TR-05 MARBLED MURRELET STUDY DRAFT REPORT

SKAGIT RIVER HYDROELECTRIC PROJECT FERC NO. 553

Seattle City Light

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Initial Study Report

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List of Acronyms and Abbreviations

°C ....degrees Celsius
AV..............................Audio-Visual
City Light...................Seattle City Light
cm..............................centimeter
dbh.............................diameter at breast height
DL ....Diablo Lake
DNR ....Department of Natural Resources (Washington State)
ESA............................Endangered Species Act
FERC..........................Federal Energy Regulatory Commission
FR...............................Federal Register
ft ....feet
GIS ....Geographic Information System
GL ....Gorge Lake
GPS ....Global Positioning System
ha................................hectares
ISR ....Initial Study Report
km ....kilometer
kph..............................kilometers per hour
kW..............................kilowatt
LB ....large branch
LiDAR........................Light Detection and Ranging
m ....meter
MB ....mossy branch
MHz ....megahertz
mph ....miles per hour
NAD 83......................North American Datum of 1983
NOAA........................National Oceanic and Atmospheric Administration
NPS ....National Park Service
O&M..........................operations and maintenance
Project ....Skagit River Hydroelectric Project
PSG ....Pacific Seabird Group

RL ....Ross Lake
RLNRA ....Ross Lake National Recreation Area
ROW ....right-of-way
RS-FRIS ....Remote-Sensing Forest Resource Inventory System
RSP ....Revised Study Plan
SE ....standard error
SR...............................State Route
ST ....split top
USFS ..........................U.S. Forest Service
USFWS ......................U.S. Fish and Wildlife Service
UTM...........................Universal Transverse Mercator
WDFW ....Washington Department of Fish and Wildlife

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1.0 INTRODUCTION

The TR-05 Marbled Murrelet Study is being conducted in support of the relicensing of the Skagit River Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 553, as identified in the Revised Study Plan (RSP) submitted by Seattle City Light (City Light) on April 7, 2021 (City Light 2021). On June 9, 2021, City Light filed a "Notice of Certain Agreements on Study Plans for the Skagit Relicensing" (June 9, 2021 Notice)[1] that detailed additional modifications to the RSP agreed to between City Light and supporting licensing participants (which include the Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, National Marine Fisheries Service, National Park Service [NPS], U.S. Fish and Wildlife Service [USFWS], Washington State Department of Ecology, and Washington Department of Fish and Wildlife [WDFW]). The June 9, 2021 Notice proposed no changes to the Marbled Murrelet Study as described in the RSP.

In its July 16, 2021 Study Plan Determination, FERC approved the Marbled Murrelet Study without modification.

This study is complete and a draft report of the study efforts is being filed with FERC as part of City Light's Initial Study Report (ISR).

1.1 Background and Existing Information

The marbled murrelet (*Brachyramphus marmoratus*) is a unique seabird because adults will fly considerable distances inland from the ocean during the breeding season to nest in old growth and mature coniferous forests. In Washington, marbled murrelets usually nest in older forests dominated by conifer trees that have large branches with substantial accumulations of moss, epiphytes, and/or other debris that form platforms on which a single egg is laid (Hamer and Nelson 1995). Marbled murrelets exhibit strong site fidelity to nesting areas and appear to nest in alternate years, on average (Desimone 2016).

The species was listed as threatened under the Endangered Species Act (ESA) in 1992 in Washington, Oregon, and California, primarily due to loss of old growth forest nesting habitat from commercial timber harvesting and mortality associated with net fisheries and oil spills. The USFWS designated critical habitat for the marbled murrelet in 1996 (61 Federal Register [FR] 26255). The Project Boundary does not contain any designated critical habitat for marbled murrelet. However, critical habitat is located within portions of the study area (defined in Section 3.0 of this report) adjacent to the following fish and wildlife mitigation lands: northern edge of Nooksack, southern boundary of Pressentin, southwest corner of Finney Creek, and the southern tip of Illabot South. Critical habitat is mapped near the town of Marblemount, approximately 1.6 kilometer (km; 1 mile) south of the Bacon Creek confluence with the Skagit River (Project transmission lines cross near this confluence) and the Illabot Creek fish and wildlife mitigation land (USFWS 2019). In the Sauk River Basin, critical habitat is mapped 3.1 km (2 miles) east of the transmission line ROW, where it runs along the Sauk River (between Rockport and Darrington). Critical habitat is mapped in the Stillaguamish River Basin approximately 3.1 km (2 miles) west of the transmission line ROW (north of Darrington) and approximately 1.5 km (0.9

[1] Referred to by FERC in its July 16, 2021 Study Plan Determination as the "updated RSP."

miles) north of the transmission line ROW (between Darrington and Arlington). Multiple active and historic marbled murrelet nest sites have been documented in close proximity to the Project transmission line ROW between Marblemount and Darrington, between Darrington and Arlington, and also near City Light fish and wildlife mitigation lands southwest of Rockport, Washington (WDFW 2021). A historic occupied murrelet site on Clear Creek 1.6 km (1 miles) south of Darrington in the Sauk watershed is also in the vicinity (6.4 km [4 miles]) of the Project transmission line ROW (Reed 2021).

The distance inland that marbled murrelets breed is variable and is influenced by several factors, including the availability of suitable habitat, climate, topography, predation rates, and maximum forage range (McShane et al. 2004). In Washington, the primary nesting range extends 64 km (40 miles) inland, but occupied nesting habitat has been documented 84 km (52 miles) from the coast (Hamer et al. 1995; Madsen et al. 1999), and the species has been detected flying up to 113 km (70 miles) inland (Huff et al. 2006). Nesting in Washington occurs over an extended period from late April through late August (McShane et al. 2004). In 2008, radar surveys recorded detections of possible marbled murrelets flying along the Skagit River near the mouths of Bacon and Thornton creeks (Hamer Environmental 2010). Thornton Creek is approximately 3 km (2 miles) from the Gorge Powerhouse. Eleven of the possible murrelet detections were very close to the Bacon Creek mitigation lands, but all were high-speed flights indicative of birds passing through as opposed to flights near nest sites. Follow-up audio-visual (AV) surveys in 2009 detected murrelets 2.4 km (1.5 miles) up the Thornton Creek drainage but failed to detect any on the Bacon Creek drainage (Hamer Environmental 2010).

No surveys (radar, AV, or acoustic) for marbled murrelets have been conducted on Gorge, Diablo, or Ross lakes. NPS records show a few incidental sightings of this species in the Ross Lake National Recreation Area (RLNRA). In May 2017, a senior NPS wildlife biologist observed a pair of marbled murrelets on Ross Lake near Roland Point 4.7 km (2.9 miles) northeast of Ross Dam and 109 km (68 miles) from the coast (Ransom 2019). Marbled murrelets typically forage in the marine environment but have been documented foraging on inland freshwater lakes in Alaska, British Columbia, Washington, and Oregon, although most documented occurrences are in lakes near coastal waters. For example, in Washington there have been sightings on Lake Washington near Seattle and Lake Quinault on the Olympic Peninsula. In British Columbia, most freshwater lakes used by murrelets were within 19 km (12 miles) of the coast but use occasionally extends to inland lakes up to 74 km (46 miles) from the coast (Carter and Sealy 1986).

1.1.1 Radar and Audio-Visual Surveys for Marbled Murrelets

In the first radar study of marbled murrelets in northern California, Hamer et al. (1995) determined that radar was a useful tool to detect and monitor marbled murrelets at inland nesting sites. Radar surveys supply information on the murrelets' flight path and flight behavior, flight direction to the nearest degree, number of birds, and the distance from the radar to the bird to the nearest meter (m) (Hamer et al. 1995; Cooper and Hamer 2003). This information is crucial in determining where birds are headed, which forest stands are likely being used, and the relative abundance of birds in the area. Radar surveys reliably sample a much larger area (up to a 1.5-km [0.9-mile] radius) than AV surveyors (less than 200-m [656-ft] radius for visual detections) (Hamer et al. 1995). If marbled murrelets are detected by radar, AV surveys would still be necessary to determine if a particular stand is 'occupied' by nesting murrelets (Cooper and Hamer 2003).

2.0 STUDY GOALS AND OBJECTIVES

The goals of the study are to map potentially suitable marbled murrelet nesting habitat within the study area and to assess the likelihood of marbled murrelet nesting. Although a previous survey documented murrelet flights at several sites between Newhalem and Marblemount, no surveys have been conducted within the Project Boundary to determine if the species occurs this far inland from their marine habitat. The observation of a pair of murrelets in 2017 on Ross Lake near Roland Point, 4.7 km (2.9 miles) northeast of the Ross Dam, suggests that murrelets may use that area, at least on occasion.

The objectives of the study are to:

- Develop a map of potentially suitable nesting habitat within the study area using existing vegetation mapping data from NPS, data developed for the TR-01 Vegetation Mapping Study, and criteria identified in the scientific literature to determine areas of potentially suitable murrelet nesting habitat.
- Use the map to select appropriate locations for radar-based surveys to document murrelet flight activity upriver of Thornton Creek and along Project reservoirs, focusing on areas near Project facilities and existing and likely future maintenance and construction noise sources.
- Conduct limited habitat assessments to verify the accuracy of the mapping of potentially suitable marbled murrelet nesting habitat.
- Conduct peak nesting season (May-July) simultaneous radar and AV surveys at selected sites to assess the likelihood of presence of marbled murrelets. If present, determine the relative abundance of these birds at each survey site in the Project Boundary.

3.0 STUDY AREA

The study area for the Marbled Murrelet Habitat Analysis is 57,500 hectares (ha; 142,088 acres). The study area includes lands within the Project Boundary as well as the surrounding area within 0.8 km (0.5 mile) of the Project Boundary, as shown in Figure 3.0-1. To organize the results of the habitat suitability modeling effort only (not radar and audiovisual study components), the study area was divided into the following six segments, as described below, and shown in Figure 3.0-1:

- **Ross Lake National Recreation Area (RLNRA):** This study area segment occurs within the upper Skagit River basin and includes all lands of the Project Boundary within the RLNRA, including the transmission line right-of-way (ROW), to the confluence of Bacon Creek with the Skagit River. For reporting purposes, this segment is further divided into the following five sub-segments:
  - Ross Lake exclusive of Big Beaver Valley;
  - Big Beaver Valley;
  - Diablo Lake, including the approximately 5.8 km (3.6 miles) of the transmission line ROW from the Ross Powerhouse to the Diablo Powerhouse;
  - Gorge Lake, including the approximately 5.6 km (3.5 miles) of the transmission line ROW from the Diablo Powerhouse to the southern end of Gorge Lake; and
  - An approximately 13.7-km (8.5-mile) corridor between Gorge Lake and Bacon Creek that includes the transmission line ROW and the Skagit River.
- **Transmission Line ROW Segments**:
  - **Bacon Creek to Sauk River Crossing:** This study area segment occurs primarily within the upper Skagit River basin and includes the 23.0 km (14.3 miles) of transmission line ROW from Bacon Creek to the Sauk River crossing. The lower approximately 4.0 km (2.5 miles) of this study segment occurs within the Sauk River basin.
  - **Sauk River Crossing to Oso:** This study area segment includes the 41.2 km (25.6 miles) of transmission line ROW from the Sauk River transmission line crossing to the community of Oso. The eastern part of this study area segment is located in the Sauk River basin from the Sauk River crossing to near Darrington. The western portion of this segment, from Darrington to Oso, is located in the North Fork Stillaguamish River basin.
  - **Oso to State Route (SR) 528:** This study area segment includes the 28.2 km (17.5 miles) of transmission line ROW from Oso to SR 528. The northern portion of this segment is located within the Stillaguamish River basin, and the southern portion of this segment is located within the Snohomish River basin.
  - **SR 528 to Bothell Substation:** This study area segment is located primarily within the Snohomish River basin and includes the 23.2 km (14.4 miles) of transmission line ROW from SR 528 to the Bothell Substation. The lower approximately 2.4 km (1.5 miles) of this segment is in the Lake Washington basin.

- **Western Mitigation Lands:** This study area segment includes all fish and wildlife mitigation lands within the study area not already captured in transmission line ROW segments as represented in Figure 3.0-1.

The radar and AV survey components of this Marbled Murrelet Study focused on a more refined portion of the study area where potential effects from Project operations and recreation activities may occur. All radar and AV survey sites were located within the RLNRA-portion of the study area from Newhalem to northern Ross Lake (see Section 4.3 of this study report).

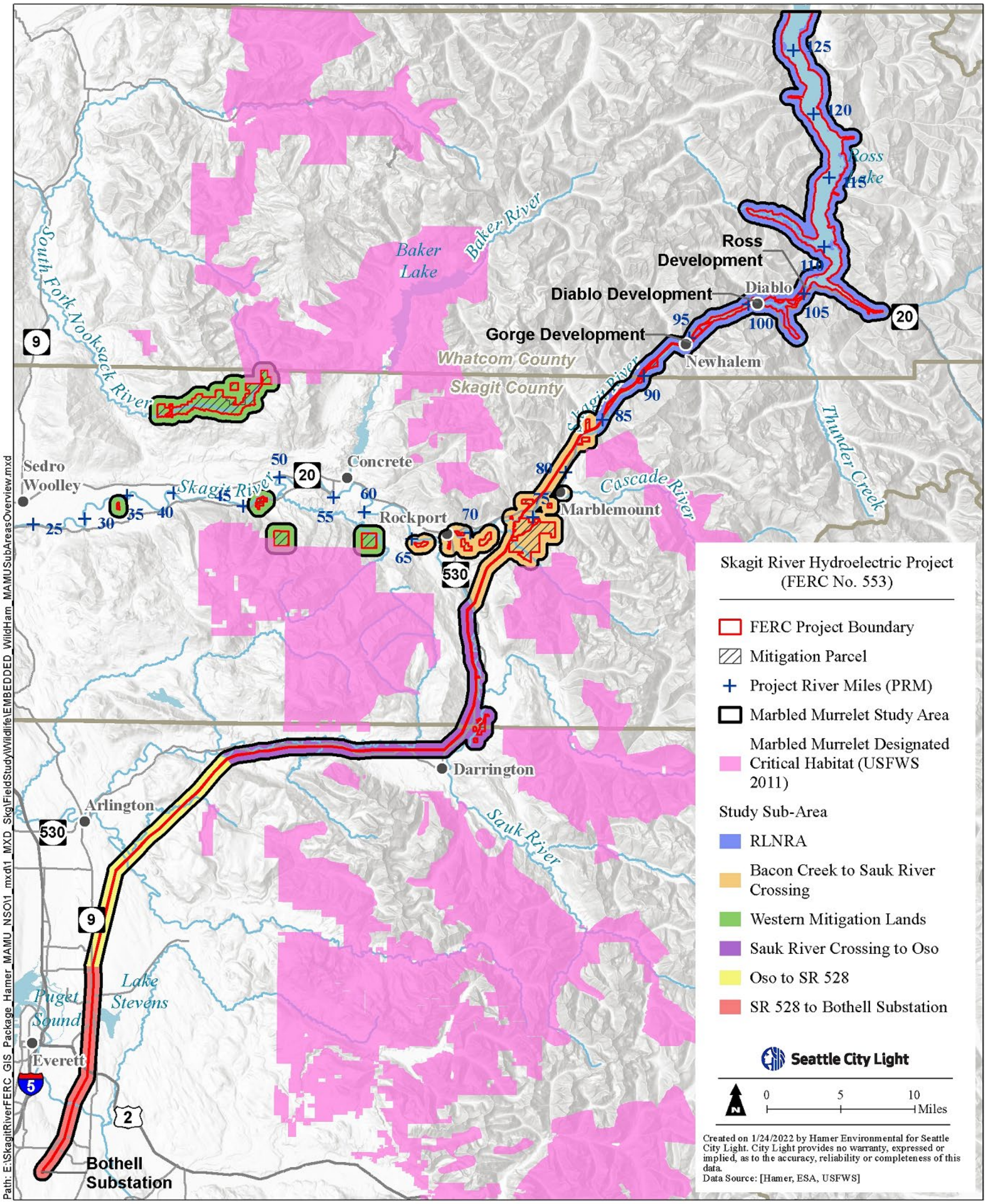

Figure 3.0-1. Study area segments for marbled murrelet nesting habitat analysis.

4.0 METHODS

4.1 Map Potentially Suitable Marbled Murrelet Nesting Habitat

In Washington State, marbled murrelet nesting habitat is generally defined as coniferous forest containing suitable nesting platforms within 113 km (70 miles) of marine waters (Desimone 2016). Any forested area with one observed nest platform is capable of supporting a murrelet nest (USFWS 2012). Marbled murrelet nesting habitat components are described below.

Nest Platforms

The first and most important structural component of suitable marbled murrelet habitat is the presence of potential nesting platforms (USFWS 2012). Platforms can be created by a wide bare branch, moss or lichen covering a branch, dwarf mistletoe, witches'-brooms, other deformities, or other structures (Evans Mack et al. 2003). In general, old growth, mature, or younger coniferous forests with appropriate structures can provide these platforms. The USFWS defines a suitable nesting platform as a relatively horizontal surface at least 10 centimeters (cm; 4 inches) in diameter and located a minimum of 10 m (33 ft) high in the live crown of a coniferous tree.

Cover

Another important attribute of nesting habitat is vertical and horizontal cover around potential nest platforms to protect both the chick and adults from predation while also allowing adults access to nest platforms (USFWS 2012). USFWS has not provided specific measurements or criteria to characterize the amount of cover at potential nest platforms or on trees with platforms, other than the requirement that a suitable nesting platform needs to be within the live crown of a coniferous tree (USFWS 2012). A study of murrelet nest site selection in Washington and Oregon by Hamer et al. (2021) found a higher proportion of horizontal cover at 46 murrelet nest platforms (mean horizontal cover category of 2, representing 34 to 66 percent cover), versus that of 4,470 non-nest platforms (mean cover category of 1.3). The study findings indicate a higher proportion of horizontal cover over a nest platform is important for murrelet nest site selection. Manley (1999) found a similar preference for platforms with higher proportions of overhead cover by nesting murrelets on the Sunshine Coast of British Columbia.

Tree Size

Other characteristics of murrelet nest trees are tree diameter and height, which have been positively correlated with platform size and abundance, though this relationship may vary depending on the tree species and forest type murrelets use for nesting (Burger et al. 2010). Hamer and Nelson (1995) found a mean tree diameter at breast height (dbh) of 212 cm (83 in) in 47 murrelet nest trees sampled in the Pacific Northwest. In western Washington, Hamer and Meekins (1999) found a mean tree dbh of 110 cm (43 in) in 22 nest trees. The USFWS (2012) notes that tree dbh and height should not be used to limit consideration as suitable habitat if adequate structures for nesting murrelets are present. Murrelets have occupied small patches of habitat within larger areas of unsuitable habitat and some occupied sites have included large, residual trees in low densities; over 20 percent of occupied sites in Oregon were less than 80 years old (USFWS 2012).

4.1.1 Potentially Suitable Marbled Murrelet Nesting Habitat Model

The Potentially Suitable Marbled Murrelet Nesting Habitat Model (Murrelet Habitat Model) developed for this study was informed by a review of NPS's mapping of vegetation associations within the North Cascades National Park, the results of the TR-01 Vegetation Mapping Study, and a literature review conducted during development of the RSP (City Light 2021, 2022). The vegetation cover type data layer from the TR-01 Vegetation Mapping Study and an existing NPS National Vegetation Classification Standards vegetation cover type data layer were combined during the TR-01 Vegetation Mapping Study and used for this modeling effort to determine areas with presence of conifers. This vegetation cover type data layer did not contain forest stand age information to allow for the explicit selection of old growth forests. Instead, a definition query was used to select vegetation types that contain conifers from the TR-01 Vegetation Mapping Study and NPS data.

The Murrelet Habitat Model was designed to be conservative and to capture all potentially suitable habitat within the study area with a binary site suitability analysis comprised of three variables described below:

Stand Age

Stand age is a key indicator of marbled murrelet habitat. There is a positive correlation between stand age and the presence of potential nesting platforms; the older a coniferous tree becomes, the more likely it is to have suitable nesting platforms for marbled murrelets. Nest sites typically occur in mature and old growth coniferous forests but are also found in younger forests containing suitable nesting platforms. Hamer and Nelson (1995) found a mean age of 522 years (range of 180-1,824 years) for 16 nest trees in the Pacific Northwest. Burger (2002) in a study of the Sunshine Coast of British Columbia found that murrelet nest trees were at least 150 years old. The Washington Department of Natural Resources (DNR) uses 70 years as a minimum stand age threshold when assessing for the potential presence of marbled murrelet habitat on State-owned lands. For the purposes of this Murrelet Habitat Model a more conservative minimum stand age of 60 years was used to reduce the chance of excluding potentially suitable habitat. This stand age threshold was also recently employed by Hamer Environmental in 2021 on another large transmission line project in Western Washington with approval from USFWS. A 2017 Washington DNR Remote-Sensing Forest Resource Inventory System (RS-FRIS) Geographic Information System (GIS) raster data layer of origin year (which contains stand age) with a 20 m^2 (66 ft^2) resolution was used to model stand age across the study area (Washington DNR 2021).

Presence of Conifers

The second Murrelet Habitat Model variable is presence of conifers. The USFWS (2012) considers only coniferous trees to be suitable for marbled murrelet nesting, although marbled murrelets have been documented nesting in deciduous trees on rare occasions. The TR-01 Vegetation Mapping Study vegetation cover type vector data were used in the Murrelet Habitat Model to isolate forested areas containing conifers as a threshold for consideration as marbled murrelet habitat (City Light 2022).

