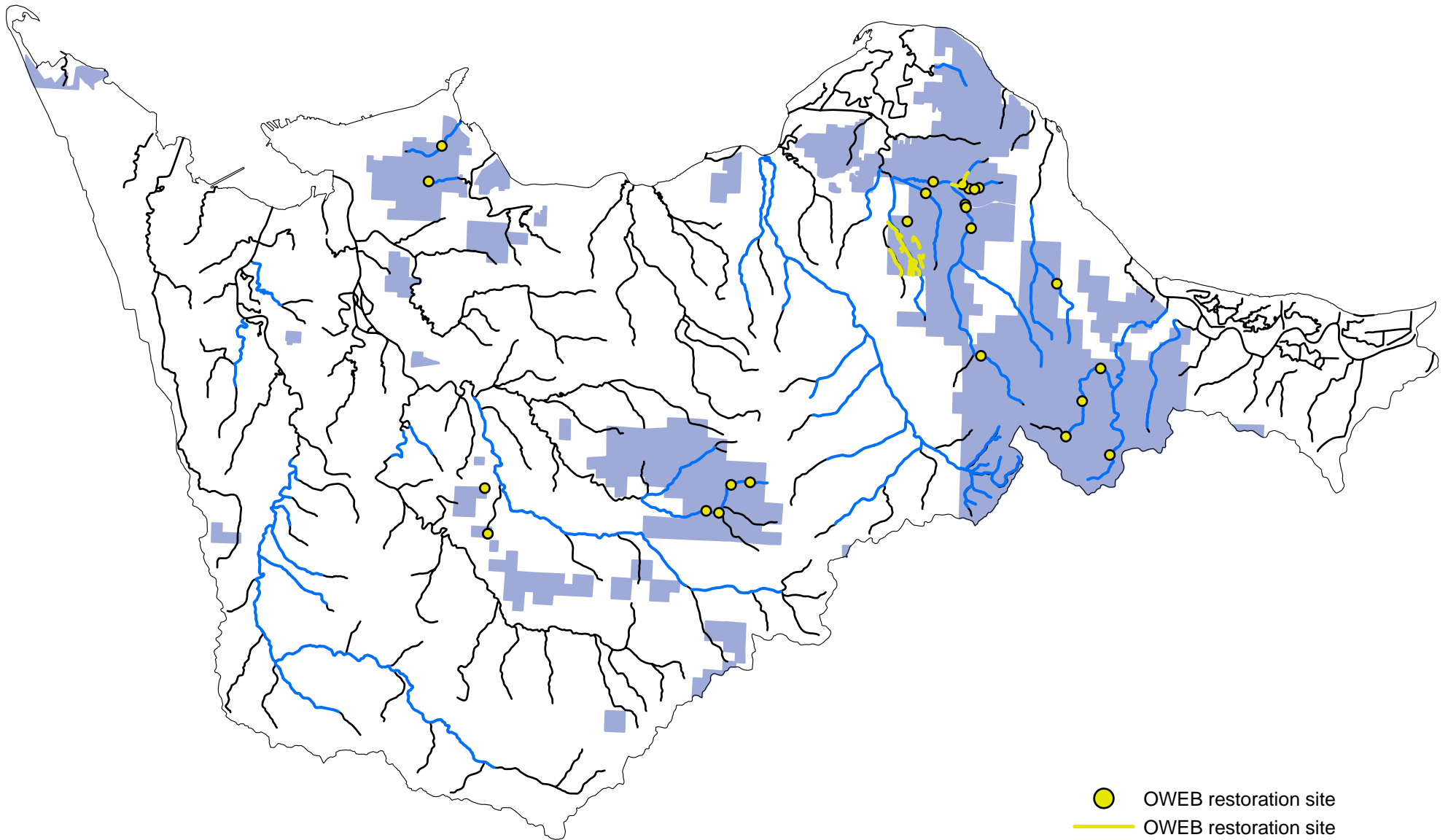
Map 17. Potential barriers to fish distribution, identified by barrier type, as identified by StreamNet in the Astoria North study area.