Canopy Height

The final Murrelet Habitat Model variable is canopy height. The available literature indicates a strong positive correlation between stand height and number of suitable nesting platforms for marbled murrelets (Hamer and Nelson 1995; Hamer and Meekins 1999; McShane et al. 2004). However, the literature does not describe specific tree height cutoffs for nesting habitat. Existing marbled murrelet nest tree data are primarily from old growth forests, where trees are typically tall, as found by Hamer and Nelson (1995), with a mean canopy height of 64 m (210 ft) and range of 30-86 m (98-282 ft) in 20 nest stands in the Pacific Northwest. Using those data to build the Murrelet Habitat Model would bias the model toward taller canopy heights and could eliminate some potentially suitable habitat in the study area from consideration. With this in mind, a minimum 26 m (85 ft) canopy height threshold was used to capture younger stands where suitable nesting platforms may occur. A 2017 Washington DNR RS-FRIS GIS raster data layer of maximum tree height, with a 20 m^2 (66 ft^2) resolution, was used to model canopy height throughout the study area (Washington DNR 2021).

To map potentially suitable marbled murrelet nesting habitat within the study area, a binary site suitability analysis was performed using Washington DNR canopy height and stand age data raster layers at 20 m^2 (66 ft^2) resolution. All raster data layers were created by Washington DNR from remotely sensed (Light Detection and Ranging [LiDAR] and Photogrammetric Detection and Ranging) data. A vector data layer of vegetation cover type from the TR-01 Vegetation Mapping Study was integrated to further distinguish areas of potential habitat based on the presence of conifers (City Light 2022). A sample of each data layer is shown in Figure 4.1-1. Given the habitat requirements for marbled murrelet nesting, the suitability analysis allowed the canopy height and stand age data layers to be analyzed simultaneously, with a second step of the model to apply the vegetation cover type vector layer to select for stands with presence of conifers. This created a Murrelet Habitat Model that selected areas where thresholds for all variables were met. The Murrelet Habitat Model indicates areas where: (1) maximum tree canopy height is 26 m (85 ft) or higher; (2) stand age is 60 years or more; and (3) vegetation cover type includes conifers (Figure 4.1-1).

The goal of this Murrelet Habitat Model approach is to identify all forested areas that are potentially suitable nesting habitat for marbled murrelet, and not to attempt to delineate where marbled murrelet nesting occurs. To briefly assess habitat connectivity to lands outside of the study area, the Washington DNR stand age data layer was reviewed for presence of older forest stands adjacent to study area lands with modeled suitable habitat. Those areas where forest stands were 60 years and older were then generally described in relation to modeled habitat in the study area.

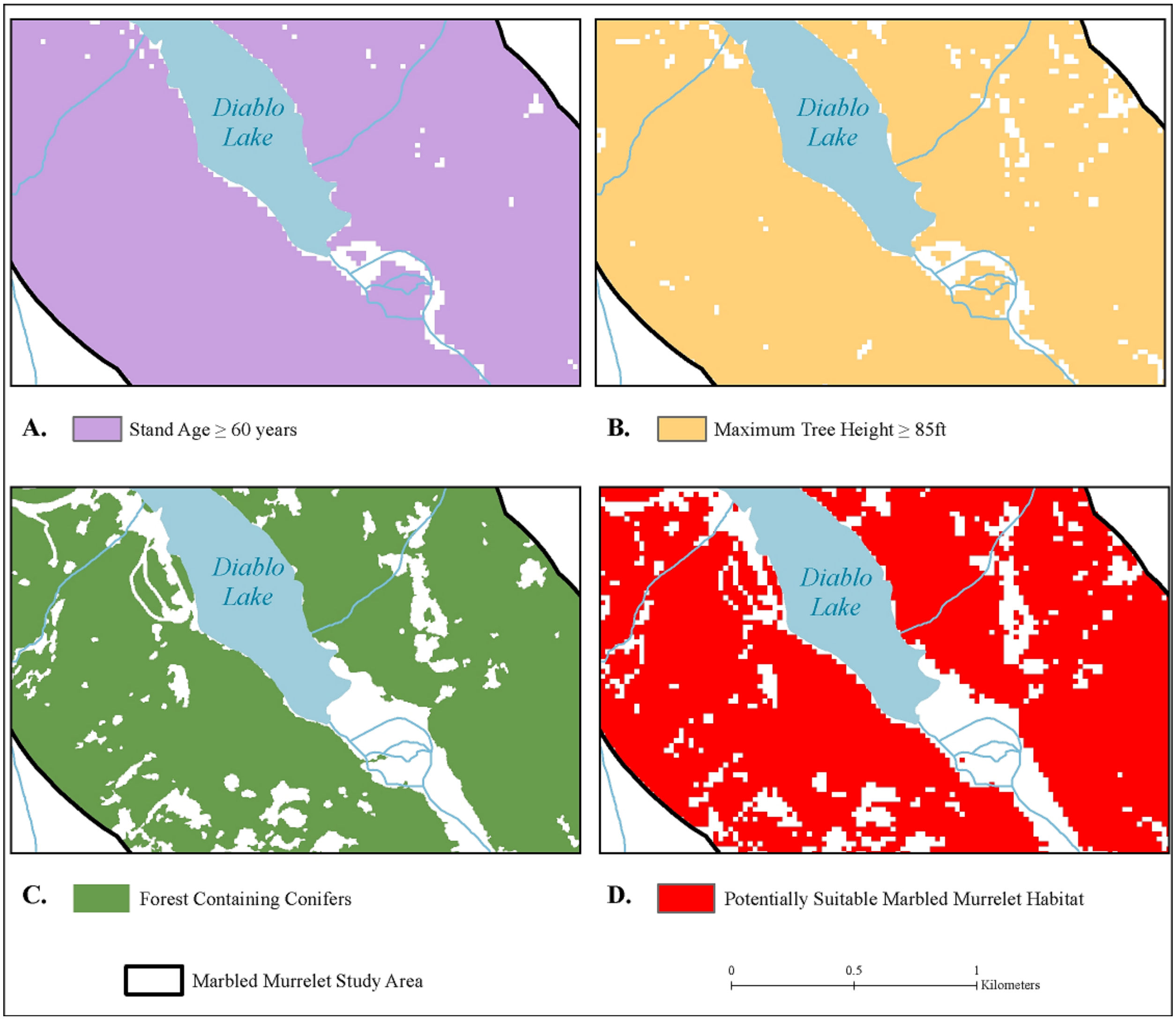

Figure 4.1-1. Murrelet Habitat Model input components (A-C) and model output sample (D) showing potentially suitable marbled murrelet nesting habitat.

4.2 Limited Field Habitat Assessment Surveys to Verify Accuracy of Model

The study team conducted limited field habitat assessments[2] to (1) verify the results of the Murrelet Habitat Model and (2) verify the accuracy of the mapping of suitable marbled murrelet nesting habitat in areas surveyed by radar. The field habitat assessment was conducted concurrently with the radar surveys and prior to the Murrelet Habitat Model analysis. Habitat plots were located in forest stands near Newhalem and near or within the Project Boundary of Gorge, Diablo and Ross lakes. In each of ten stands, a 25-m (82-ft) radius habitat plot was assessed to collect information on potential nest platform abundance (see USFWS platform criteria in Section 4.1). A platform

[2] The TR-01 Vegetation Mapping Study conducted field verification plots that were reviewed by the study team for use in the verification of the Murrelet Habitat Model. The dbh measures at those plots were of codominant trees and were binned and not collected for residual older trees likeliest to contain suitable nesting platforms. As explained above, the study team could not use the TR-01 Vegetation Mapping Study as anticipated, and, for that reason, the team conducted field verification plots as part of this study consistent with Section 2.6.2 of the RSP.

was at least 10 cm (4 in) in diameter and 10 m (33 ft) or higher in the live crown of a conifer tree to be quantified as a suitable nest platform. In each plot, information was also collected on average percent moss cover on tree limbs (5 percent increments), average moss depth on tree limbs (none, marginal, thick), presence of dwarf mistletoe, tree species, tree diameters, potential nest platforms, number of tree canopy layers (1-5), and flight access of murrelets.

The study team used a rangefinder and binoculars to identify suitable platforms, dbh tape to measure tree diameters, and a Garmin GPSMAP 65st Global Positioning System (GPS) unit to record habitat assessment plot locations. The study team also traveled by boat, vehicle, or on foot along the shorelines of Gorge Lake, Diablo Lake, and Ross Lake, scanning trees along the shoreline with binoculars to qualitatively note the presence or lack of potentially suitable nest structures and habitat within the Project Boundary. This qualitative effort was limited to areas accessible by boat, vehicle, or foot, and was particularly limited along Gorge Lake, to areas of the shoreline that were viewable from SR 20.

4.3 Radar and Audio-Visual Surveys

4.3.1 Radar Site Selection

Radar survey locations were intended to document murrelet flight activity upriver of Goodell Creek and along Project reservoirs, focusing on areas near Project facilities and at sites where current and likely future maintenance, construction, or recreation activities may result in noise disturbance. Radar survey locations were chosen using four criteria: (1) within the Project Boundary where operations and maintenance (O&M) activities may have the highest likelihood of impacting nesting marbled murrelets, if present; (2) presence of suitable marbled murrelet nesting habitat; (3) presence of a major river valley or reservoir that could be used as potential flight corridors; and (4) suitability to detect birds using ornithological radar.

Per the criteria above, the radar study included horizontal (surveillance) radar sampling at nine sites: five water-based sites with a radar lab mounted on a boat and four land-based sites with the boat trailered as a radar lab. Sites denoted with an asterisk (*) represent radar sites that were changed modestly from the preliminary proposed site locations presented in the RSP; these radar site locations were further refined in the field prior to the first survey based on site access, safety issues, and suitability in detecting birds (Figure 4.3-1):

- Ross Lake (water-based sites)
  - Little Beaver Creek* (northernmost point – near Canada border)
  - Roland Point
  - Resort (above Ross Dam)
- Diablo Lake (water-based [two], and land-based [one])
  - Thunder Arm*
  - Midway*
  - Sand Spit* (land-based, near Environmental Learning Center)

- Gorge Lake (land-based)
  - Bridge
  - West End
- Newhalem (land-based)

Radar sites were tested and adjusted, if needed, prior to the first survey to ensure proper radar coverage and limit ground clutter as described in the RSP at Section 2.6.3.3. At all boat-based sites, the radar lab was positioned (i.e., boat location) and the radar tested the day prior to conducting the first survey; at two boat-based sites (Ross Lake Resort and Ross Lake Roland), the locations changed between some survey visits due to weather conditions and reservoir water level fluctuations (Attachment A).

4.3.2 Radar and Audio-Visual Survey Methods

AV surveys (Section 4.3.2.5 of this study report) were conducted concurrent with radar surveys in the immediate vicinity of the radar lab. The concurrent AV surveys provided: (1) real-time calibration of "targets" observed by the radar technician; (2) assessment of the relative abundance of potentially confounding species; and (3) the means to filter out non-murrelet radar targets from the radar's database to improve analysis. The term "target" used here describes "bird-like moving echoes" detected by radar because the species composition of birds cannot be confirmed by radar alone. The term "echo" refers to an individual point of a bird, insect, or bat as detected during a single sweep of the radar, with a series of echoes comprising a flight track of a target.

Murrelets are primarily identified on radar by their flight speed, which tends to be greater than most other species (Hamer et al. 1995). There are individual sites, however, that can have problematic species present, like band-tailed pigeons, gulls, or waterfowl such as common merganser and Canada goose that can fly at speeds similar to those of murrelets (Cooper and Blaha 2002). Therefore, concurrent AV observations (near the radar lab) can be made to assess the relative abundance of potentially confounding species and to help filter out non-murrelets from the radar database (Hamer et al. 1995; Cooper et al. 2001; Burger 2001).

Radar surveys followed established marbled murrelet survey protocols for horizontal radar surveys (Cooper and Hamer 2003; Evans Mack et al. 2003). Simultaneous radar and AV surveys were completed during the morning murrelet activity period—this period is strongly tied to sunrise and light levels, which changed throughout the breeding season. To determine survey start times throughout the study, "sunrise" was based on the National Oceanic and Atmospheric Administration (NOAA) Sunrise/Sunset tables for Newhalem, Washington.

Surveys began 105 minutes before sunrise and ended 75 minutes after sunrise for a total of 3 hours of sampling each day to capture the known peak of daily murrelet activity. The AV surveyor was positioned outside of the radar lab at a distance sufficient to have no auditory impact from the radar RV generator to attempt to visually and auditorily verify the identification of radar targets. Real-time verification was done via hand-held radio communications between surveyors during each survey.

Five radar and AV surveys were completed at each of the nine sites for a total of 45 radar/AV surveys. Surveys were conducted in May 2021 (Visit 1), June 2021 (Visits 2 and 3), and July 2021 (Visits 4 and 5) to coincide with the peak breeding period of marbled murrelets. The higher sampling intensity in June and July corresponds to a greater probability of detecting marbled murrelets during incubation and chick rearing periods, when activity rates are most pronounced.

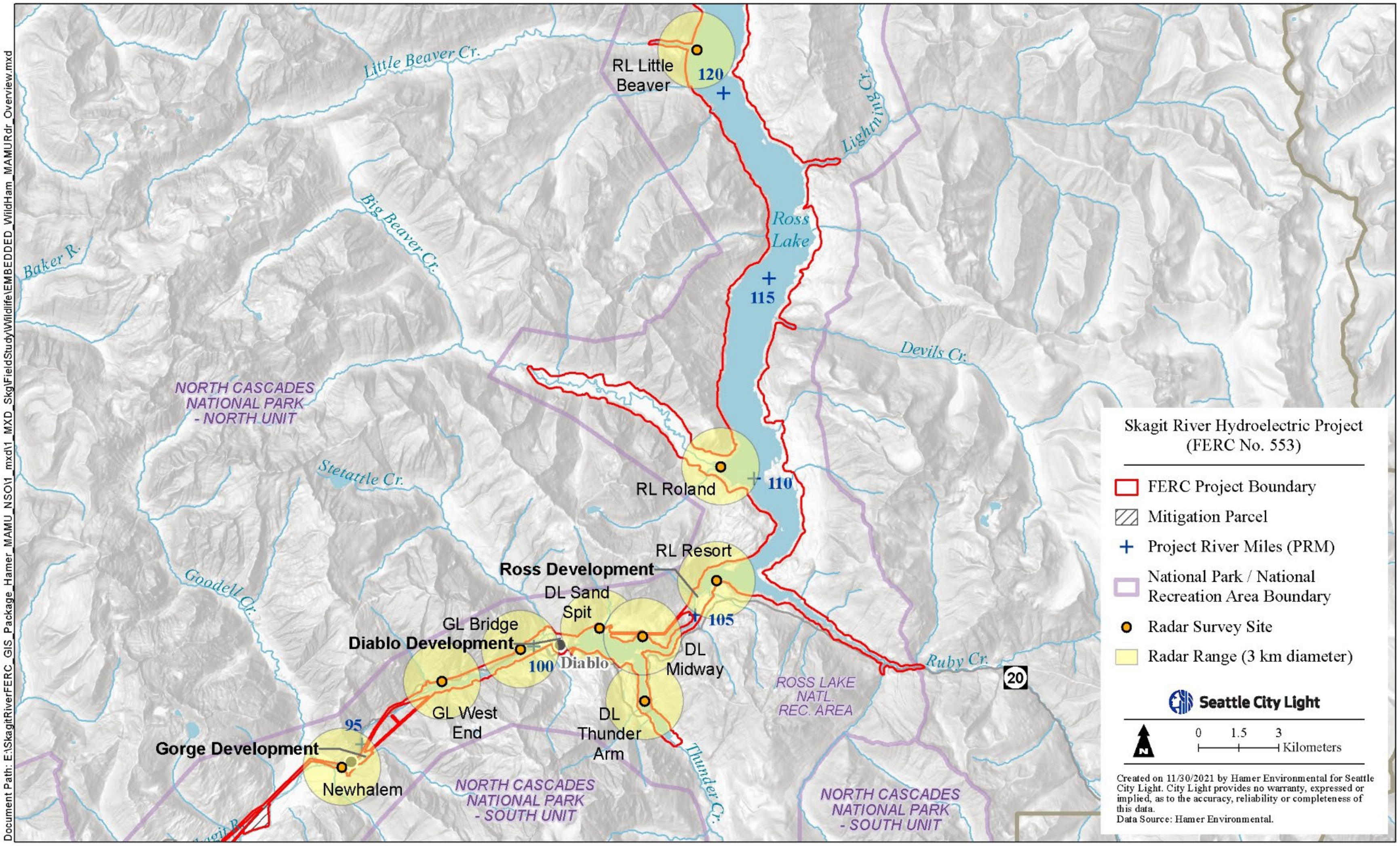

Figure 4.3-1. Radar and audio-visual marbled murrelet survey site locations.

4.3.2.1 Radar Equipment

Ornithological radar tracking in horizontal (surveillance) mode was performed using a high-frequency marine radar (Furuno Model 2117, Furuno Electric Company, Nishinomiya, Japan) modified per established standards for ornithological surveying of nocturnal birds. The radar system was customized to incrementally aim the radar antenna higher in the sky where birds are flying, which reduces the quantity of clutter resulting from radar energy hitting the ground, water, or surrounding landforms. The radar unit was mounted on a motorized boat (HewesCraft™ Ocean Pro 220 aluminum 24-ft boat) to survey the five water-based sites and trailered as a radar lab to survey the four land-based sites (Figure 4.3-2). A gasoline RV generator powered the radar unit and associated equipment (an inverter, the radar, radar recording computer and control keyboard, radar viewing monitor [Figure 4.3-3], and laptop for manual data collection).

The radar unit transmitted at 9,410 megahertz (MHz) ±30 MHz (i.e., X-band) with a 2 m-long slotted wave guide antenna and peak power output of 12 kilowatts (kW). The radar was operated at a range of 1.5-km (0.9-mile) radius. Target detection was enhanced by sophisticated signal processing techniques Furuno employs, such as the radar interference rejecter, which reduced the amount of noise received by the radar, while not affecting the resolution of targets being detected. The radar antenna had a horizontal beam width of 1.23 degrees.

To enhance detection of small targets and discriminate between close targets, the pulse length was set to 0.07 microseconds when operating the unit. The shorter pulse allowed better definition of small targets and increased range resolution. Range resolution is a measure of the capability of the radar to detect separation between targets on the same bearing with small differences in range. Maximum detection range capability can be reduced when using the shorter pulse length, but better target definition and range accuracy allow for more accurate assessments of movement rates and behavior, justifying some reduction in range. Range accuracy was 1 percent of the maximum range of the scale in use, or 30 m (98 ft), whichever was greater.

4.3.2.2 Radar Recording Software (automated data recording)

Raw output (video, trigger pulse, ship’s heading marker, and bearing pulse) from the radar was collected using a dedicated computer. Each sweep of the radar and associated echoes were stored as a single digital archive file. All sweeps from a given survey period were archived together in a single folder on an external hard drive, which was copied to a separate hard drive at the end of each morning for data back-up.

Echoes on the radar screen were recorded for the duration of each morning survey using digital radar technologies. An automated data collection system allowed permanent digital storage of all radar data along with replay or re-analysis of the data from any morning at any time.

Figure 4.3-2. Radar boat lab for marbled murrelet surveys, showing radar antenna tilted at 20 degrees and metal clutter screen on antenna facing stern of boat.

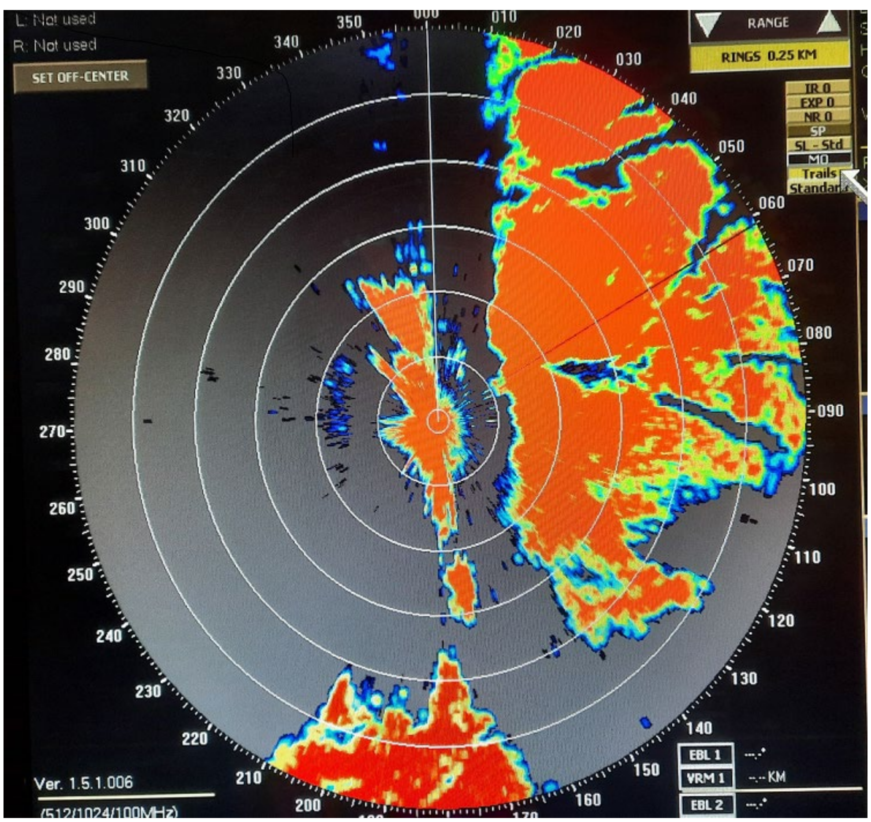

Figure 4.3-3. Radar monitor screen of GL Bridge survey site showing ground clutter (orange).

4.3.2.3 Manual Data Collection by Radar Technician

During each survey, an experienced radar technician collected real-time radar target data simultaneous to automated data recording via computer. Established protocol for surveying marbled murrelets using ornithological radar was used (Cooper and Hamer 2003). The data collection process consisted of three phases: (1) pre-survey set-up; (2) surveying period; and (3) post-survey break-down. Each phase included tasks that were important for consistency and efficiency in data collection. Both manual (technician) and automatic (computer) data collection processes complimented each other and helped to improve, streamline, and guarantee that data were collected and backed up throughout the study.

Pre-survey Set-up

Pre-survey set-up was done prior to each morning survey because each survey occurred at a different location and at slightly different times during the season (based on timing of sunrise). The order of tasks for pre-survey set-up was conducted differently between water- and land-based sites; primarily, most set-up tasks were conducted the night prior at water-based sites and the morning of at land-based sites. Prior to each survey, the radar antenna tilt and clutter screen were adjusted to pre-determined settings; settings for land-based sites remained the same throughout the study, whereas water-based site settings varied somewhat due to initial changes in some survey sites and varying weather conditions (for example, when wave clutter needed to be reduced) (see Section 4.3.2.4 of this study report).

Site-specific data were recorded prior to surveying to allow and/or enhance radar data collection and analyses. These data included the GPS coordinates for each site using handheld Garmin GPSMAP 65st. Site-specific data collected pre-survey also included time of sunrise (hence, survey start time), "North" heading of radar unit (compass bearing in degrees set with appropriate declination), radar antenna tilt (in degrees), clutter screen angle (in degrees), and numerical computations (and input to computers) necessary to allow for data collection via tracking software.

Weather data were collected by the radar technician and AV surveyor each morning immediately pre- and post-surveying. Weather variables collected included wind speed (kph [kilometer/hour]) and air temperature (degrees Celsius [°C]) using a hand-held Kestrel 3500 wind anemometer, wind direction (degrees), cloud cover (percent), estimated ceiling height (m), minimum horizontal visibility (m), light condition (daylight, twilight, dark), and precipitation (as described in Section 2.6.4.4 of the RSP).

Surveying Period

Horizontal (surveillance) radar was operated each sampling morning (as described at Section 2.6.3.5 of the RSP). The surveillance radar allowed for the collection of target information that included detection time, radar species identification, AV surveyor's species identification (if observed), flight behavior (straight, arcing, circling), overall flight direction (bearing), flight direction in relation to the drainage (i.e., "Inbound," "Outbound," "Other") further described in Section 4.3.3.3 of this report, initial detection location and final detection location (distance and bearing from radar to map full flight path), movement rate (kph), farthest distance detected from the radar unit, echo size, and flock size. To plot the flight paths of each target identified, the x and y coordinates of the first and last echo location were recorded. Surveying (manually) consisted of monitoring the radar screen for each three-hour survey and recording target activity in real-time on a laptop computer into a Microsoft Excel spreadsheet (see sample in Figure 4.3-4).

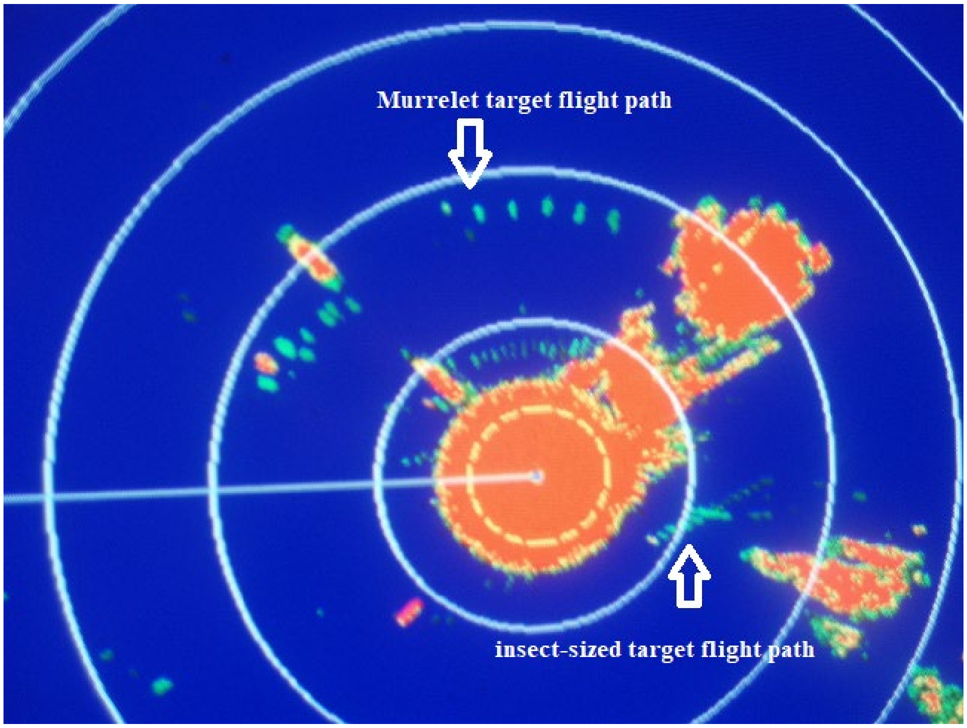

Figure 4.3-4. Sample radar monitor screen showing marbled murrelet radar target and non-murrelet (insect) target flight path tracks, white rings represent 250-meter (820-ft) distance increments.

Post-survey Break-down

Post-survey break-down included disassembly and storage of gear for transport, as well as backing up all data collected during that session. Data were copied from the laptop (manual data collected) and from an external hard drive connected to the radar processing computer (automatic data collected). Copied data were put onto a second hard drive that was kept in a safe and separate location; data from this drive were regularly sent to the main office as another security step in the data backup process.

4.3.2.4 Radar Surveying Environment

Under ideal conditions murrelet-type targets can be detected up to 1.5 km (0.9 miles) away from the radar. Surveying was conducted at locations that had the highest potential to serve as flight corridors for marbled murrelets, including the Skagit River, Gorge Lake, Diablo Lake, and Ross Lake. Because these waterbodies are located in valleys of steep mountains within the study area, prominent land features often blocked the radar from reaching such distances in some directions. To show the portion of each radar site where clutter and shadows (areas that appear to be open on the radar screen but are blocked by topographic features) blocked the ability of the radar to see targets, a clutter map was created. Clutter maps were created using a combination of radar screen shots, topographic maps, and the data analyst’s knowledge of shadow areas where no avian or insect targets were observed during surveys (Attachment B). The proportion of each 1.5 km-radius (0.9 miles) site obscured by clutter was also calculated.

The use of radar is limited by weather conditions. It was not possible to collect radar data during periods of heavy rain when a solid mass of precipitation echoes obscured all or the majority of the radar display screen. If more than 15 minutes of the peak pre-sunrise period were compromised by rain or clutter and more than 35 percent of radar screen was compromised, then the passage rate data for that survey were disqualified as a "weather out." However, all actual surveillance radar data for the entire survey was retained for other analyses or counts. When possible, throughout the study, weather replacement surveys were scheduled and conducted when a survey session had rain that precluded radar data collection for more than fifteen minutes of the pre-sunrise period of the survey session (Nelson et al. 2013).

Cragg et al. (2016) concluded that radar identification of murrelets was less reliable in winds exceeding 18 kph (11 miles per hour [mph]). The Pacific Seabird Group's (PSG) Inland Survey Protocol for Marbled Murrelets recommends that radar surveys only be conducted when average wind speeds are < 25 kph (< 15 mph) so that slowly flying birds with tailwinds are not counted as murrelet targets (Evans Mack et al. 2003). Accordingly, surveyors avoided sampling on days with higher wind speeds, whenever possible (as described in the RSP at Section 2.6.3.5).

Cloud cover (height and percent), precipitation, and light levels are known to affect the timing and duration of murrelet flight activity—activity levels are generally higher, and flights are often lower, delayed, and prolonged during cloudy or foggy conditions (Nelson and Peck 1995; Rodway et al. 1993; Burger 2001; Evans Mack et al. 2003).

4.3.2.5 Audio-Visual Surveys

Simultaneous AV surveys were conducted adjacent to the radar lab to attempt to confirm the identification of radar targets detected by the radar technician. Since radar cannot absolutely determine species identification of targets detected, AV surveys assisted in confirming radar detections as marbled murrelets or other birds. Data collection for AV surveys followed methods established in PSG's Marbled Murrelet Inland Survey Protocol (Evans Mack et al. 2003). The AV surveyor was specifically trained and recertified in spring 2021 to conduct marbled murrelet surveys according to the protocol.

The AV surveyor used a night-vision device (AN PVS-14) during the dark periods of each survey and binoculars during light periods to aid in avian identification. Field data were collected using a hand-held digital audio recorder during each survey. On the digital files, the surveyor noted any murrelet detections and details of the observation, survey start and end times, any pertinent changes in weather conditions, and observations of other birds that may have also been detected by the radar. The AV surveyor stayed in radio contact with the radar technician for the entire survey. The radar technician provided the AV surveyor with target distance and direction of radar targets, which assisted in locating and identifying these radar targets as specific avian species. All data were transcribed from recorders onto standardized survey forms and noted when the target bird was also recorded by the radar technician.

4.3.3 Data Analyses

4.3.3.1 Filtering Radar Data for Analysis

Using digital radar technology software, a permanent digital file of all radar data was created for each survey morning with ability for replay or re-analysis of the data from any morning at any time.

All radars have a corona-effect, where radar signal interference creates clutter within a small area immediately surrounding the radar location, and effectively masks any target detections in that area. The corona-effect for this study included a 100- to 150-m (328 to 492-ft) radius area surrounding each radar site location. Thus, no targets were likely to be detected with ranges < 150 m (492 ft) from the radar.

Radar and weather data were entered into Excel spreadsheets. Individual targets were tracked on the monitor over time with a minimum threshold of four echoes before a target's flight path was recorded to help eliminate non-murrelet targets. The resulting tracks were then filtered based on flight speed and echo reflectivity to exclude insects and smaller avian targets. Murrelet-type targets detected on radar were distinguished from other avian-like targets by movement speed, echo size, echo shape, and timing of detection. Marbled murrelets have a dense body represented on the radar monitor as distinctive large, round echoes that are typically strong (high reflectivity) throughout the radar's 1.5 km (0.9 miles) coverage, compared to the echoes of non-murrelet species, which typically vary in echo shape, size, and strength. Since the individual echo size of a target can vary slightly depending on the orientation of the target when detected by the radar, murrelets were further distinguished from non-murrelet species by a qualitative visual assessment of each target's full echo trail.

For murrelets flying in an inbound or outbound direction, the earlier the detection during the survey session (before sunrise), the higher the likelihood that the detection is a marbled murrelet. Likewise, the faster the target speed during transit inbound or outbound towards the ocean that are over the threshold of 64 kph (40 mph), the more likely the target is a marbled murrelet. Recorded speeds of marbled murrelets range from 40 to over 70 mph (Cooper and Hamer 2003; Hamer Environmental 2010). Therefore, only targets flying >64 kph (>40 mph) (at the 1.5 km radar range) were recorded as murrelet-type targets. In addition, murrelet-type targets sometimes show a higher mean flight speed for outbound versus inbound flights. Murrelets heading inland to nest sites usually gain altitude prior to flying over nearby ridges and hills, essentially slowing their flight speed.

Manually recorded radar data collected on standardized Excel forms by the radar technician were reviewed during the data analysis and Quality Assurance/Quality Control processes while simultaneously reviewing automated recordings of each radar survey session. The data analyst watched the full radar survey session to ensure that no potential murrelet-type targets were missed during a survey session. If a target was missed by the radar technician, the data analyst added the target and all associated flight information to the target spreadsheet for the survey. Then the data analyst verified that the flight speed for each radar target recorded met the minimum speed criteria for murrelets. For every target that met the minimum speed threshold, all other associated flight data were reverified and corrected, if needed, by the data analyst. This process was repeated for each radar survey session. The data analyst, while reviewing each radar survey session, had the ability to stop, pause, and review any portion of the radar survey session. This allowed for highly accurate data review and data correction over that of the radar technician who recorded radar data in real time. Once all radar survey data had been reviewed and verified, any recorded targets that did not meet the minimum flight speed of > 64 kph (> 40 mph) were filtered out. Potential targets with irregular echo shape and/or small echo size were similarly reviewed and filtered out if they were consistently irregular in shape (not round like a murrelet-target) or small in size. After removal of non-murrelets, the murrelet-type target tracks were then mapped using ArcMap from initial to final echo as full tracks.

4.3.3.2 Radar Counts and Passage Rates

Data were analyzed by "hour" and by "survey morning" for the breeding season. Counts of murrelet-type flight tracks during each sampling period were summed. These counts were used to calculate movement rates (targets/hour) based on the number of hours sampled in each period analyzed (per hour and per day). Counts of murrelet-type targets were also binned into 15-minute increments by survey site to show when target detections occurred over the course of the 3-hour survey sessions and to identify those detections that occurred during pre-light periods that have the highest potential to be marbled murrelets. Radar passage rates are an index of the number of murrelet-type targets flying over a location and can be used to assess the relative biological importance of sites being analyzed. Passage rates were adjusted for minutes of data lost due to heavy rain or radar lab equipment issues during the morning surveys.

4.3.3.3 Flight Directions, Locations, and Behavior

Flight directions were calculated for each murrelet-type radar target track by averaging the bearing of each echo within the track and then converting the final bearing to a cardinal direction based on the track start and end echo x and y coordinates. Mean flight directions (degrees) and standard error (SE) were calculated for all survey periods and at each radar site using ORIANA 4.02 circular statistics software (ORIANA 2013). Flight path behavior was noted for each radar target recorded as straight, arcing, or circling, and these behaviors were totaled to determine proportion of flight behaviors exhibited by radar targets.

The more direct flight paths of murrelets along drainages and east-west flight directions on their way to and from marine waters typically help to distinguish a murrelet-type target from other avian-like targets. Due to the varying orientation of water bodies and drainages in the study area, all murrelet-type targets recorded were included regardless of flight path direction. A target was considered "Inbound" if it headed within ±45 degrees of an easterly direction (90 degrees), "Outbound" if headed within ±45 degrees of a westerly direction (270 degrees), and "Other" if the flight direction was outside of Inbound and Outbound directions.

4.3.3.4 Flight Speeds

The horizontally spinning antenna rotated and scanned the horizon once every 2.5 seconds. With each rotation the radar monitor displays an echo of the target(s) being tracked. Because the radar rotates at fixed time intervals, the distance between adjacent echoes is directly proportional to the flight speed of the targets. Therefore, the speed of a target was calculated by measuring the distance between echoes, with echoes farther apart indicating faster moving targets. Flight speeds of targets were compared amongst sites, as well as by flight direction (Inbound, Outbound, Other).

5.0 RESULTS

5.1 Summary of Potentially Suitable Marbled Murrelet Nesting Habitat Model

Potentially suitable nesting habitat for marbled murrelets was mapped throughout the study area, as shown in Attachment C, and the acreages for each segment are summarized below (Table 5.1-1). The RLNRA contains the largest segment of the study area with 22,710 ha (56,118 acres) comprising 39 percent of the study area. The largest amount of potentially suitable murrelet nesting habitat is in the RLNRA, 10,753 ha (26,570 acres), comprising 47 percent of the RLNRA segment. The Bacon Creek to Sauk River Crossing contained the second largest amount of potentially suitable habitat, which comprises 21 percent of the total area. The southernmost segment of the study area, SR 528 to Bothell Substation, contained both the smallest total area of all study area segments and the smallest amount of potentially suitable murrelet nesting habitat, comprising only 13 percent of the segment. An analysis of the Washington DNR stand age data layer in the study area, with forest stands younger than 60 years removed, resulted in a mean stand age of 273 ± 125 years (range of 60 to 506 years) for the entire study area.

The Western Mitigation Lands segment of the study area contains a total area of 8,100 ha (20,016 acres), with 24 percent of the total segment area potentially suitable murrelet nesting habitat. The Pressentin and Finney Creek mitigation lands, exclusive of the 0.8-km (0.5-miles) study buffer, both contain high quantities of potentially suitable murrelet nesting habitat (Table 5.1-2). The Pressentin mitigation land contains 79 percent, or 205 ha (506 acres), of potentially suitable murrelet nesting habitat. Finney Creek mitigation land contains 48 percent or 125 ha (310 acres) of potentially suitable murrelet nesting habitat. Lands within 0.8 km (0.5 mile) of the transmission line ROW from Sauk River Crossing to the Bothell Substation adjacent to the study area were minimally assessed but did not contain significant areas of older forest.

5.1.1 Potentially Suitable Marbled Murrelet Nesting Habitat in the RLNRA

The RLNRA segment of the study area, which contains the largest amount of potentially suitable murrelet habitat, was further divided into five sub-segments (Table 5.1-3). Ross Lake (exclusive of Big Beaver Valley) contains the largest sub-segment of the RLNRA at 13,696 ha (33,844 acres), comprising 60 percent of the total area of the RLNRA segment. Potentially suitable murrelet nesting habitat is present on 49 percent of the Ross Lake sub-segment. The Big Beaver Valley sub-segment of the RLNRA of Ross Lake contains a similar proportion of potentially suitable murrelet nesting habitat at 49 percent or 970 ha (2,396 acres). Diablo Lake, at 2,161 ha (5,341 acres), contains the highest proportion of potentially suitable murrelet nesting habitat, comprising 59 percent of the Diablo Lake sub-segment.

Table 5.1-1. Potentially suitable marbled murrelet nesting habitat area in the study area by segment.

Study Area Segment[1]	Potentially Suitable Habitat: Area (ha [acres])	Potentially Suitable Habitat: Percent of Segment	Potentially Suitable Habitat: Area Within Project Boundary[2] (ha [acres])	Total Study Area Segment (ha [acres])
RLNRA	10,753 (26,570)	47%	1,628 (4,023)	22,710 (56,118)
Bacon Creek to Sauk River Crossing	2,107 (5,206)	21%	318 (785)	9,923 (24,520)
Western Mitigation Lands	1,944 (4,803)	24%	583 (1,441)	8,100 (20,016)
Sauk River Crossing to Oso	1,293 (3,196)	16%	35 (85)	7,943 (19,628)
Oso to SR 528	234 (579)	5%	< 1 (1)	4,732 (11,694)
SR 528 to Bothell Substation	54 (133)	1%	-	4,092 (10,112)
Total	**16,385 (40,487)**	**28%**	**2,564 (6,335)**	**57,500 (142,088)**

1 See Figure 3.0-1 for map of study area segments.
2 Area within Project Boundary includes fish and wildlife mitigation lands.

Table 5.1-2. Potentially suitable marbled murrelet nesting habitat in fish and wildlife mitigation land properties (not including study area buffer).

Mitigation Land Property Name	Potentially Suitable Habitat: Area (ha [acres])	Potentially Suitable Habitat: Percent of Mitigation Land	Total Mitigation Land Property Area (ha [acres])	Study Area Segment Where Located[1]
Newhalem Ponds	18 (44)	40%	45 (111)	RLNRA
County Line Ponds	4 (11)	20%	23 (56)	RLNRA
Bacon Creek	12 (30)	25%	48 (119)	Bacon Ck to Sauk River Crossing
B & W Road 1	5 (13)	17%	32 (79)	Bacon Ck to Sauk River Crossing
B & W Road 2	1 (2)	14%	4 (11)	Bacon Ck to Sauk River Crossing
Corkindale Creek	3 (8)	5%	58 (143)	Bacon Ck to Sauk River Crossing
South Marble 40	6 (15)	37%	17 (41)	Bacon Ck to Sauk River Crossing
Bogert and Tam	0 (0)	0%	7 (17)	Bacon Ck to Sauk River Crossing
O'Brien Slough	0 (1)	2%	19 (47)	Bacon Ck to Sauk River Crossing
Illabot North	20 (48)	7%	294 (726)	Bacon Ck to Sauk River Crossing
Illabot South	185 (456)	18%	1,021 (2,522)	Bacon Ck to Sauk River Crossing
Barnaby Slough	16 (39)	17%	91 (225)	Bacon Ck to Sauk River Crossing
False Lucas Slough	38 (94)	46%	83 (204)	Bacon Ck to Sauk River Crossing
Johnson	3 (7)	96%	3 (7)	Bacon Ck to Sauk River Crossing
Napoleon Slough	10 (25)	41%	25 (62)	Bacon Ck to Sauk River Crossing
McLeod	13 (33)	26%	51 (126)	Bacon Ck to Sauk River Crossing
Nooksack	221 (546)	14%	1,560 (3,854)	Western Mitigation Lands
Bear Lake	5 (11)	7%	63 (155)	Western Mitigation Lands
Nooksack West	26 (65)	17%	157 (389)	Western Mitigation Lands
Savage Slough	2 (5)	2%	85 (211)	Western Mitigation Lands

Mitigation Land Property Name	Potentially Suitable Habitat		Total Mitigation Land Property Area (ha [acres])	Study Area Segment Where Located[1]
	Area (ha [acres])	Percent of Mitigation Land		
Day Creek Slough	0 (0)	0%	16 (38)	Western Mitigation Lands
Pressentin	205 (506)	79%	258 (637)	Western Mitigation Lands
Finney Creek	125 (310)	48%	260 (642)	Western Mitigation Lands
North Sauk	4 (9)	20%	18 (46)	Sauk River Crossing to Oso
Sauk Island	1 (2)	10%	9 (21)	Sauk River Crossing to Oso
North Everett Creek	20 (49)	28%	70 (174)	Sauk River Crossing to Oso
Everett Creek	4 (10)	25%	16 (39)	Sauk River Crossing to Oso
Dan Creek	3 (8)	19%	17 (42)	Sauk River Crossing to Oso
Total	**949 (2,345)**	**22%**	**4,348 (10,744)**	

1 See Figure 3.0-1 for map of study area segments.

Table 5.1-3. Potentially suitable marbled murrelet nesting habitat area in the RLNRA by sub-segment.