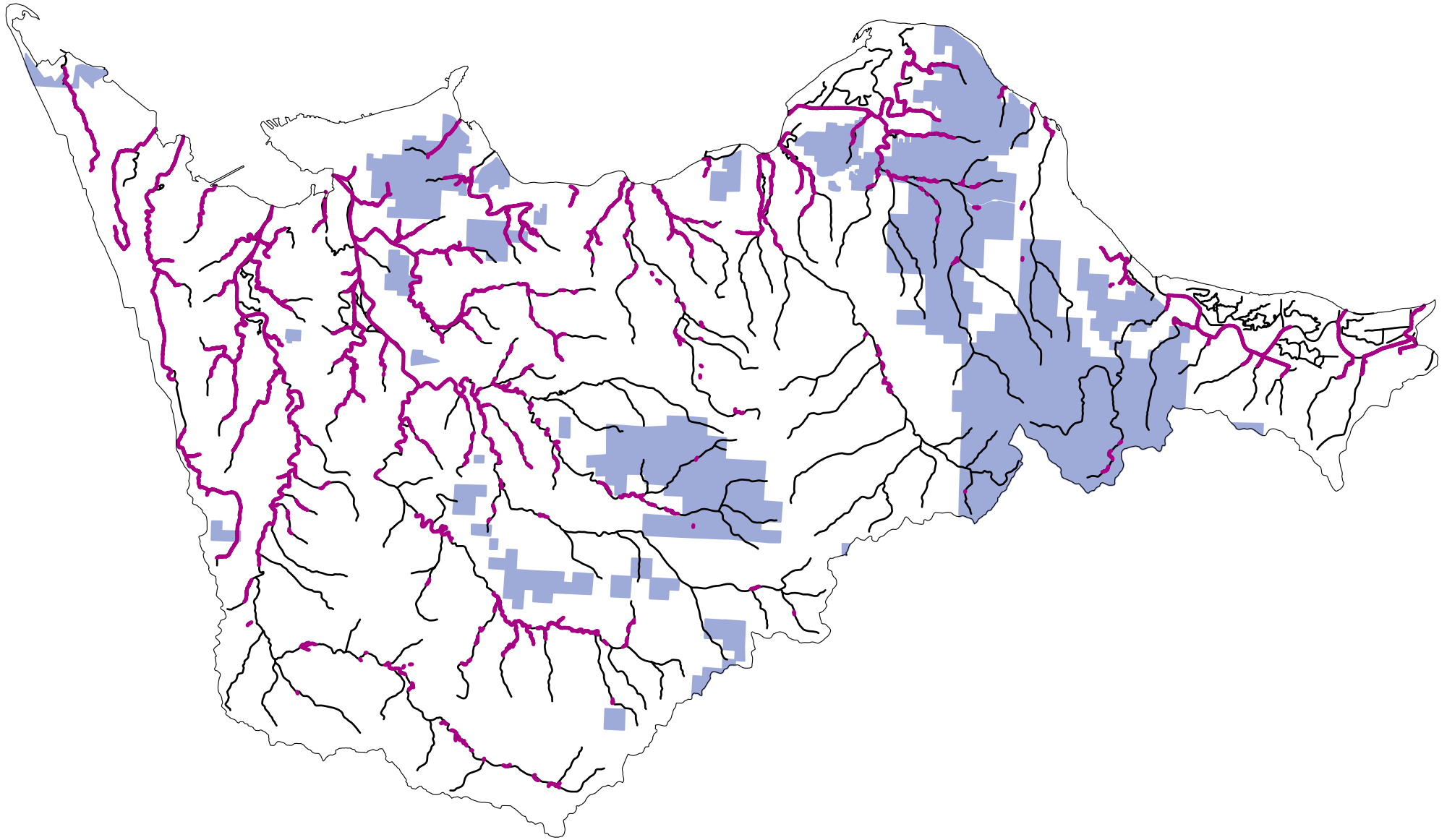
Map 18. Anadromous fish distribution and the location of potential barriers as identified by Streamnet in the Astoria North study area.