RLNRA Sub-Segment Name[1]	Potentially Suitable Habitat			Total Land Area (ha [acres])
	Area (ha [acres])	Percent of Sub-Segment	Area Within Project Boundary[2] (ha [acres])	
Ross Lake (exclusive of Big Beaver Valley)	6,710 (16,581)	49%	1,173 (2,899)	13,696 (33,844)
Big Beaver Valley	970 (2,396)	49%	249 (614)	1,969 (4,866)
Diablo Lake	1,286 (3,177)	59%	96 (238)	2,161 (5,341)
Gorge Lake	581 (1,436)	45%	60 (148)	1,306 (3,226)
Gorge Lake to Bacon Creek	1,206 (2,980)	34%	50 (123)	3,578 (8,841)
Total	**10,753 (26,570)**	**47%**	**1,628 (4,022)**	**22,710 (56,118)**

1 See Figure 3.0-1 for map of study area segments.
2 Area within Project Boundary includes fish and wildlife mitigation lands.

5.1.2 Habitat Connectivity to Modeled Habitat in the Study Area

A brief review of the Washington DNR GIS-based stand age layer used in the Murrelet Habitat Model was completed to determine areas of potential habitat connectivity adjacent to, but outside of, the study area. This assessment was qualitative in that it relied on one model input data layer and a visual scan of stand ages in GIS, with particular focus on adjacent lands surrounding the RLNRA and Western Mitigation Lands portions of the study area. The Washington DNR data layer did not cover lands beyond the study area for most of Ross Lake, so no assessment of habitat outside of the study area was made north of Cougar Island, located halfway between Ross Lake Resort and Roland Point (Attachment C, page 6). From Ross Lake's Ruby Arm, younger forest stands > 60 years and some older forest stands > 120 years are adjacent to the study area. On Diablo Lake's Thunder Arm, a similar mix of forest stands > 60 years and > 120 years extend beyond the study area, with a particularly large area of forest > 120 years south of the study area from Thunder Arm. South of the Gorge Lake study area there are many older forest stands > 120 years and older within lands administered by NPS, both inside and outside of the 2015 Goodell Creek fire boundary (Attachment C, pages 10-11), and these stands of older trees extend almost to Newhalem.

At Western Mitigation Lands, the Corkindale mitigation lands have older forest habitat extending to the northwest from the study boundary on lands managed by WDFW and the U.S. Forest Service (USFS); at the Illabot South mitigation lands, older forest extends from the study boundary to the southeast. The Nooksack mitigation lands have some forest stands > 60 years continuing northeast from the study area boundary. Older forest stands extend from the southwest corner of the Pressentin mitigation land. On the west side of the FERC boundary, many forest stands > 60 years extend beyond the study area from Texas Pond down to Everett Creek mitigation lands. On the south side of the FERC boundary near French Point, forest stands > 60 years and few > 100 years extend beyond the study area.

5.2 Field Habitat Assessment Surveys

A total of ten 25 m radius habitat assessment plots were sampled within or just outside of murrelet radar survey sites throughout the study area (Attachment C). Each of the ten habitat plots contained conifers with one or more platform with a minimum diameter of 10 cm (4 inch) to meet the definition of potentially suitable nesting habitat for marbled murrelets. In areas where conifer trees with suitable platforms for murrelet nesting were common, habitat plots were placed in representative areas of forest stands. Those representative habitat plots included: Newhalem (at Trail of Cedars), Diablo Lake (DL) Midway (northwest of Buster Brown Campground), Ross Lake (RL) Resort 1 (along RL Resort Trail), RL Resort 2 (off Green Point Trail), RL Roland Point 2 (along Big Beaver Creek Trail on creek), and RL Little Beaver (at Little Beaver Trail) (Table 5.2-1).

In other areas, where potentially suitable nesting habitat was largely absent, habitat plots were placed in stands where the only suitable nesting habitat was observed. These non-representative habitat plots included: Gorge Lake (GL) Bridge (near bridge), DL Sand Spit (near the spit and Environmental Learning Center), DL Thunder Arm (in Colonial Creek Campground), and RL Roland Point 1 (near Pumpkin Mountain Camp) (Table 5.2-1).

Suitable nesting platforms were primarily observed in Douglas fir trees—one western hemlock and several western red cedars with platforms were also identified at the Newhalem habitat plot. Suitable nesting platforms were most commonly large branch structures, but mossy branches and one split-top platform were also documented in the habitat plots.

Of the ten habitat plots sampled, nine (90 percent) were within areas also designated by the Murrelet Habitat Model as potentially suitable murrelet nesting habitat. One habitat plot, Newhalem, was field-verified as suitable habitat, but was 19 m (62 ft) outside of potentially suitable habitat as mapped by the Murrelet Habitat Model. This discrepancy may have resulted from low accuracy of the GPS-recorded habitat assessment plot location due to surrounding mountainous terrain or due to the resolution of the Murrelet Habitat Model, which was at 20 m^2 (66 ft^2).

Table 5.2-1. Marbled murrelet field habitat assessment survey plots.

Plot[1]	Habitat		Within Modeled Potential Habitat?	Notes[2]
	Suitable?	Representative?		
Newhalem	Y	Y	N	7 Douglas firs and western red cedars, LB & MB plats, 2-10+ plats/tree; 18 m outside of modeled potentially suitable habitat.
GL Bridge	Y	N	Y	3 Douglas firs with LB, ST plat, 1-2 plats/tree
DL Sand Spit	Y	N	Y	2 Douglas firs, MB plats, 2-5 plats/tree
DL Midway	Y	Y	Y	4 Douglas firs with LB plats, 2-5 plats/tree
DL Thunder Arm	Y	N	Y	5 Douglas firs, LB & MB plats, 4-10+ plats/tree
RL Resort 1	Y	Y	Y	3 Douglas firs with LB plats, 2-3 plats/tree
RL Resort 2	Y	Y	Y	4 Douglas firs with LB plats, 5-15+ plats/tree
RL Roland Point 1	Y	N	Y	4 Douglas firs, 1 western hemlock, LB plats, 2-10+ plats/tree
RL Roland Point 2	Y	Y	Y	1 Remnant Douglas fir 67 cm dbh, LB plats, 10+ plats/tree
RL Little Beaver	Y	Y	Y	8 Douglas firs, LB plats, 2-10+ plats/tree

1 Location of plot can be found in Attachment B Potentially Suitable Nesting Habitat Mapbook (pages 2-11).
2 LB = large branch; MB = mossy branch; plat = platform; ST = split top.

The qualitative habitat assessment extended from Newhalem northeast to the north end of Ross Lake. Newhalem to Gorge Lake Bridge contained steep topography that precluded access to directly assess habitat on foot. Instead, biologists used binoculars to visually assess the patches of forests from vantage points along SR 20, looking for trees with suitable nesting platforms. A majority of this area burned in the 2015 Goodell Fire (Attachment C, pages 10-12). No suitable platform structures were observed, and trees were too small to contain branches large enough for suitable nest platforms.

The Diablo Lake shoreline has steep topography, limited accessibility to safely land the survey boat, and few trails, so this area was primarily scanned from the radar lab boat or kayak with binoculars. Mature stands of conifers were not observed, but a few suitable nesting platforms were observed. The Thunder Arm portion of Diablo Lake contained patches of mature Douglas fir trees with suitable nesting platforms in the Colonial Creek Campground southwest of the bridge (Attachment C, pages 9-10) The Midway habitat plot was northwest of the Buster Brown Campground; suitable nesting habitat of older remnant conifers may extend from this plot location to the northwest in the bottomlands (Attachment C, page 10).

Ross Lake shoreline was investigated primarily from boat but also by hiking some trails along the lake, which revealed conifer stands with scattered remnant trees supporting suitable nesting platforms. Along the Ross Lake Resort trail, the habitat plot was representative of suitable habitat observed around Ross Lake Resort (Attachment C, pages 6-7). The Big Beaver Trail from Green Point northeast to the Sourdough Mountain Trail did not contain suitable nesting platforms, as the forest transitioned from Douglas fir to lodgepole pine (*Pinus ponderosa*). Scattered remnant trees with suitable nest platforms were observed at Devil's Junction Campground and also along the East Bank Trail northeast of the campground.

Little Beaver Creek was steep with mostly bare slopes along the creek area with the best habitat located higher up on the ridge away from the creek. Scattered habitat trees with suitable nesting platforms were observed along the Little Beaver Creek Trail. Observations were made from the boat north from Little Beaver towards the Hozomeen Campground with potential habitat stands where the lake shoreline is less steep (Attachment C, page 2). The forest transitioned from mixed conifer to cottonwood in the bottomlands on the Canadian side of the lake near where the Skagit River flows into Ross Lake. The east bank of the lake, where forest transitioned back to conifers, appeared to have potentially suitable platform trees as observed from the boat.

Findings of the limited field habitat assessment survey plots and qualitative assessment of potential murrelet nesting habitat in the study area were largely consistent with the results of the Murrelet Habitat Model. On Ross Lake and Diablo Lake, habitat plot results confirmed a presence of suitable nesting platforms in older conifer trees, and the qualitative assessment of presence of nesting habitat was consistent with that of the potentially suitable habitat identified by the Murrelet Habitat Model. Similarly, in areas where suitable habitat was largely absent from the limited field verification (e.g., from Newhalem to Gorge Lake), the Murrelet Habitat Model found little potentially suitable habitat.

5.3 Radar and Audio-Visual Survey Results

5.3.1 Radar and Audio-Visual Survey Effort

A total of 45 simultaneous radar and AV surveys were successfully completed, five at each of nine radar and AV sites in the study area (Table 5.3-1). Two radar and AV surveys were deemed weather outs: Newhalem on May 18, 2021, and DL Sand Spit on June 13, 2021. Weather replacement surveys were completed at these sites on subsequent days during the same survey visits. Periods of rain and presence of insects were noted during surveys as both resulted in small amounts of clutter on the radar monitor (Table 5.3-1).

5.3.1.1 Challenges of Water-Based Radar Site Surveys

Weather and water conditions changed rapidly on Ross Lake and Diablo Lake, with gusty winds of variable directions common in the afternoons and evenings when personnel were attempting to anchor and set-up the radar boat lab for the next morning's survey. Early mornings at the survey start were often calmer, but, as sunrise approached, conditions frequently deteriorated as the winds increased and the lake conditions became choppy. Wind and water conditions were particularly challenging for the first two survey visits, when spring storms were common in the North Cascades and water levels rose rapidly from rain and snow melt, resulting in waves and strong currents. Weather and strong currents impacted radar data collection during two survey sessions by causing the anchored boat heading to rapidly swing/shift, resulting in land clutter on the radar screen to shift and preclude usable data collection. These instances occurred during two surveys at RL Resort (May 27 and June 10, 2021), where radar data collection was not possible during the last portion of the survey (24 minutes and 35 minutes, respectively). Subsequent survey visits at RL Resort did not have this issue, as they were conducted while the radar boat lab was tied to a temporary dock installed in mid-June near the boat launch above Ross Dam.

One additional period where weather precluded data collection occurred due to rapid water level rise and strong currents during the first water-based survey visit at DL Thunder Arm on May 23, 2021. The first 72 minutes of the survey data were unusable (automated recorded data), due to the radar lab boat's bow and stern anchors dragging and needing to be reset to stabilize the boat. These three radar survey sessions were not repeated, due to limited scheduling flexibility for access to boat-based survey sites and tight survey windows. These periods of no data collection or unusable data were noted and deducted from each survey for all subsequent passage rate calculations (Table 5.3-1).

Table 5.3-1. Marbled murrelet radar and AV sampling effort during the 2021 breeding season.

Date	Site Name	Survey Visit	Sunrise Time	Radar and AV Sampling Start and End Times	Survey Length (min)[1]	Comments
5/18/2021	Newhalem	-	5:18	3:33-6:33	45	Rain out, 135 min of rain > 35% of radar screen
5/19/2021	GL West End	1	5:17	3:32-6:32	179	Radar starts 1 min late
5/20/2021	GL Bridge	1	5:16	3:31-6:31	180	Very light rain early in survey
5/21/2021	Newhalem	1	5:15	3:30-6:30	170	Radar/equip. issue (3:30-3:39, 10 min)
5/22/2021	DL Sand Spit	1	5:13	3:29-6:29	180	
5/23/2021	DL Thunder Arm	1	5:13	3:28-6:28	108	Late start due to boat anchoring issue (start at 4:40, 72 min)
5/24/2021	DL Midway	1	5:12	3:27-6:27	180	Some boat/radar shifting
5/25/2021	RL Little Beaver	1	5:11	3:26-6:26	180	Insects at start
5/26/2021	RL Roland	1	5:10	3:25-6:25	180	Some boat/radar shifting, some insects
5/27/2021	RL Resort	1	5:09	3:24-6:24	156	High boat/radar shifting last 24 min of survey (effective end time at 6:00), rain > 35% of radar screen for last 20 min of survey
6/8/2021	RL Little Beaver	2	5:02	3:17-6:17	177	Some boat/radar shifting, equip issue (3 min)
6/9/2021	RL Roland	2	5:02	3:17-6:17	180	Insects, some boat/radar shifting at survey end
6/10/2021	RL Resort	2	5:02	3:17-6:17	143	Boat issue at start (2 min), high boat/radar shifting last 35 min of survey (effective end time at 5:42)
6/11/2021	DL Thunder Arm	2	5:01	3:16-6:16	180	
6/12/2021	DL Midway	2	5:01	3:16-6:16	171	9 min of rain > 35% of radar screen (4:06-4:11, 4:52-4:56), light rain
6/13/2021	DL Sand Spit	-	5:01	3:16-6:16	52	Rain out, 128 min of rain > 35%
6/14/2021	GL Bridge	2	5:01	3:16-6:16	168	Drizzle early in survey
6/15/2021	GL West End	2	5:01	3:16-6:16	180	
6/16/2021	Newhalem	2	5:01	3:16-6:16	180	
6/17/2021	DL Sand Spit	2	5:01	3:16-6:16	180	
6/23/2021	Newhalem	3	5:03	3:18-6:18	180	
6/24/2021	GL West End	3	5:03	3:18-6:18	180	
6/25/2021	GL Bridge	3	5:03	3:18-6:18	180	
6/26/2021	DL Sand Spit	3	5:04	3:19-6:19	180	Many insects within 500 m
6/27/2021	DL Thunder Arm	3	5:04	3:19-6:19	180	
6/28/2021	DL Midway	3	5:05	3:20-6:20	180	Minimal boat/radar shifting

Date	Site Name	Survey Visit	Sunrise Time	Radar and AV Sampling Start and End Times	Survey Length (min)[1]	Comments
6/29/2021	RL Little Beaver	3	5:06	3:21-6:21	180	Some insects, minimal boat/radar shifting
6/30/2021	RL Roland	3	5:06	3:21-6:21	180	Insects, no boat/radar shifting
7/1/2021	RL Resort	3	5:06	3:21-6:21	175	Insects, no boat/radar shifting, radar equip issue (5 min, 6:11-6:16)
7/13/2021	RL Roland	4	5:27	3:32-6:32	180	Some boat/radar shifting
7/14/2021	DL Thunder Arm	4	5:19	3:34-6:34	179	Late start (1 min), some boat/radar shifting
7/15/2021	DL Midway	4	5:20	3:35-6:35	180	Some boat/radar shifting
7/16/2021	DL Sand Spit	4	5:21	3:36-6:36	180	
7/17/2021	GL Bridge	4	5:22	3:37-6:37	180	
7/18/2021	GL West End	4	5:23	3:38-6:38	180	
7/20/2021	RL Little Beaver	4	5:25	3:40-6:40	180	Some boat/radar shifting, min. wave clutter
7/21/2021	RL Resort	4	5:26	3:41-6:41	180	Insects
7/22/2021	RL Little Beaver	5	5:28	3:43-6:43	180	Some boat/radar shifting, min. wave clutter
7/23/2021	RL Roland	5	5:29	3:44-6:44	180	Insects, little boat/radar movement
7/24/2021	RL Resort	5	5:30	3:45-6:45	180	
7/25/2021	DL Thunder Arm	5	5:31	3:46-6:46	180	
7/26/2021	DL Midway	5	5:33	3:48-6:48	180	
7/27/2021	Newhalem	4	5:34	3:49-6:49	180	
7/28/2021	DL Sand Spit	5	5:35	3:50-6:50	180	
7/29/2021	GL Bridge	5	5:37	3:52-6:52	180	
7/30/2021	GL West End	5	5:38	3:53-6:53	180	
7/31/2021	Newhalem	5	5:39	3:54-6:54	180	

1 Survey length was 180 minutes for a standard radar survey (105 minutes before and 75 minutes after sunrise). Survey length was reduced in whole minute increments when heavy rain (> 35 percent of viewable portion of radar monitor was blocked by rain) (Nelson et al. 2013) occurred, radar lab equipment issues occurred, or radar/boat shifting was high (movement of radar lab caused by high winds or strong currents caused ground clutter to continually shift).

5.3.1.2 Radar Clutter Maps

Radar clutter maps were created for each radar site to show the specific portion of each 1.5-km (0.9-mile) radius site that was obscured by clutter and shadow, and for some individual radar site survey visits if locations changed throughout the survey season (Attachment B). For water-based sites, like RL Resort, when individual survey locations differed only slightly between visits, they were represented by a single visit's clutter map (Attachment B). Radar sites had a range of 28.7 to 79.5 percent of the total survey area obscured from viewing targets by clutter and shadow (Table 5.3-2).

Table 5.3-2. Proportion of 1.5 km (0.9 miles) radius radar survey site obscured by clutter.

	Gorge Lake		Diablo Lake			Ross Lake		
Newhalem	**West End**	**Bridge**	**Sand Spit**	**Midway**	**Thunder Arm**	**Resort[1]**	**Roland[2]**	**Little Beaver**
48.4%	79.5%	54.1%	41.2%	28.7%	33.1%	62.9%	44.6%	35.8%

1 RL Resort Clutter by Survey Visit (V): V1 = 52.6 percent, V2 = 52.3 percent, V3-V5 = 69.8 percent.
2 RL Roland Clutter by Survey Visit: V1 = 22.4 percent, V2-V5 = 50.2 percent.

5.3.2 Weather Observations

Weather conditions were variable and dependent on the particular radar site and survey visit (Table 5.3-3). Two rain-out weather events occurred, one on the first survey morning at Newhalem (May 18, 2021) and the second at DL Sand Spit (June 13, 2021). Short periods of drizzle and light rain occurred sporadically during the first two survey visits at other sites, with no periods of precipitation during the last three survey visits in late June and July. Cloud cover ranged from 0 to 100 percent cover, with overcast conditions most common during the first two survey visits (late May and mid-June), and clear conditions typical in late June and throughout July.

Winds varied between 0.0 and 24.1 kph (0.0 and 15.0 mph) at all sites with a mean wind speed of 3.8 kph (2.4 mph) and remained within the protocol-recommended limits (Cooper and Hamer 2003). Winds were consistently highest at the three sites on Ross Lake, particularly at the Resort location, with a mean wind speed of 9.5 kph (5.9 mph), and Little Beaver with 9.1 kph (5.7 mph), followed by Roland with 5.7 kph (3.5 mph). Winds at radar sites on Diablo Lake, Gorge Lake, and in Newhalem were calmer with mean speeds ranging from 0.3 to 3.1 kph (0.2 to 1.9 mph). Wind directions were highly variable between sites and amongst survey visits. Where winds were highest on Ross Lake, Little Beaver had the most consistency, with mean winds out of the northwest (298 degrees), whereas the other two sites were highly variable (RL Resort mean of 188 degrees; RL Little Beaver mean of 225 degrees).

Presence of waves was not consistently recorded for water-based survey sites on Diablo and Ross Lakes but were typically noted and observed on the radar when wind conditions were ≥ 10 kph (6 mph) and also when water levels on Ross Lake rapidly increased during the second survey visit (June 8-10, 2021).

Table 5.3-3. Weather observations recorded just before and after each session during 2021 murrelet radar surveys.

Site Name	Date	Start/ End Time	Wind Speed (kph)	Wind Direction[1] (degrees)	Cloud Cover (%)	Ceiling Height[2] (m)	Horizontal Visibility[2] (m)	Precipitation	Air Temp. (°C)	Weather Notes
Newhalem	5/18	3:33	13.0	256	100	501-1,000	1,001-2,500	rain	7.8	Wind gusts up 15 mph
		6:48	0.0	0	100	1,001-2,500	1,001-2,500	fog	9.2	High ceiling with low fog in hills
GL West End	5/19	3:32	0.0	0	0	> 5,000	> 5,000	none	7.0	Clear
		6:34	0.0	0	0	> 5,001	> 5,001	none	5.0	Clear
GL Bridge	5/20	3:02	0.0	0	100	501-1,000	1,001-2,500	fog	8.8	Drizzle on radar but sparse < 35%: 4:59-5:24 (25 min)
		6:35	0.0	0	100	2,501-5,000	> 5,000	fog	8.7	High ceiling with low fog in hills
Newhalem	5/21	3:20	1.0	275	0	> 5,000	> 5,000	none	6.0	Clear at start
		6:44	1.0	0	80	> 5,000	> 5,000	none	8.0	Partly cloudy
DL Sand Spit	5/22	2:51	0.0	0	0	> 5,000	> 5,000	none	10.7	Clear, starry sky
		6:33	2.3	90	0	> 5,000	> 5,000	none	7.5	Clear
DL Thunder Arm	5/23	4:40	0.0	0	0	> 5,000	> 5,001	none	8.8	Perfectly still morning
		6:30	0.0	0	80	> 5,000	> 5,001	none	9.8	Cloudy, calm
DL Midway	5/24	3:17	11.0	360	100	1,001-2,500	> 5,000	drizzle	10.9	Boat rocking in the wind and waves, fog on hillsides, drizzle
		6:34	7.0	200	95	> 5,000	> 5,000	light misty rain	10.5	Overcast
RL Little Beaver	5/25	3:20	7.2	332	100	1,001-2,500	2,501-5,000	none	10.3	Overcast
		6:32	11.0	312	80	1,001-2,500	> 5,000	none	9.9	Fog settling on top of hillsides
RL Roland	5/26	3:06	14.6	170	100	1,001-2,500	> 5,000	none	11.1	Overcast and windy
		6:31	24.1	216	70	> 5,000	> 5,000	none	10.9	Light misty rain 5:22-5:35
RL Resort	5/27	3:01	8.5	180	0	> 5,000	> 5,000	none	10.1	Light wind, clear skies
		6:30	10.0	200	100	1,001-2,500	> 5,000	light rain	11.0	Light rain
RL Little Beaver	6/8	2:30	10.5	270	10	> 5,000	> 5,000	none	7.0	Breezy
		6:25	10.5	310	90	> 5,000	> 5,000	none	7.2	Breezy
RL Roland	6/9	3:12	3.8	190	90	> 5,000	> 5,000	none	9.6	Cloudy
		6:27	1.2	variable	90	> 5,000	> 5,000	none	10.0	Cloudy
RL Resort	6/10	3:15	9.7	110	0	> 5,000	> 5,000	none	9.7	Breezy and clear skies
		6:25	10.3	145	40	> 5,000	> 5,000	none	9.3	Breezy

Site Name	Date	Start/ End Time	Wind Speed (kph)	Wind Direction[1] (degrees)	Cloud Cover (%)	Ceiling Height[2] (m)	Horizontal Visibility[2] (m)	Precipitation	Air Temp. (°C)	Weather Notes
DL Thunder Arm	6/11	2:45	4.3	114	50	> 5,000	> 5,000	none	7.3	Part cloudy
		6:24	0.0	0	100	> 5,000	> 5,000	none	9.3	Overcast, no wind
DL Midway	6/12	2:45	0.0	0	90	> 5,000	> 5,000	none	10.9	Light patchy rain, some minor precipitation >35%
		6:21	3.0	39	65	> 5,000	> 5,000	none	9.8	Partly cloudy
DL Sand Spit	6/13	2:45	1.2	variable	100	1,001-2,500	> 5,000	light rain	13.5	Rain out, rain until 5:45
		6:20	0.0	0	100	0	1,001-2,500	sparse rain	13.2	Between 6:07-6:17AM rain clutter >35%, overcast, calm
GL Bridge	6/14	3:00	0.0	0	100	510-1,000	1,001-2,500	heavy rain	13.3	Rain at start, then sparse drizzle, then dry
		6:22	0.0	0	100	510-1,000	501-1,000	none	14.8	Overcast, calm
GL West End	6/15	3:00	0.0	0	100	> 5,000	> 5,000	none	11.3	Overcast, calm
		6:22	0.0	0	90	> 5,000	> 5,000	none	13.3	Cloudy, calm
Newhalem	6/16	3:13	0.0	0	90	2,501-5,000	2,501-5,000	none	13.2	A few raindrops, calm
		6:23	0.0	0	90	> 5,000	2,501-5,000	none	12.5	Cloudy, calm
DL Sand Spit	6/17	3:05	0.0	0	0	> 5,000	> 5,000	none	9.3	Clear, calm
		6:21	0.0	0	0	> 5,000	> 5,000	none	10.9	Clear, calm
Newhalem	6/23	3:11	2.0	226	0	> 5,000	> 5,000	none	14.3	Clear
		6:20	0.0	0	0	> 5,000	> 5,000	none	13.9	Clear, calm
GL West End	6/24	3:08	0.0	0	0	> 5,000	> 5,000	none	16.3	Clear, calm
		6:22	0.0	0	0	> 5,000	> 5,000	none	16.2	Clear, calm
GL Bridge	6/25	3:01	2.7	90	10	> 5,000	> 5,000	none	17.6	Light breeze
		6:25	4.0	90	45	> 5,000	> 5,000	none	19.3	Partly cloudy, breezy
DL Sand Spit	6/26	3:10	0.0	0	0	> 5,000	> 5,000	none	19.4	Full Moon setting at start
		6:25	0.0	0	0	> 5,000	> 5,000	none	18.8	Clear, calm
DL Thunder Arm	6/27	3:10	3.0	163	0	> 5,000	> 5,000	none	16.3	Clear, breezy
		6:22	4.0	156	0	> 5,000	> 5,000	none	16.5	Clear, breezy
DL Midway	6/28	3:10	1.3	72	0	> 5,000	> 5,000	none	21.3	Moon over mountains, clear
		6:25	3.7	65	0	> 5,000	> 5,000	none	21.6	Clear, light breeze
RL Little Beaver	6/29	3:10	14.5	344	0	> 5,000	> 5,000	none	22.2	Clear with wind

Site Name	Date	Start/ End Time	Wind Speed (kph)	Wind Direction[1] (degrees)	Cloud Cover (%)	Ceiling Height[2] (m)	Horizontal Visibility[2] (m)	Precipitation	Air Temp. (°C)	Weather Notes
		6:30	12.1	309	0	> 5,000	> 5,000	none	20.1	Clear with wind
RL Roland	6/30	3:13	3.5	43	0	> 5,000	> 5,000	none	22.2	Clear
		6:25	1.8	280	0	> 5,000	> 5,000	none	19.1	Clear
RL Resort	7/1	3:16	11.1	249	100	> 5,000	> 5,000	none	16.7	Overcast with wind
		6:26	11.5	237	100	> 5,000	> 5,000	none	16.6	Overcast with wind
RL Roland	7/13	3:25	1.0	variable	0	> 5,000	> 5,000	none	18.8	Breezy after survey start until 5:45
		6:36	1.0	variable	0	> 5,000	> 5,000	none	17.9	Clear
DL Thunder Arm	7/14	3:28	3.1	128	0	> 5,000	> 5,000	none	14.1	Clear, light breeze
		6:40	2.5	153	0	> 5,000	> 5,000	none	14.4	Clear, light breeze
DL Midway	7/15	3:25	3.8	19	0	> 5,000	> 5,000	none	16.6	Clear, light breeze
		6:43	1.0	variable	5	> 5,000	> 5,000	none	15.1	Very light breeze
DL Sand Spit	7/16	3:28	0.0	0	0	> 5,000	> 5,000	none	16.6	No wind
		6:42	0.0	0	10	> 5,000	> 5,000	none	13.7	No wind
GL Bridge	7/17	3:30	5.6	188	10	> 5,000	> 5,000	none	17.4	Breezy
		6:40	3.1	188	75	> 5,000	> 5,000	none	16.3	Cloudy, light breeze
GL West End	7/18	3:32	4.0	256	70	> 5,000	> 5,000	none	15.4	Cloudy, light breeze
		6:42	< 1	variable	50	> 5,000	> 5,000	none	16.1	Part cloudy
RL Little Beaver	7/20	3:35	9.0	290	0	> 5,000	> 5,000	none	16.4	Clear, breezy
		6:49	7.3	252	0	> 5,000	> 5,000	none	14.5	Clear, breezy
RL Resort	7/21	3:37	13.0	242	50	> 5,000	> 5,000	none	15.8	Windy; rocking at dock a bit
		6:45	12.2	260	80	> 5,000	> 5,000	none	14.2	Windy
RL Little Beaver	7/22	3:40	2.8	290	0	> 5,000	> 5,000	none	13.5	Clear, light breeze
		6:48	5.6	268	0	> 5,000	> 5,000	none	11.3	Clear, light breeze
RL Roland	7/23	3:40	2.0	210	0	> 5,000	> 5,000	none	12.9	Clear, light breeze
		6:50	3.9	316	0	> 5,000	> 5,000	none	12.6	Clear, light breeze
RL Resort	7/24	3:42	2.0	71	0	> 5,000	> 5,000	none	15.1	Clear, light breeze
		6:50	6.6	71	0	> 5,000	> 5,000	none	14.8	Clear, light breeze
DL Thunder Arm	7/25	3:42	2.2	154	0	> 5,000	> 5,000	none	14.7	Clear, light breeze

Site Name	Date	Start/ End Time	Wind Speed (kph)	Wind Direction¹ (degrees)	Cloud Cover (%)	Ceiling Height² (m)	Horizontal Visibility² (m)	Precipitation	Air Temp. (°C)	Weather Notes
		6:52	2.8	154	0	> 5,000	> 5,000	none	13.5	Clear, light breeze
DL Midway	7/26	3:46	0.0	0	0	> 5,000	> 5,000	none	16.9	Full moon at start of survey
		6:52	0.0	0	0	> 5,000	> 5,000	none	20.5	Clear and calm
Newhalem	7/27	3:40	0.0	0	0	> 5,000	> 5,000	none	16.7	Clear and calm
		6:52	0.0	0	0	> 5,000	> 5,000	none	19.9	Clear and calm
DL Sand Spit	7/28	3:47	0.0	0	0	> 5,000	> 5,000	none	20.8	Clear and calm
		6:53	0.0	0	5	> 5,000	> 5,000	none	18.3	Moon out during survey
GL Bridge	7/29	3:46	2.1	90	0	> 5,000	> 5,000	none	17.6	Moon out during survey
		6:57	4.4	90	0	> 5,000	> 5,000	none	18.6	Moon out during survey
GL West End	7/30	3:46	2.5	60	0	> 5,000	> 5,000	none	20.1	Moon out during survey
		6:57	6.7	100	0	> 5,000	> 5,000	none	20.3	Overcast
Newhalem	7/31	3:50	0.0	0	5	> 5,000	> 5,000	none	21.1	Clear, calm
		6:56	1.3	160	95	> 5,000	> 5,000	none	22.2	Cloudy

1 Wind Direction: direction wind was coming from.

2 Ceiling Height and Horizontal Visibility (m): binned categories used to estimate ceiling height and horizontal visibility included: 1-500, 501-1,000, 1,001-2,500, 2,501-5,000, and > 5,000.

5.3.3 Radar Counts and Passage Rates

A total of 119 targets were documented by surveillance radar with flight speeds ≥ 64.0 kph (40 mph) minimum threshold speed for marbled murrelet. Of these 119 targets, 53 percent were marbled murrelet-type targets, 38 percent were other species targets, 8 percent were band-tailed pigeon targets, and 1 percent were osprey targets. Over the 45 survey days, and one weather-out survey day (June 13, 2021, at DL Sand Spit), a total of 63 murrelet-type targets (targets) were recorded on the surveillance radar (Table 5.3-4). The single target detected during the weather-out survey at DL Sand Spit was not utilized for passage rate calculations. DL Midway and DL Sand Spit sites had the highest total counts of targets during the five survey visits, with 14 and 13 targets respectively, while GL West End had the lowest count, with 0 murrelet-type targets. Both DL Midway and DL Sandspit had one or more target(s) detected at each of five survey visits (Table 5.3-4). Newhalem, RL Roland and RL Little Beaver had one or more target(s) detected at four of five survey visits. DL Thunder Arm and GL Bridge had one or more target(s) detected at three of five survey visits, and RL Resort had one or more target(s) at two of five survey visits. A mean of 12.4 murrelet-type targets were detected per survey visit (n = 5), with the highest number of targets, 17, detected during Visit 4 (July 13-21, 2021), and the lowest number of targets, 3, detected during Visit 5 (July 22-26, 28-31, 2021).

Any portions of a survey session that were lost due to weather, boat shifting, or radar equipment issues were subtracted from the total survey period when calculating daily and hourly adjusted passage rates. To determine the adjusted daily passage rate for each survey visit, the count of murrelet-type targets was divided by the proportion of survey day (where 1.0 represents a complete survey day of 3 hours). The daily adjusted mean passage rate and standard error for all sites combined was 1.4 ± 0.2 targets/day (range 0.0 to 2.8), with the highest daily passage rate at DL Midway with 2.8 targets/day (Table 5.3-4). To determine the adjusted hourly passage rate, the count of murrelet-type targets was multiplied by 60 (minutes) and the sum then divided by the total minutes surveyed. Hourly adjusted mean passage rates for all sites combined was 0.5 ± 0.1 targets/hour, with the highest hourly passage rate at DL Midway with 0.9 ± 0.2 targets/hour, followed by DL Sand Spit with 0.8 ± 0.3 targets/hour. The highest adjusted hourly passage rate for a single survey was 2.0 targets/hour on May 22, 2021, at DL Sand Spit. Of the three radar sites on Ross Lake, RL Roland had the highest adjusted mean passage rate of 0.6 ± 0.2 targets/hour. The hourly adjusted mean passage rate at Newhalem was 0.5 ± 0.1 targets/hour, at GL Bridge was 0.2 ± 0.1 targets/hour, and at GL West End was 0.0 ± 0.0 targets/hour.

Table 5.3-4. Murrelet-type target counts, daily passage rates, and hourly passage rates by site and survey date.

Survey Site/Date		Survey Visit	Count of Murrelet-type Targets	Proportion of Survey Day	Daily Passage Rate[1] (targets/day) (adjusted)	Total Survey Length (min)	Hourly Passage Rate[1] (targets/hour) (adjusted)	Standard Error of Hourly Passage Rate
Newhalem/	5/21/2021	1	1	0.9	1.1	170	0.4	
	6/16/2021	2	2	1.0	2.0	180	0.7	
	6/23/2021	3	2	1.0	2.0	180	0.7	
	7/27/2021	4	2	1.0	2.0	180	0.7	
	7/31/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**7**	**4.9**	**1.4**	**890**	**0.5**	**0.1**
GL West End/	5/19/2021	1	0	1.0	0.0	179	0.0	
	6/15/2021	2	0	1.0	0.0	180	0.0	
	6/24/2021	3	0	1.0	0.0	180	0.0	
	7/18/2021	4	0	1.0	0.0	180	0.0	
	7/30/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**0**	**5.0**	**0.0**	**899**	**0.0**	**0.0**
GL Bridge/	5/20/2021	1	1	1.0	1.0	180	0.3	
	6/14/2021	2	1	0.9	1.1	168	0.4	
	6/25/2021	3	1	1.0	1.0	180	0.3	
	7/17/2021	4	0	1.0	0.0	180	0.0	
	7/29/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**3**	**4.9**	**0.6**	**888**	**0.2**	**0.1**
DL Sand Spit/	5/22/2021	1	6	1.0	6.0	180	2.0	
	6/13/2021	-	1	n/a	n/a	n/a	n/a	
	6/17/2021	2	1	1.0	1.0	180	0.3	
	6/26/2021	3	1	1.0	1.0	180	0.3	
	7/16/2021	4	3	1.0	3.0	180	1.0	
	7/28/2021	5	1	1.0	1.0	180	0.3	
	Total	**All**	**13**	**5.0**	**2.4**	**900**	**0.8**	**0.3**
DL Midway/	5/24/2021	1	2	1.0	2.0	180	0.7	
	6/12/2021	2	4	1.0	4.2	171	1.4	
	6/28/2021	3	3	1.0	3.0	180	1.0	

Survey Site/Date		Survey Visit	Count of Murrelet-type Targets	Proportion of Survey Day	Daily Passage Rate[1] (targets/day) (adjusted)	Total Survey Length (min)	Hourly Passage Rate[1] (targets/hour) (adjusted)	Standard Error of Hourly Passage Rate
	7/15/2021	4	4	1.0	4.0	180	1.3	
	7/26/2021	5	1	1.0	1.0	180	0.3	
	Total	**All**	**14**	**5.0**	**2.8**	**891**	**0.9**	**0.2**
DL Thunder Arm/	5/23/2021	1	0	0.6	0.0	108	0.0	
	6/11/2021	2	2	1.0	2.0	180	0.7	
	6/27/2021	3	3	1.0	3.0	180	1.0	
	7/14/2021	4	1	1.0	1.0	179	0.3	
	7/25/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**6**	**4.6**	**1.3**	**827**	**0.4**	**0.2**
RL Resort/	5/27/2021	1	1	0.9	1.2	156	0.4	
	6/10/2021	2	2	0.8	2.5	143	0.8	
	7/1/2021	3	0	1.0	0.0	175	0.0	
	7/21/2021	4	0	1.0	0.0	180	0.0	
	7/24/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**3**	**4.6**	**0.6**	**834**	**0.2**	**0.2**
RL Roland/	5/26/2021	1	3	1.0	3.0	180	1.0	
	6/9/2021	2	1	1.0	1.0	180	0.3	
	6/30/2021	3	2	1.0	2.0	180	0.7	
	7/13/2021	4	3	1.0	3.0	180	1.0	
	7/23/2021	5	0	1.0	0.0	180	0.0	
	Total	**All**	**9**	**5.0**	**1.8**	**900**	**0.6**	**0.2**
RL Little Beaver/	5/25/2021	1	2	1.0	2.0	180	0.7	
	6/8/2021	2	0	1.0	0.0	177	0.0	
	6/29/2021	3	1	1.0	1.0	180	0.3	
	7/20/2021	4	4	1.0	4.0	180	1.3	
	7/22/2021	5	1	1.0	1.0	180	0.3	
	Total	**All**	**8**	**5.0**	**1.6**	**897**	**0.5**	**0.0**
Total - All Sites Combined		**All**	**63**	**43.0**	**1.4**	**7926**	**0.5**	**0.1**

1 Daily Passage Rate/Hourly Passage Rate values listed under “Total” rows for each site, and “Total-all sites combined,” represent the mean daily passage rate/hourly passage rate.

5.3.4 Time of Detections

Sixty-seven percent (n = 42) of a total 63 murrelet-type targets were detected pre-sunrise (Figure 5.3-1, Table 5.3-5). Seven of nine radar sites, or 78 percent, had a majority of murrelet-type target detections before sunrise (Figure 5.3-1). Only one site, Newhalem, had a higher proportion, 71 percent, of post-sunrise (n = 5) detections to pre-sunrise (n = 2). Of the 42 pre-sunrise murrelet-type targets, 43 percent (n = 18) were Other, 36 percent (n = 15) were Outbound and 21 percent (n = 9) were Inbound flight directions. The 21 post-sunrise murrelet-type targets had a similar distribution of flight path directions; 57 percent (n = 12) were Other, 29 percent (n = 6) were Outbound and 14 percent (n = 3) were Inbound flights. The earliest detected target was recorded 98 minutes before sunrise at RL Little Beaver and was Outbound, while the earliest Inbound target was detected 78 minutes before sunrise. The mean timing of target movement was 24 ± 6.6 minutes before sunrise (mean ± SE). The mean timing of target movement for Inbound targets (n = 12) was 19 ± 6.7 minutes before sunrise, for Outbound targets (n = 21) was 38 ± 6.2 minutes before sunrise, and for Other targets (n = 30) was 16 ± 6.8 minutes before sunrise. Across all radar sites, survey Visit 1 (May 19-27, 2021) targets had the earliest mean detection time of 48 minutes before sunrise (n = 15), while survey Visit 4 (July 14-21 and 27, 2021) targets had the latest mean detection time of 7 ± 12.0 minutes post-sunrise (n = 17). For all sites combined, 54 percent of targets (n = 34) were detected during the pre-dawn (dark) periods of the survey sessions (Table 5.3-5).

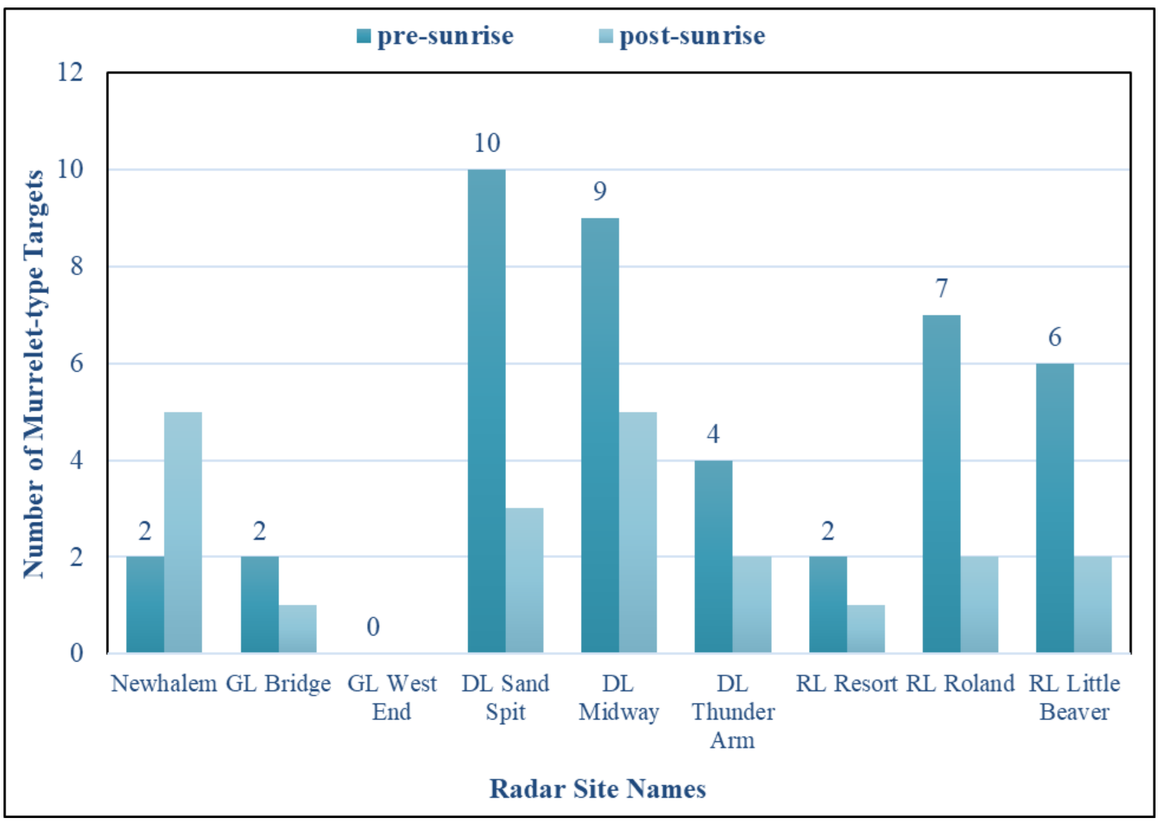

Figure 5.3-1. Time (pre-sunrise/post-sunrise) of murrelet-type target detections at each radar survey site.