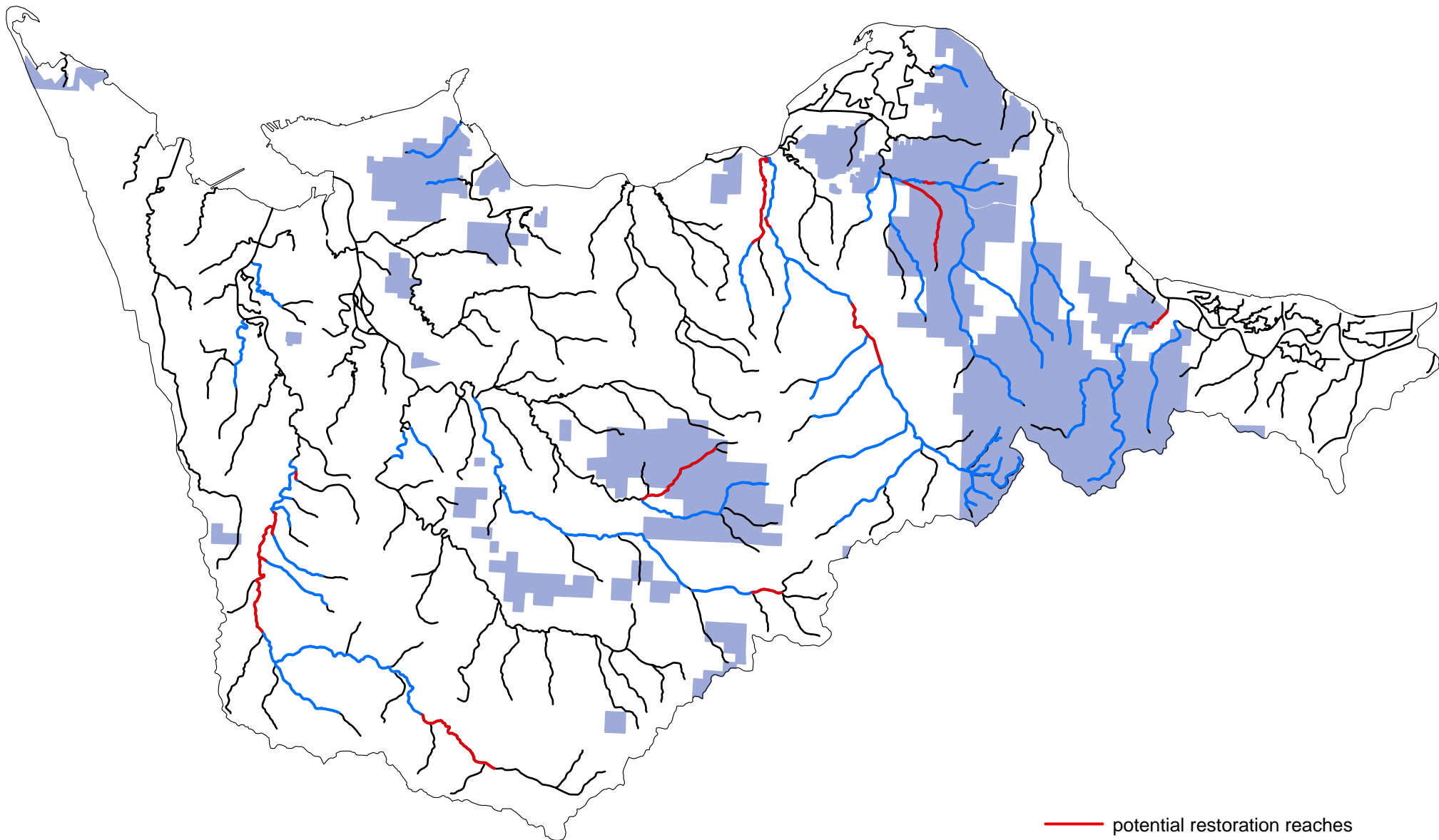
Map 19. Potential barriers to fish movement as identified by habitat crews and Streamnet in the Astoria North study area.



Map 20. Instream restoration sites funded by OWEB in the Astoria North project area.



Map 21. Intrinsic potential for coho salmon (>0.8 = high) in red in the Astoria North study area (source: CLAMS).



Map 22. Potential restoration site locations as identified by Barber, Moore, and Nicholas (1995) in the Astoria North study area.