Table 5.3-5. Timing of activity in relation to sunrise (15-minute periods) for murrelet-type target detections at each radar survey site.

	Minutes Before/After Sunrise											
Site Name	**-105 to -90**	**-90 to -75**	**-75 to -60**	**-60 to -45**	**-45 to -30**	**-30 to -15**	**-15 to 0**	**0 to 15**	**15 to 30**	**30 to 45**	**45 to 60**	**60 to 75**
Newhalem	-	1	1	-	-	-	-	-	2	1	1	1
GL Bridge	-	-	1	-	-	1	-	-	-	-	-	1
GL West End	-	-	-	-	-	-	-	-	-	-	-	-
DL Sand Spit	3	2	-	3	-	2	-	-	1	1	-	1
DL Midway	-	1	2	2	3	1	-	1	1	3	-	-
DL Thunder Arm	1	-	-	-	3	-	-	-	-	-	2	-
RL Resort	1	1	-	-	-	-	-	-	-	1	-	-
RL Roland	-	1	2	-	1	2	1	1	-	-	-	1
RL Little Beaver	2	1	-	1	1	-	1	-	1	-	-	1
Total	**7**	**7**	**6**	**6**	**8**	**6**	**2**	**2**	**5**	**6**	**3**	**5**

5.3.5 Flight Directions, Locations, and Behavior

While highly variable, the predominant flight direction of murrelet-type targets was Outbound (westward) during all survey sessions at all radar sites combined, with a mean flight direction of 270 degrees ± 35 degrees SE (n = 63).

- At Newhalem, the mean flight direction was 316 degrees ± 42 degrees (n = 7);
- At GL Bridge the mean flight direction was 73 degrees ± 43 degrees (n = 3);
- At DL Sand Spit the mean flight direction was 215 degrees ± 20 degrees (n = 13);
- At DL Midway the mean flight direction was 236 degrees ± 27 degrees (n = 14);
- At DL Thunder Arm the mean flight direction was 7 degrees ± 17 degrees (n = 6);
- At RL Resort the mean flight direction was 284 degrees ± 40 degrees (n = 3);
- At RL Roland the mean flight direction was 6 degrees ± 35 degrees (n = 9); and
- At RL Little Beaver the mean flight direction was 116 degrees ± 35 degrees (n = 8).

Forty-eight percent (n = 30) of murrelet-type targets detected had Other flight directions, while 19 percent (n = 12) had Inbound flight paths, and 33 percent had Outbound flight paths. DL Midway and DL Sandspit had the largest number of Outbound targets, with 7 targets and 5 targets, respectively (Figure 5.3-2). Other flight directions were the most common flight path at 6 out of 9 radar sites. Of the targets detected pre-sunrise, 41 percent were Other flight directions, 34 percent were Outbound, and 25 percent were Inbound. The post-sunrise-detected targets, while fewer in overall number (n = 19), had similar proportions of flight path direction types as pre-sunrise.

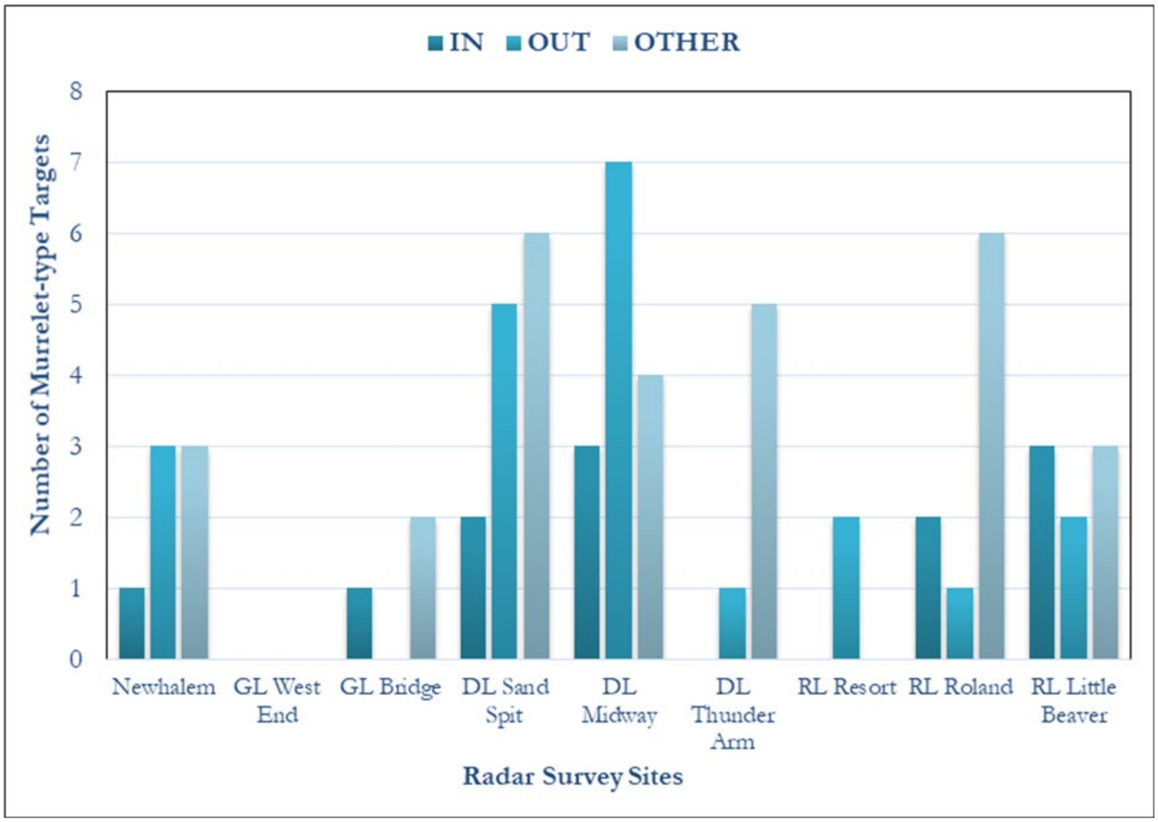

Figure 5.3-2. Inbound, Outbound, and Other flight path directions of murrelet-type targets by radar survey site.

Flight paths for each murrelet-type target were mapped at each of nine radar sites in the study area (Attachment D). Mapped flight path lines indicate the actual flight path length between the first and last location a murrelet-type target was detected by radar. The arrow indicates both the flight direction and last location the target was detected on the radar.

- At Newhalem, 6 of the 7 mapped murrelet-type targets were flying along Newhalem Creek, with 5 of the targets exiting the creek and 1 flying toward the creek;
- At DL Sand Spit 11 of 13 targets were flying along Diablo Lake, 9 of which were flying toward Gorge Lake and 2 toward the eastern portion of Diablo Lake;
- At DL Midway 6 of 14 targets were flying westerly toward Gorge Lake, 4 were flying toward Thunder Arm and 1 was flying from Thunder Arm;
- At RL Roland 3 of 9 targets were flying up Ross Lake, 2 were flying down Ross Lake and 2 were flying across the lake; and
- At RL Little Beaver 5 of 8 targets were flying across Ross Lake, 2 were flying down the lake and 1 was flying up the lake. No targets were documented flying up Little Beaver Creek corridor.

Flight behavior was recorded for each radar target as a straight, arcing, or circling flight path. A majority of murrelet-type targets were recorded with a straight flight path (92 percent, n = 58), with a small portion (8 percent, n = 5) exhibiting an arcing flight path, and none with a circling flight path.

5.3.6 Flight Speeds

Over the 2021 murrelet breeding season, a total of 63 targets were recorded in the study area with a mean flight speed of 91.9 kph (57.1 mph) with a range from 65.6-153.1 kph (40.8-95.1 mph). The fastest flight speed of 153.1 kph (95.1 mph) was exhibited by a target detected at the Newhalem site on June 16, 2021 at 5:57 am, with an Outbound flight path. Mean Inbound flight speeds for all sites was 81.1 kph (50.4 mph, n = 12). Mean Outbound flight speeds for all sites was 94.7 kph (58.8 mph, n = 21), and mean flight speed for targets with an Other flight direction was 96.9 kph (60.2 mph, n = 30).

Flight speeds of murrelet-type targets collected by radar were not adjusted for wind speed and direction, due to the variability of wind speeds and direction documented during each survey session. Weather information was collected at ground level using a hand-held weather unit at the start and end of each survey session. To properly account for wind speed and direction effects on flight speeds of murrelet-type targets detected by radar, weather data would need to be collected from an elevated source, such as a meteorological tower or weather station (Nelson et al. 2013).

5.3.7 Audio-Visual Surveys

Simultaneous AV surveys were conducted with radar surveys throughout the 2021 marbled murrelet breeding season (Table 5.3-6, Attachment D). For all surveys, the AV surveyor was located within open areas along road or reservoir edges, or an open field at Newhalem with canopy closure of 0 to 25 percent. All AV and radar survey sites were also located in valley bottoms or the lower third of slopes.

The AV surveyor did not have any visual or auditory detections of marbled murrelets during any of the murrelet breeding season surveys. However, the AV surveyor regularly observed other birds detected by radar, to confirm those targets as non-murrelets and eliminate them from consideration as potential murrelet-type targets. Commonly observed species included common nighthawk (*Chordeiles minor*) and bats during the dark periods of surveys; common raven (*Corvus corax*), band-tailed pigeon (*Columba fasciata*), and osprey (*Pandion haliaetus*) were commonly observed during the light periods (Table 5.3-7). Various waterfowl were also observed during surveys, including Canada goose (*Branta canadensis*), common merganser (*Mergus merganser*), and common loon (*Gavia immer*).

Table 5.3-6. Audio-visual survey locations and basic descriptions.

Radar Site Name	AV Site	UTM Location[1]	Elevation (m)	Position on Slope	Canopy Cover	Visit
Newhalem	1	628716, 5392515	166	Bottom	0-25%	All
GL West End	1	632368, 5395797	331	Middle	0-25%	All
GL Bridge	1	635182, 5397007	278	Bottom	0-25%	1
	2	635055, 5396871	279	Bottom	0-25%	2,4,5

Radar Site Name	AV Site	UTM Location[1]	Elevation (m)	Position on Slope	Canopy Cover	Visit
	3	635530, 5397280	264	Bottom	0-25%	3
DL Sand Spit	1	638164, 5398024	384	Bottom	0-25%	All
DL Midway	1	639803, 5397763	386	Bottom	0-25%	All
DL Thunder Arm	1	639787, 5395127	387	Bottom	0-25%	All
RL Little Beaver	1	641108, 5419758	471	Bottom	0-25%	1
	2	641101, 5419736	483	Lower	0-25%	2
	3	641101, 5419749	491	Lower	0-25%	3,4,5
RL Roland Point	1	644204, 5403972	497	Bottom	0-25%	1
	2	642564, 5404193	497	Bottom	0-25%	2
	3	642585, 5404219	500	Bottom	0-25%	3
	4	642552, 5404253	500	Bottom	0-25%	4,5
RL Resort	1	643993, 5400160	486	Lower	0-25%	1,2
	2	642446, 5399781	482	Bottom	0-25%	3,4,5

1 Universal Transverse Mercator (UTM) coordinates in North American Datum of 1983 (NAD 83) projection coordinate system; all locations in Zone 10N.

Table 5.3-7. Avian species regularly observed during audio-visual surveys.

Common Name	Scientific Name	Notes
Common raven	*Corvus corax*	Most commonly seen on radar
Common nighthawk	*Chordeiles minor*	Most commonly seen on radar pre-sunrise
Band-tailed pigeon	*Columba fasciata*	Commonly observed on radar after sunrise
Osprey	*Pandion haliaetus*	Commonly observed on radar around sunrise
Canada goose	*Branta canadensis*	Occasionally seen on radar at RL Little Beaver, RL Roland and DL Sand Spit
Bald eagle	*Haliaeetus leucocephalus*	Occasionally seen on radar
Common merganser	*Mergus merganser*	Occasionally seen on radar at DL and RL sites
Common loon	*Gavia immer*	Occasionally seen on radar at RL sites
Western gull	*Larus occidentalis*	Occasionally seen on radar
Violet-green swallow	*Tachycineta thalassina*	Likely to see on radar post-sunrise
Northern rough-winged swallow	*Stelgidopteryx serripennis*	Likely to see on radar post-sunrise
Barn swallow	*Hirundo rustica*	Likely to see on radar post-sunrise
Spotted sandpiper	*Actitis macularius*	Close to shore & low when flying
American robin	*Turdus migratorius*	
Barred owl	*Strix varia*	
Brown creeper	*Certhia americana*	
Canada jay	*Perisoreus canadensis*	
Cedar waxwing	*Bombycilla cedrorum*	
Dark-eyed junco	*Junco hyemalis*	
European starlings	*Sturnus vulgaris*	
Great-blue heron	*Ardea herodias*	
Hairy woodpecker	*Picoides villosus*	
Hermit thrush	*Catharus guttatus*	
Northern flicker	*Colaptes auratus*	
Pacific wren	*Troglodytes pacificus*	
Pacific-slope flycatcher	*Empidonax difficilis*	
Pileated woodpecker	*Dryocopus pileatus*	
Spotted towhee	*Pipilo maculatus*	
Steller's jay	*Cyanocitta stelleri*	
Swainson’s thrush	*Catharus ustulatus*	
Varied thrush	*Ixoreus naevius*	
Western tanager	*Piranga ludoviciana*	
White-crowned sparrow	*Zonotrichia leucophrys*	
Yellow warbler	*Dendroica petechia*	

6.0 DISCUSSION AND FINDINGS

This study has met the objectives stated in the RSP and presented in Section 2.0 of this study report. These objectives included: (1) developing a map of potentially suitable murrelet nesting habitat; (2) selecting radar-based survey sites that cover potentially suitable murrelet nesting habitat and areas of Project facilities and activities upriver of Thornton Creek; (3) conducting limited habitat assessments to verify the accuracy of habitat mapping; and (4) conducting simultaneous ornithological radar and AV surveys at selected sites to assess the likelihood of a presence of marbled murrelets and, if present, their abundance at radar sites.

This ornithological radar and AV study was located well-outside (far inland) of areas considered to be high-use or highly suitable for marbled murrelet nesting and occurrence (USFWS 1997). The westernmost radar site, Newhalem, was located 93.2 km (57.9 miles) east of Padilla Bay Estuary, and is beyond the 50-mile zone generally considered to be the farthest distance from saltwater for nesting marbled murrelets in Washington (USFWS 1997). In the Northern Washington Cascades, 90 percent of all observations have been made within 37 miles of the coast (57 FR 15328). Prior to this study, marbled murrelets have only been documented within the Project reservoirs once on Ross Lake by NPS in 2017, though a 2008-2009 radar and AV study conducted by Hamer Environmental (2010) detected murrelet-type targets by radar and confirmed AV detections of marbled murrelets on Thornton Creek, 3 km (2 miles) from the Gorge Dam Powerhouse, and also detected murrelet-type targets by radar at the mouth of Bacon Creek within the Project transmission line ROW. This radar and AV study focused coverage on areas closest to Project activities and did not address areas of potentially suitable murrelet habitat further west within the Stillaguamish and Sauk watersheds where sections of the Project transmission line ROW and most fish and wildlife mitigation lands occur.

6.1 Potentially Suitable Marbled Murrelet Nesting Habitat Model

Existing marbled murrelet habitat models have been created over the years, using a number of different variables, to model the extent of potentially suitable habitat. Early habitat suitability models were very basic and simply included suitable northern spotted owl (*Strix occidentalis caurina*) habitat with an inland distance from marine waters threshold. Other models have since been created, using a range of different variables to try and identify potentially suitable habitat on a larger scale. These models, including various iterations devised as part of the Northwest Forest Plan's Effectiveness Monitoring (McShane et al. 2004; Spies et al. 2018), centered around a range of different variables, many of which were provided by forest plot data collected in the field. These variables included tree dbh, tree height, and number of potential nesting platforms. Smaller regional models, such as Mather et al. (2010), utilized similar variables to the Northwest Forest Plan models. Given the absence of large-scale forest habitat data collected in the field within the study area, a habitat suitability model similar to those previous models was not possible. Instead, the Murrelet Habitat Model developed in this study relied on remotely sensed data and a small sample of field habitat assessment plot data centered around the radar study conducted in 2021, with stand age, tree height, and the presence of conifers as the variables driving this study's Murrelet Habitat Model.

The Murrelet Habitat Model found the greatest proportion of potentially suitable nesting habitat in the northeastern portions of the study area, particularly within the Ross Lake and Diablo Lake sub-segments of the RLNRA study area segment at the far inland extent of the known range for the marbled murrelet. The lowest quantity of potentially suitable nesting habitat was found in the southwestern portions of the study area, along the transmission line ROW segments from Oso to the Bothell Substation and had a patchy distribution (Attachment C). The parameters of the Murrelet Habitat Model were intentionally conservative to avoid excluding any suitable habitat, deeming forest stands containing conifer trees 60 years and older, and 85 ft or taller as potentially suitable nesting habitat.

Trees in the Pacific Northwest, however, do not typically attain platforms suitable for nesting until they are 200 to 250 years old (61 FR 26256), and Hamer and Nelson (1995) found a mean age of 522 years (range of 180-1,824 years) for 16 nest trees in the Pacific Northwest. However, younger forest stands, particularly those with mistletoe infections or damage, can sometimes provide suitable structures for nesting, as found in Oregon with two nest trees in 60- to 70-year stands of mistletoe-infected conifers (Nelson 1997). A mean forest stand age within the study area of 273 years (range of 60 to 506 years) indicates that many of the areas mapped as potentially suitable are old enough to have likely developed platforms suitable for marbled murrelet nesting (see Section 5.1 of Results). However, the single most important factor for determining marbled murrelet nesting habitat is the presence of suitable nesting platforms, which cannot be assessed to confirm nesting habitat suitability without ground-based field verifications conducted by a trained biologist. Since the Murrelet Habitat Model is conservative, it is likely that some of the mapped habitat quality is only marginally suitable, and the field habitat assessments completed during this study were too limited to assess quality of potentially suitable nest habitat for the study area.

6.2 Audio-Visual Surveys

No murrelets were detected by the AV surveyor during the course of 45 simultaneous surveys conducted at radar sites throughout the 2021 breeding season. This outcome is not unusual considering both the smaller area of coverage an AV surveyor can survey (200 m [656 ft] visual distance) compared to that of the radar (up to 1.5 km [0.9 mile]) and that the dark periods (105 to 46 minutes before sunrise) during the pre-sunrise portion of each survey session further limit visibility by the AV surveyor, despite use of night vision equipment. Other radar and AV studies conducted in western Washington have had comparable results of detections of murrelets by radar without any AV observations made during simultaneous surveys (Cedar River Municipal Watershed study by Cooper et al. 2005; Skookumchuck Wind study by Sanzenbacher et al. 2015). Further, the mean daily rate of murrelet-type targets detected by radar was very low at 1.4 ± 0.2 targets per day (range of 0 to 2.8 targets per day), so very few opportunities existed during each survey session for the AV surveyor to detect a marbled murrelet.

At 27 high-quality habitat sites in Washington and Oregon where simultaneous radar and AV surveys were conducted, Cooper and Blaha (2002) found between 10 and 23 percent of all radar targets were detected by the AV surveyor, though "amongst site" and "amongst surveyor" variation was high. The 10 to 23 percent radar target verification rate of the Cooper and Blaha (2002) surveys has some important caveats relevant to this study: (1) those surveys were conducted in high-quality habitats within 30 miles of the coast, with documented murrelet nesting at each site; (2) only radar targets detected within 200 m (656 ft) of the AV surveyor were included in the analysis to assure the AV surveyor had an opportunity to detect the target; (3) only radar targets flying inbound/outbound or over a site, but not transiting through a site were included; and (4) only a two-hour survey period (45 minutes before to 75 minutes after sunrise) of a standard inland AV survey was used, compared to the three-hour survey period (105 minutes before to 75 minutes after sunrise) of this study. Cooper and Blaha (2002) found that this period of 105 to 46 minutes before sunrise, though completely dark and thus discounted from AV and radar verifications, accounted for 25 percent of all daily murrelet detections. Given the low daily rate of murrelet-type targets detected by radar, and that targets appeared to be in transit along waterways versus flying into forest stands for nesting, no AV detections of marbled murrelets during this study may be typical of far inland, very low use sites.

The AV surveyor commonly identified other birds, including common nighthawk during the dark periods, and common raven, band-tailed pigeons, and osprey during the light periods of survey sessions post-sunrise (Table 5.3-7). The surveys were conducted according to PSG protocol, but the probability of detection of murrelets at far inland areas like this study area, and at some distance from potentially suitable nesting habitat, is not known (Evans Mack 2003).

6.3 Radar Surveys

6.3.1 Radar Survey Site Selection and Survey Conditions

Under ideal survey conditions, radar sites are positioned along ridgelines or other open areas to allow unobstructed views by the radar in all directions out to 1.5-km (0.9 mile). However, the RLNRA has steep, mountainous topography with limited access to areas to locate radar sites. To capture potential murrelet flyways and Project-operation facilities, some sites were unavoidably located in steep valleys and others were conducted by boat on Project reservoirs. Clutter maps created for each radar site showed the spatial limitations of radar coverage due to topographic features (Attachment B). The 2008 radar study conducted in North Cascades National Park at the west end of the RLNRA included some radar sites with similar topographic locations, and, likely, a similarly high proportion of clutter (though clutter was not mapped for the 2008 study), with one site on SR 20, and two others along the shorelines of lakes (Baker Lake and Chilliwack Lake) (Hamer Environmental 2010).

Radar sites surveyed for this study all had excellent radar coverage of the waterways they were located on or adjacent to (and good opportunity to detect murrelet-type targets over water) but were more variable in their coverage of forested areas of potentially suitable marbled murrelet nesting habitat. A good portion (≥ 20 percent) of potentially suitable habitat was clear of clutter at RL Roland, DL Midway, DL Thunder Arm, DL Sand Spit, and Newhalem, which provided an opportunity to detect radar targets flying over land (Attachment B). Conversely, RL Little Beaver, RL Resort, GL Bridge, and GL West End had little potentially suitable habitat that was uncluttered (unobscured), which was limited to low-lying areas adjacent to waterways. Since murrelets are more likely to use open corridors for travel (i.e., areas over waterways) the radar survey sites were optimized to assess the likelihood of presence of marbled murrelets, rather than use of potential nest stands.

While clutter was present at sites in forested areas and steeper slopes, the locations where murrelets are most likely to be flying (over waterways) had little clutter and were unobscured at all sites. Boat-based surveys conducted within the RLNRA portion of the study area presented unique challenges that required careful planning and coordination with City Light for access onto and off of Diablo and Ross lakes. Weather and water conditions changed rapidly on Diablo and Ross lakes, with gusty winds of variable directions and frequently choppy lake conditions. These conditions, combined with strong currents and rapidly rising water levels in May and June, caused the boat and radar lab to periodically swing and shift, increasing clutter on the radar screen and making data collection sometimes difficult.

6.3.2 Radar Survey Findings

Since no marbled murrelets were identified during the simultaneous AV surveys, an accuracy rate for the 63 radar detected murrelet-type targets could not be calculated. Beyond initial filters applied to remove non-murrelet targets, including flight speed and target echo size (described in Section 4.3.3.1), several factors were analyzed to assess the likelihood that radar detections of murrelet-type targets were actually marbled murrelets, whether they were present at each site, and how they used the study area. These factors included the timing of detection, flight speed, flight direction, flight behaviors, and passage rates. The most important factor in determining likelihood of murrelet presence was the timing of activity. Marbled murrelets start flying inland as much as 105 minutes before sunrise when most other birds are not yet active, common nighthawks being the primary exception (Cooper and Hamer 2003). No other shorebirds or seabirds would likely be flying inland as early as a marbled murrelet (Colclazier et al. 2010). Therefore, targets flying inland pre-sunrise are more likely to be murrelets, and pre-sunrise detections comprised 68 percent (n = 42) of detections, indicating high confidence that they were marbled murrelets. The survey protocol for studies of murrelets at wind energy developments (Nelson et al. 2013) bases all passage rates on only those targets detected pre-sunrise. This was done to increase confidence in the elimination of non-murrelet targets, which has also been done in several previous studies (extrapolating passage rates to cover the post-sunrise portion of the survey period) (Burger 2001; Cooper et al. 2005; Sanzenbacher et al. 2015). Of note, 63 murrelet-type targets are not necessarily equivalent to 63 marbled murrelets, as a single bird can be detected more than one time per survey session due to their inbound-outbound flight paths between inland nesting and marine foraging sites. Conversely, a single murrelet-type target detected by radar can represent more than one bird if multiple birds are flying in a tight formation that does not separate over the course of their flight path as detected by radar.

Murrelet flight speeds can range from 64 to over 113 kph (40 to over 70 mph), so the faster a target was flying above the minimum speed threshold, the more likely the target was a marbled murrelet. All murrelet-type targets recorded were flying at speeds fast enough to be considered marbled murrelet targets. The average flight speed of murrelet-type targets detected during this survey effort of 91.9 kph (57.1 mph) was higher than the average 84.9 kph (50.9 mph) flight speed for murrelet-type targets recorded during a 2008 study in North Cascades National Park at the western end of the RLNRA (Hamer Environmental 2010). Similar to the findings of a murrelet radar study in British Columbia by Burger (2001), mean outbound flight speeds of murrelet-type targets in this study were faster at 94.7 kph (58.8 mph) than mean inbound flight speeds 81.1 kph (50.4 mph).

This pattern of faster outbound than inbound flight speeds is typical, as marbled murrelets lose altitude flying from inland nest sites outbound to the ocean. In addition, daily murrelet-type detections usually show a pulse of early inbound (eastward) detections and then a pulse of outbound (westward) detections sometime later in the morning—though this pattern may be different at far inland sites like this study area. The difference between the inbound and outbound flight times is due to the time it takes the birds to fly inland to exchange incubation duties and feed their young.

Due to the low overall radar detection rates of this study, no inbound and outbound detection patterns were discernable at individual sites, but the earliest inbound detection was recorded 78 minutes before sunrise, and the earliest outbound target was detected 98 minutes before sunrise, counter to the pattern typically found. In further contrast to this expected pattern, 47 percent (n = 30) of targets detected had Other flight paths, meaning they fell outside of the eastward/westward flight directions. Possibly, the far inland nature of the study area and the steep and variable topography of the RLNRA caused murrelets to use different flight paths for inbound and outbound flights than exhibited in coastal forest areas. The north-south orientation of Ross Lake, Diablo Lake's Thunder Arm, and varying orientation of associated creeks and streams may further explain why many murrelet-type targets exhibited flight directions not classified as Inbound or Outbound. Despite the atypical pattern of flight directions, having 68 percent (n = 42) of the murrelet-type targets detected before sunrise, combined with their flight speed, and echo size and shape, provides high confidence that the majority of the murrelet-type targets were marbled murrelets.

Even when targets meet all criteria for being considered a potential marbled murrelet, it is possible that some radar detections were other species, such as small waterfowl or shorebirds. Although infrequent, ducks, loons, and band-tailed pigeons that can fly at speeds comparable to murrelets were occasionally visually observed during and after radar and AV surveys, providing evidence that some of the 63 murrelet-type targets, especially those detected after sunrise, could be other species. Band-tailed pigeons are commonly confused with marbled murrelets by radar, but band-tailed pigeons typically do not become active until 20 minutes after sunrise. Further, band-tailed pigeons can usually be discerned from murrelet targets on radar by their flocking habit (showing up as multiple targets splitting and regrouping throughout their flights), and their distinct echo shape that is rectangular in contrast to the round echo of the marbled murrelet. The common nighthawk is the only non-murrelet bird regularly detected by radar during the dark period of the survey morning at non-coastal sites, but their flight speeds are usually well below the minimum threshold. In addition, common nighthawks exhibit bat-like, erratic flight behavior patterns distinctly different from the direct flight paths of murrelets. Waterfowl are the most difficult to differentiate from marbled murrelets, as they have similarly dense bodies, and their flight speeds can also exceed 64 kph (40 mph), but they are typically active during only the light portions of the day. Due to presence of other avian species that can be confused with marbled murrelets documented during radar and AV surveys, there is a lower confidence that all of the 19 murrelet-type targets detected after sunrise were marbled murrelets.

Combined, all sites had a mean passage rate of 1.4 ± 0.2 murrelet-type targets per survey morning, which was less than half of the mean passage rate of 3.3 murrelet-type targets per survey morning at six sites surveyed by radar in 2008 at the western end of the RLNRA in North Cascades National Park (Hamer Environmental 2010). Radar data on marbled murrelets collected from 12 watersheds in high-quality habitats on the Olympic Peninsula of Washington from 1996 to 2004 had mean counts of inbound flights ranging from 30 to 150 targets per morning (Cooper et al. 2006). Data from five independent radar studies, which surveyed 108 watersheds in British Columbia, had mean annual maximum counts that varied from 7 to 1,005 targets per morning (Burger 2002). Of these 108 sites, 91.7 percent had ≥ 20 detections per survey morning (mean annual maximum count). Those studies only counted inbound birds (birds flying in an easterly direction), whereas this study counted all birds regardless of flight direction (Inbound, Outbound, or Other). However, the most important difference from the earlier radar studies is the location of this study area, which is far inland compared to the near-coastal regions of the other studies. In comparison to radar studies conducted in other regions of the Pacific Northwest, these detection rates for marbled murrelets can be considered very low.

Notably, no murrelet-type targets detected by radar exhibited circling flight paths, usually documented during the breeding season near marbled murrelet nesting locations as an indicator of nesting activity. Most targets, 92 percent, exhibited straight flight paths, and were also documented over water (not land), further indicating these targets were using the waterways for transiting the area (Attachment D). The findings of this study indicate with high confidence that a very small number of marbled murrelets are likely using the upper Skagit River, Diablo Lake, and Ross Lake waterways as travel corridors to transit through the Project Boundary. Only two of the radar sites, DL Midway and DL Sand Spit, had one or more murrelet-type target detected on every survey visit, but Newhalem, RL Little Beaver, and RL Roland each had one or more murrelet-type target(s) detected on four of five survey visits. Though detection rates were low at each of these five sites, the regular detection of targets on four or all five visits throughout the breeding season serves as another indicator of likely use of these sites as flyways by transiting marbled murrelets. Further, for all sites combined, the highest number (n = 17) of murrelet-type targets detected during Visit 4 (July 13-21, 27, 2021) followed by the lowest number (n = 3) of murrelet-type targets during Visit 5 (July 22-26, 28-31, 2021) corresponds to the expected peak of murrelet detections as nestlings begin to fledge (July 15-21, 2021) followed by a steep decline in subsequent weeks (July 22-28, July 29-August 5, 2021) as the final nestlings fledge and adults stop visiting nest sites and begin a full body molt that reduces their ability to fly long distances (Baldwin 2001; Hamer 2022).

The study team reached out to biologists conducting marbled murrelet survey work in 2021 to assess the 2021 breeding/nesting season in relation to weather and climatic factors that may have an impact on breeding (as described in Section 2.8 of the RSP). Biologists in Washington and Oregon have noted that detection rates for the 2021 Inland Survey Season were promising compared to years associated with El Niño conditions and the presence of the warm water Blob of the West Coast. City Light will confirm this assessment when the 2021 Inland Survey Season results are available in spring 2022. Unless 2021 is shown by regional monitoring to have been a poor year for breeding, no further marbled murrelet surveys are proposed. Site-specific AV surveys may be warranted in the future if Project-related work is located adjacent to suitable nesting habitat.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

7.1 Potentially Suitable Marbled Murrelet Nesting Habitat Model Data Variance

One variance from the methodology described in the study plan for the Murrelet Habitat Model was made to ensure the study goals and objectives were met. A GIS data layer of old growth forest derived from LiDAR was to be used to map potential murrelet habitat; however, this data layer did not provide full coverage of the study area and was at an extremely fine resolution that required further data analyses to aggregate to a scale compatible with other model data layers. Therefore, Washington DNR data layers of maximum tree height and stand age were utilized to select older forest stands (over 60 years of age) with trees tall enough (at least 26 m [85 ft]) to support potential murrelet nesting platforms (Washington DNR 2021). The Washington DNR GIS data layers are at a suitable and relatively fine resolution, 20 m by 20 m (66 ft by 66 ft) for the model analysis, and they cover the entirety of the study area. The data layers used are derived from field measurements and remotely sensed data, and are updated every two years, making them robust data sources for the Murrelet Habitat Model. The DNR datasets meet the intent of the proposed method.

7.2 Radar Data Processing and Analysis Variance

Manual tracking of targets by an experienced radar technician supplemented the use of automated radar tracking software. Although the RSP described the use of automated radar target tracking alone, manual tracking provided superior results. The automated radar tracking data were dismissed in favor of the manual tracking data for the following reasons. Presence of minor wave clutter during some portions of an automated survey created false radar target tracks that were difficult to filter out without eliminating the area from analysis for the full length of the survey. Additionally, clutter from surrounding landforms shifted when wind, waves, or currents shifted the direction of the boat, and similarly was difficult to eliminate from automated analysis. Further, side-by-side tests of several survey sessions indicated that automated target tracking sometimes missed a potential murrelet-type target compared to manual tracking recorded by the radar technician. These missed targets were due to presence of ground clutter or because a target track skipped an echo, creating smaller three-echo tracks by a single target that were excluded by the automated software target track parameters. For these reasons, radar data collected manually by the radar technician was used and carefully reviewed and refined by the data analyst during manual review of the radar data survey session recordings. The use of manual tracking in lieu of automated target tracking software met the goals and objectives of the study plan and was a positive impact on the resulting analysis. City Light met the intent of the study plan by using manual tracking, and the goals and objectives of this study were accomplished.

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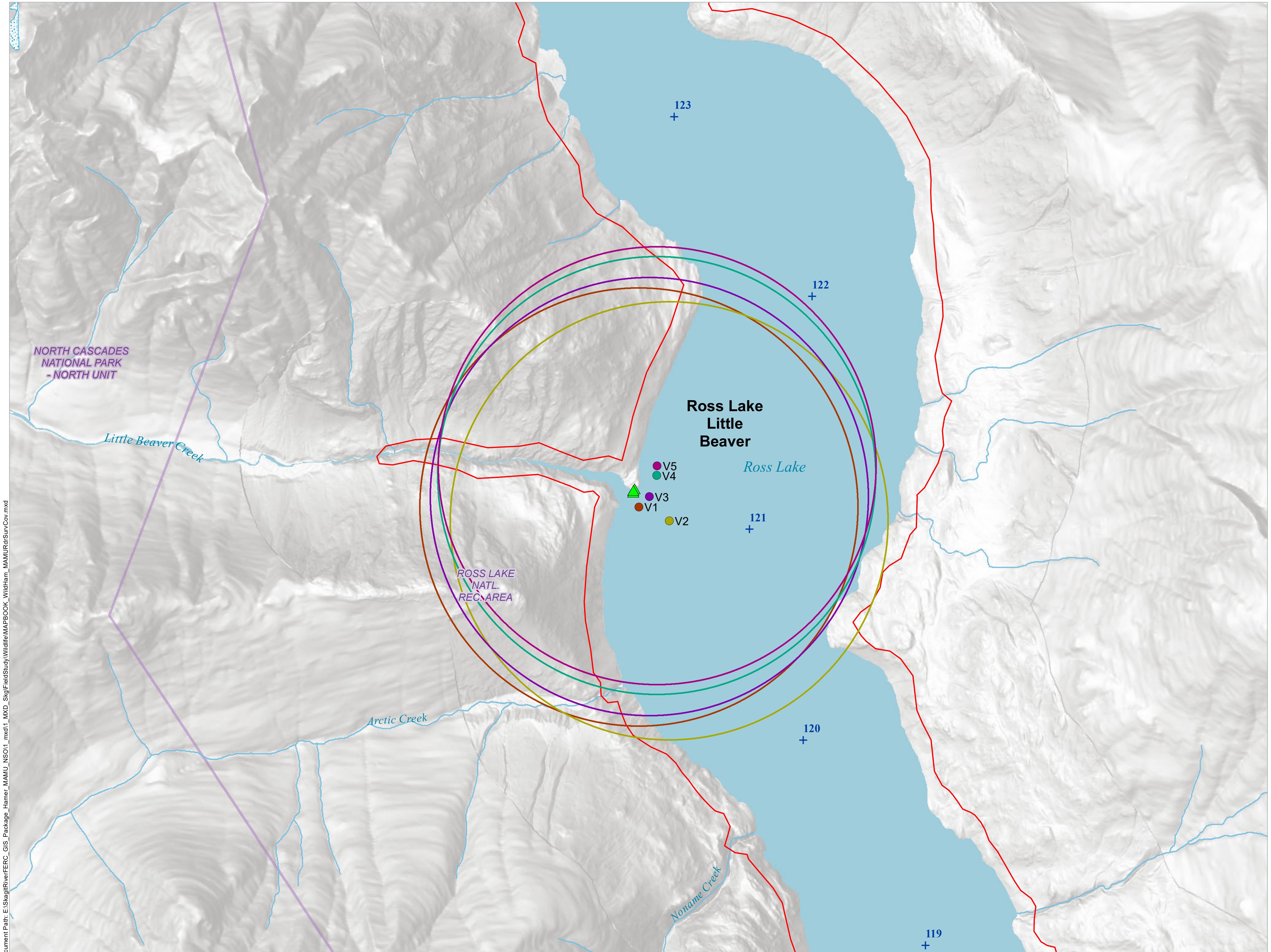
MARBLED MURRELET STUDY DRAFT REPORT

ATTACHMENT A

MARBLED MURRELET RADAR SURVEY COVERAGE AND AUDIO-VISUAL OBSERVER LOCATION MAPBOOK

TR-05 MARBLED MURRELET STUDY RADAR SURVEY COVERAGE & AV SURVEYOR LOCATION MAPBOOK



FERC Project Boundary

Project River Miles (PRM)

National Park / National Recreation Area Boundary

Audio Visual Surveyor

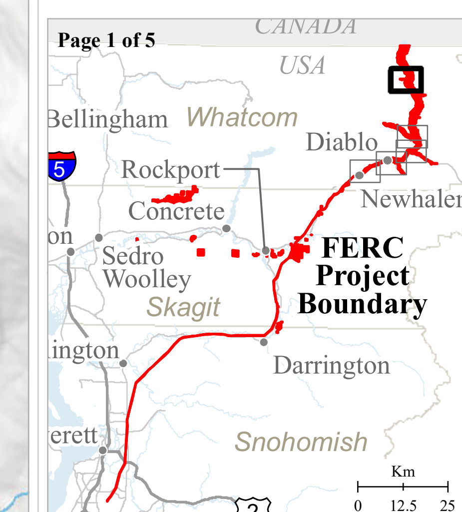
Radar Survey Site

- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5

Radar Range (3 km diameter)

- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5

0 0.25 0.5 0.75
Kilometers



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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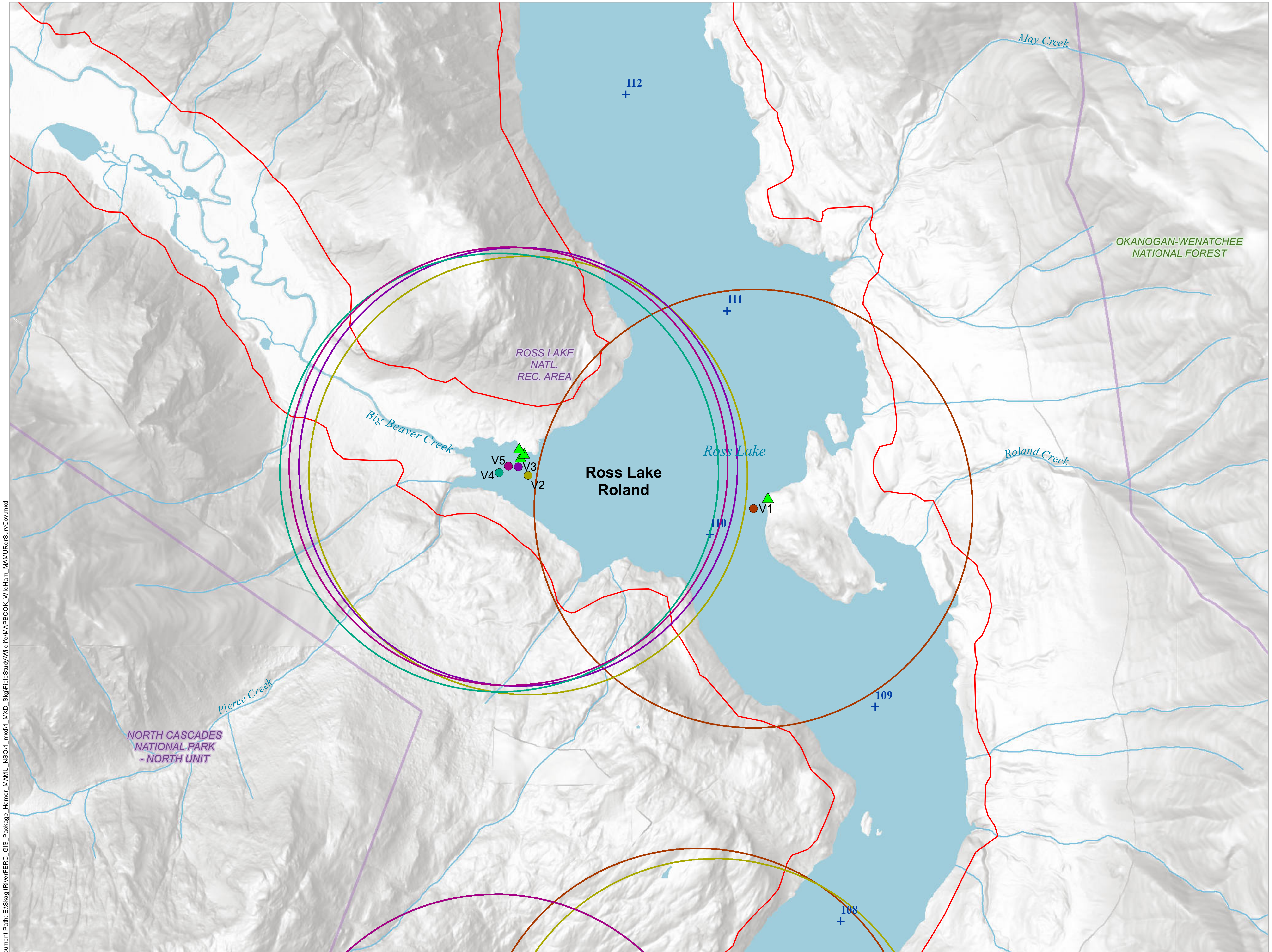
TR-05 MARBLED MURRELET STUDY RADAR SURVEY COVERAGE & AV SURVEYOR LOCATION MAPBOOK



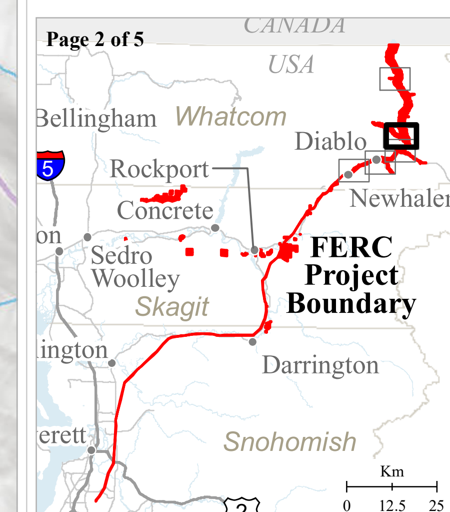
FERC Project Boundary
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Audio Visual Surveyor

Radar Survey Site
- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5

Radar Range (3 km diameter)
- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5

0 0.25 0.5 0.75
Kilometers

Page 2 of 5



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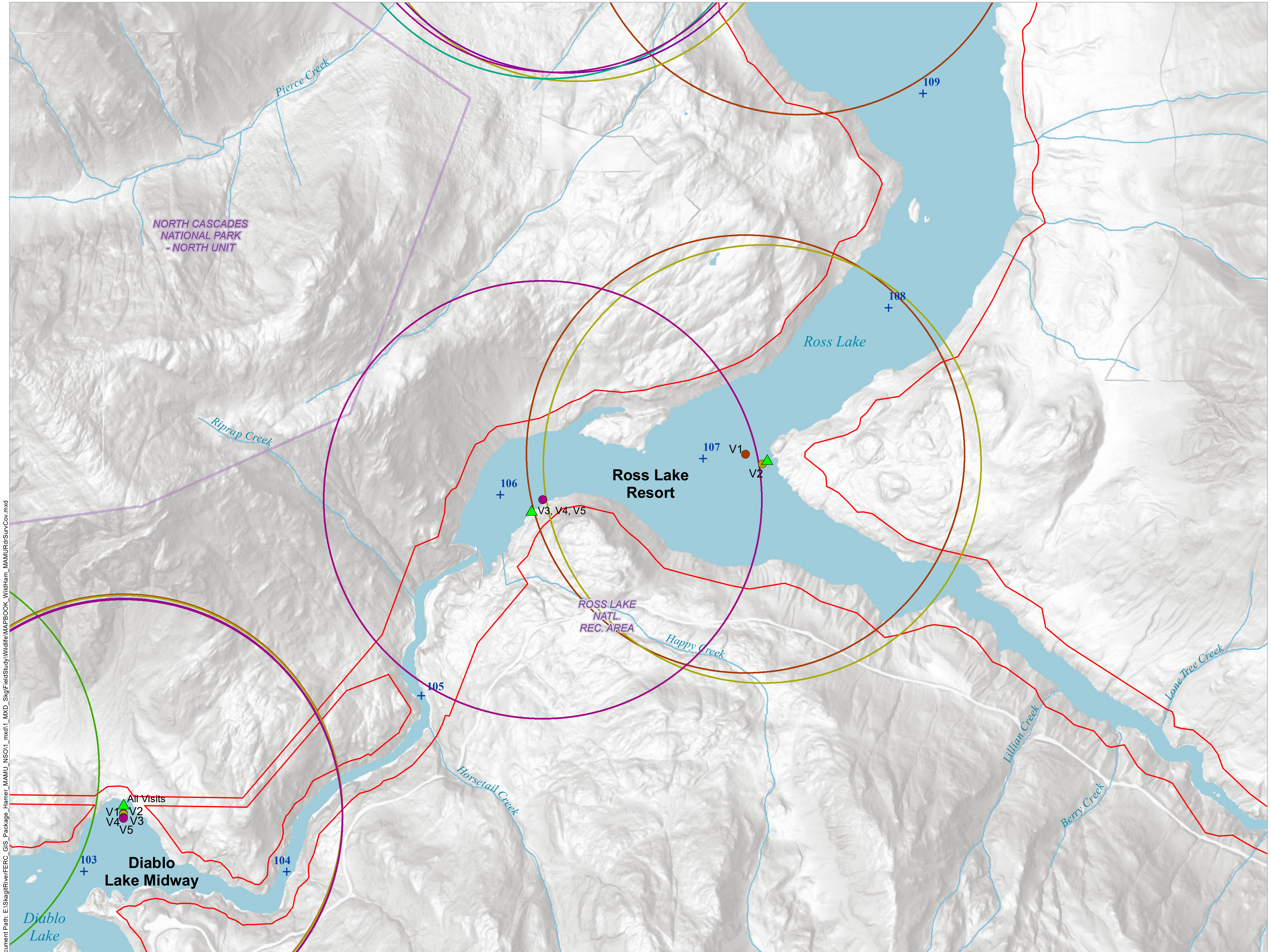
TR-05 MARBLED MURRELET STUDY RADAR SURVEY COVERAGE & AV SURVEYOR LOCATION MAPBOOK



- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Audio Visual Surveyor

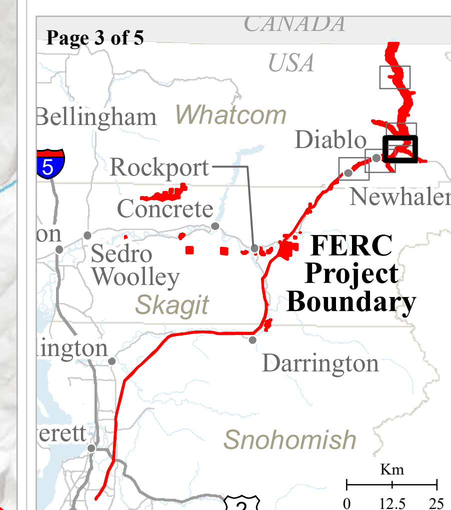
Radar Survey Site

- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5

Radar Range (3 km diameter)

- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5
- All Visits

0 0.25 0.5 0.75
Kilometers



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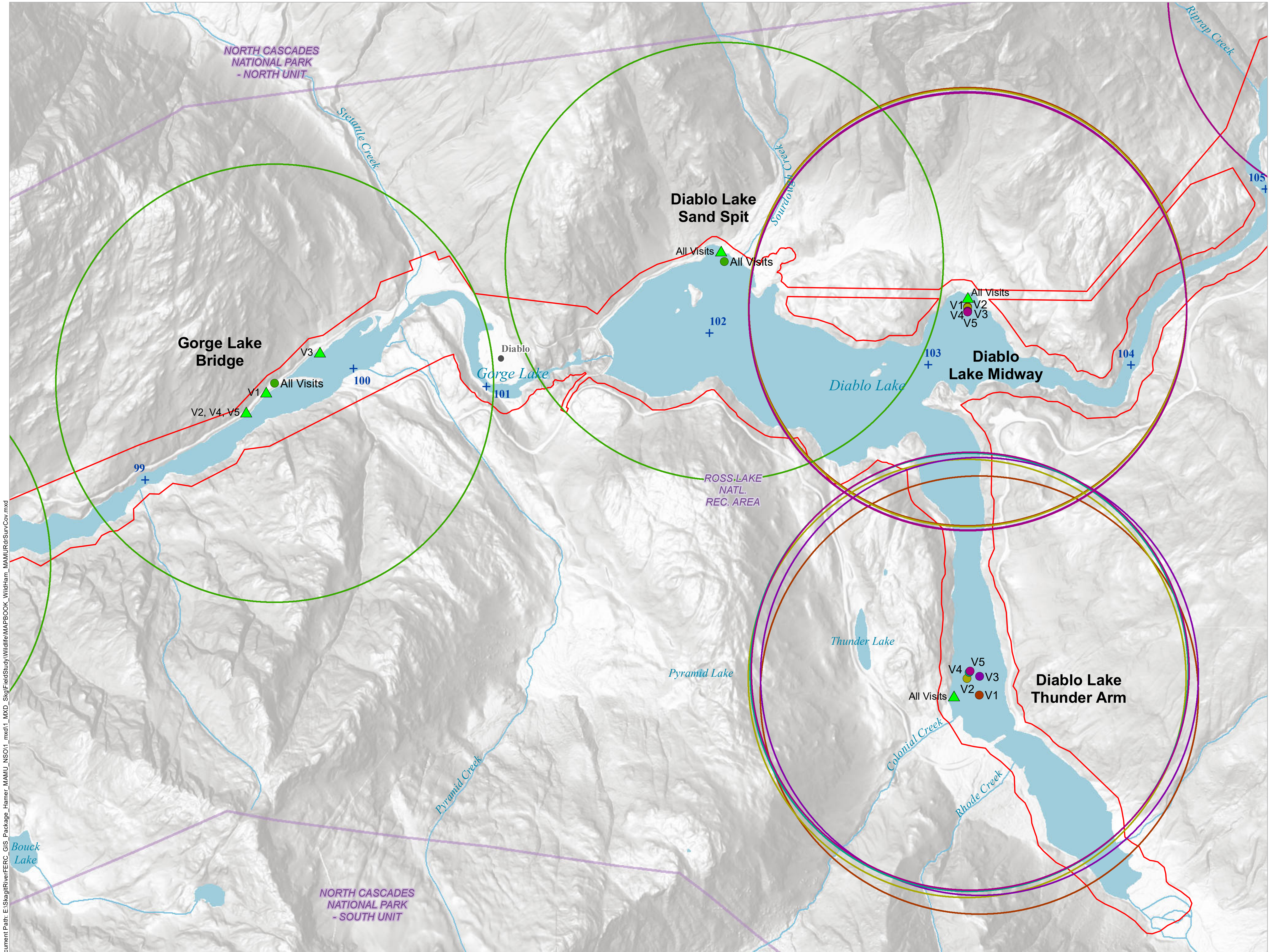
Document Path: E:\SkagitRiverFERC_GIS_Package_Hamer_MAMU_NSO\1_mxd\1_MXD_SkagFieldStudy\Wildlife\MAPBOOK_WildHam_MAMURdrSurvCov.mxd



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TR-05 MARBLED MURRELET STUDY RADAR SURVEY COVERAGE & AV SURVEYOR LOCATION MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Audio Visual Surveyor

Radar Survey Site

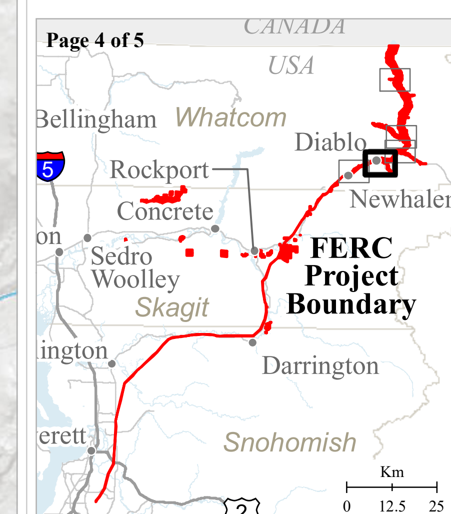
- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5
- All Visits

Radar Range (3 km diameter)

- Visit 1
- Visit 2
- Visit 3
- Visit 4
- Visit 5
- All Visits

0 0.25 0.5 0.75
Kilometers

N



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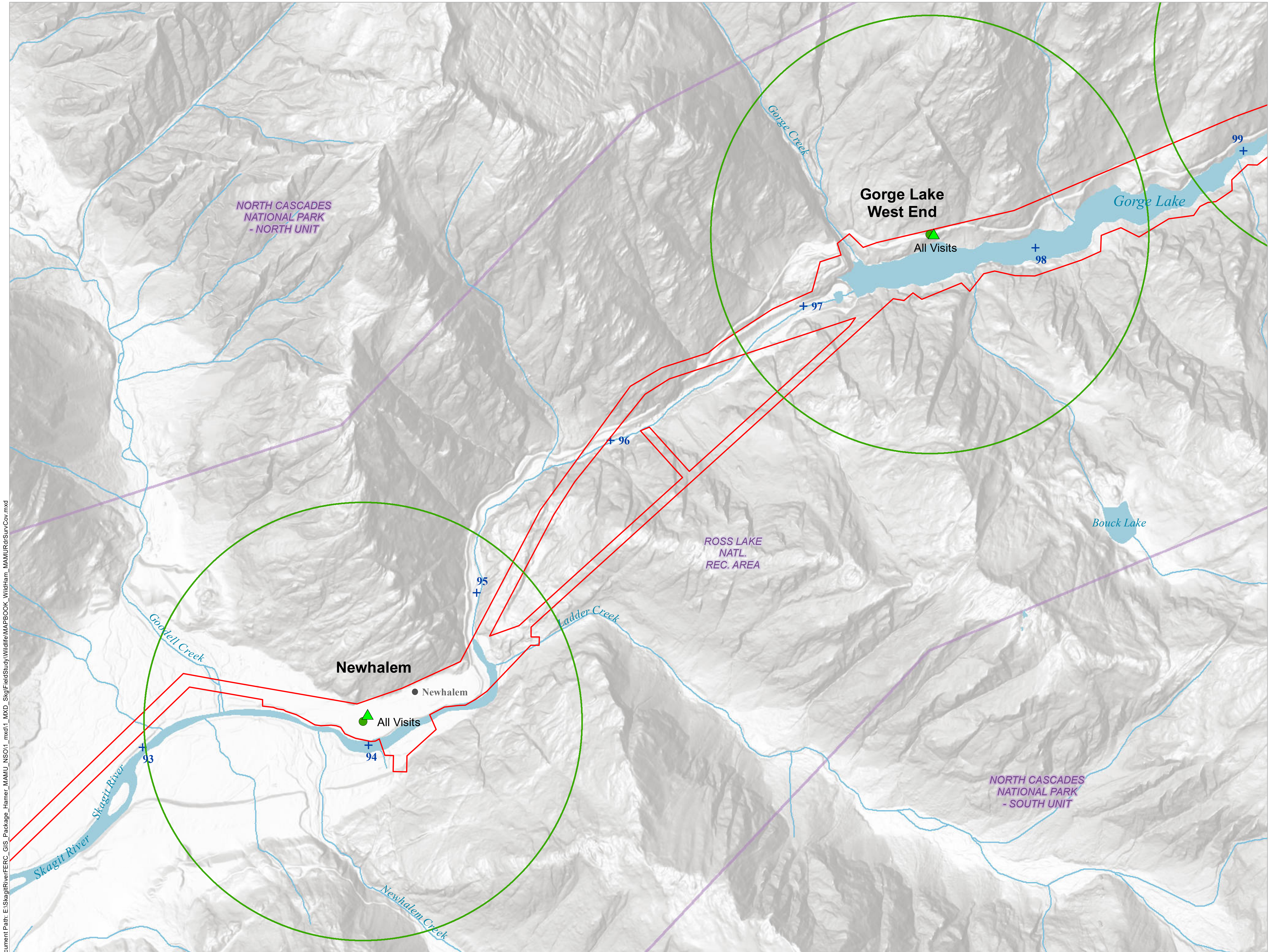
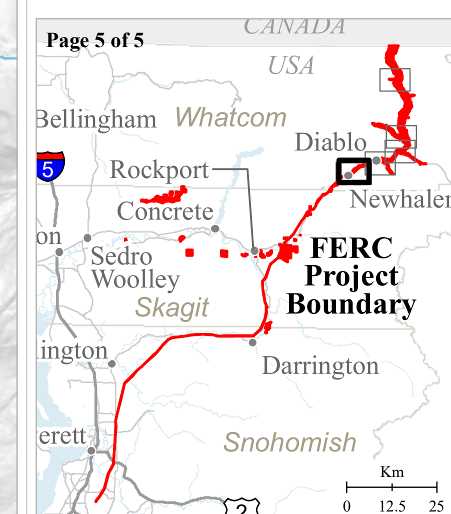
TR-05 MARBLED MURRELET STUDY RADAR SURVEY COVERAGE & AV SURVEYOR LOCATION MAPBOOK



FERC Project Boundary
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Audio Visual Surveyor
Radar Survey Site
All Visits
Radar Range (3 km diameter)
All Visits

N
0 0.25 0.5 0.75
Kilometers

Page 5 of 5



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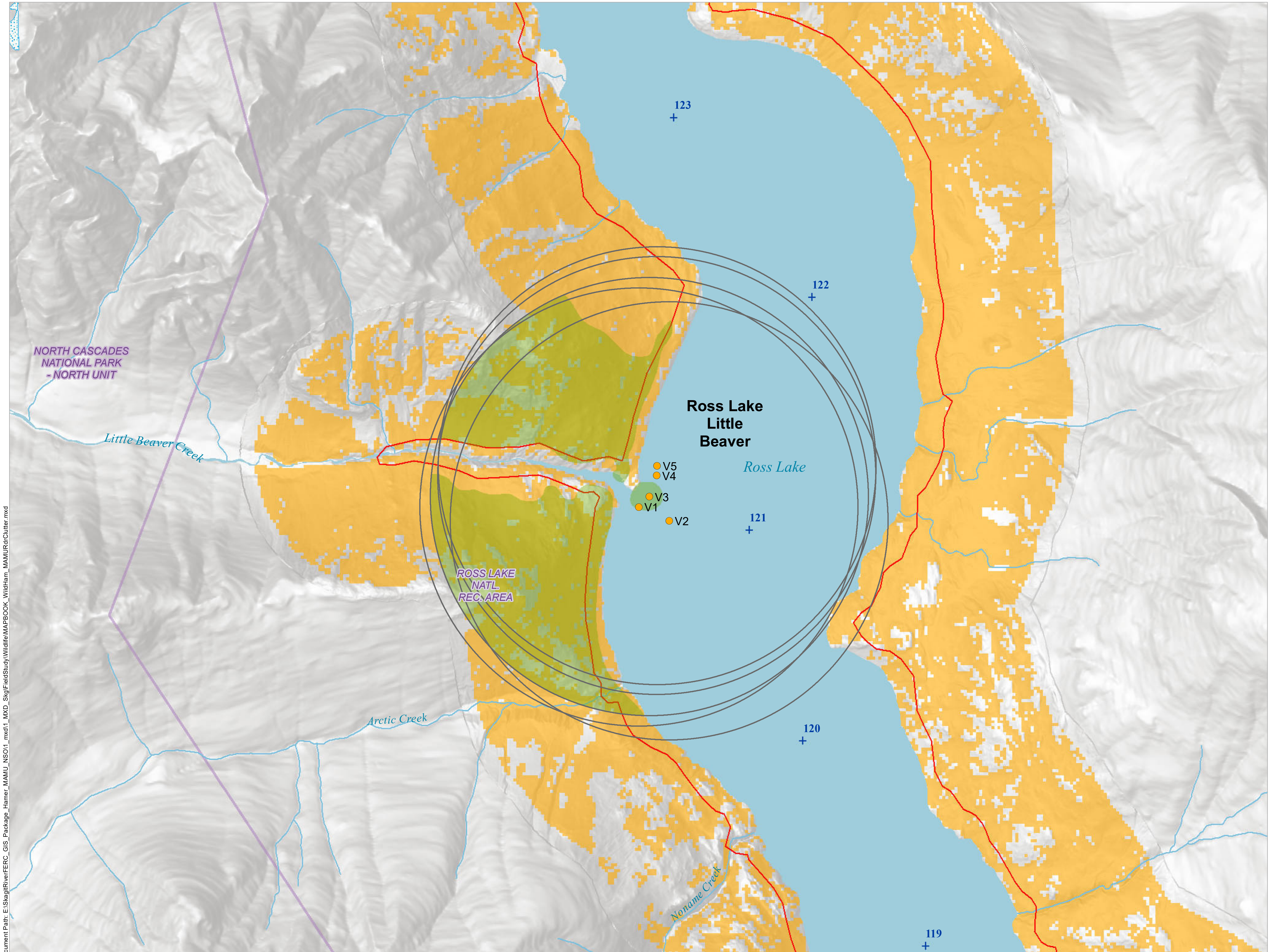
MARBLED MURRELET STUDY DRAFT REPORT

ATTACHMENT B

MARBLED MURRELET RADAR SURVEY SITE CLUTTER MAPBOOK

TR-05 MARBLED MURRELET STUDY RADAR CLUTTER MAPBOOK

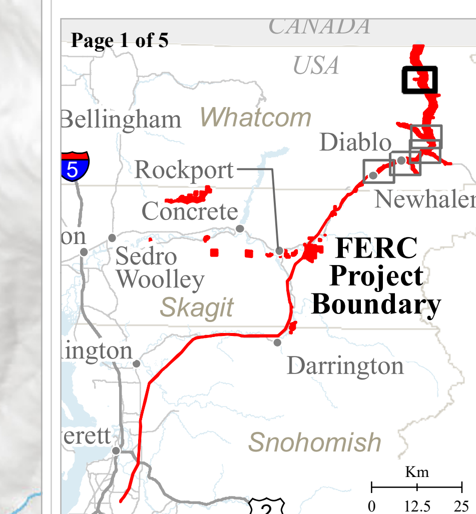


- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Ross Lake Little Beaver Clutter
- Potentially Suitable Marbled Murrelet Nesting Habitat

*Clutter maps show representative areas of clutter at each survey site and were not mapped separately for individual survey visits if the radar location changed only slightly.

0 0.25 0.5 0.75
Kilometers

Page 1 of 5



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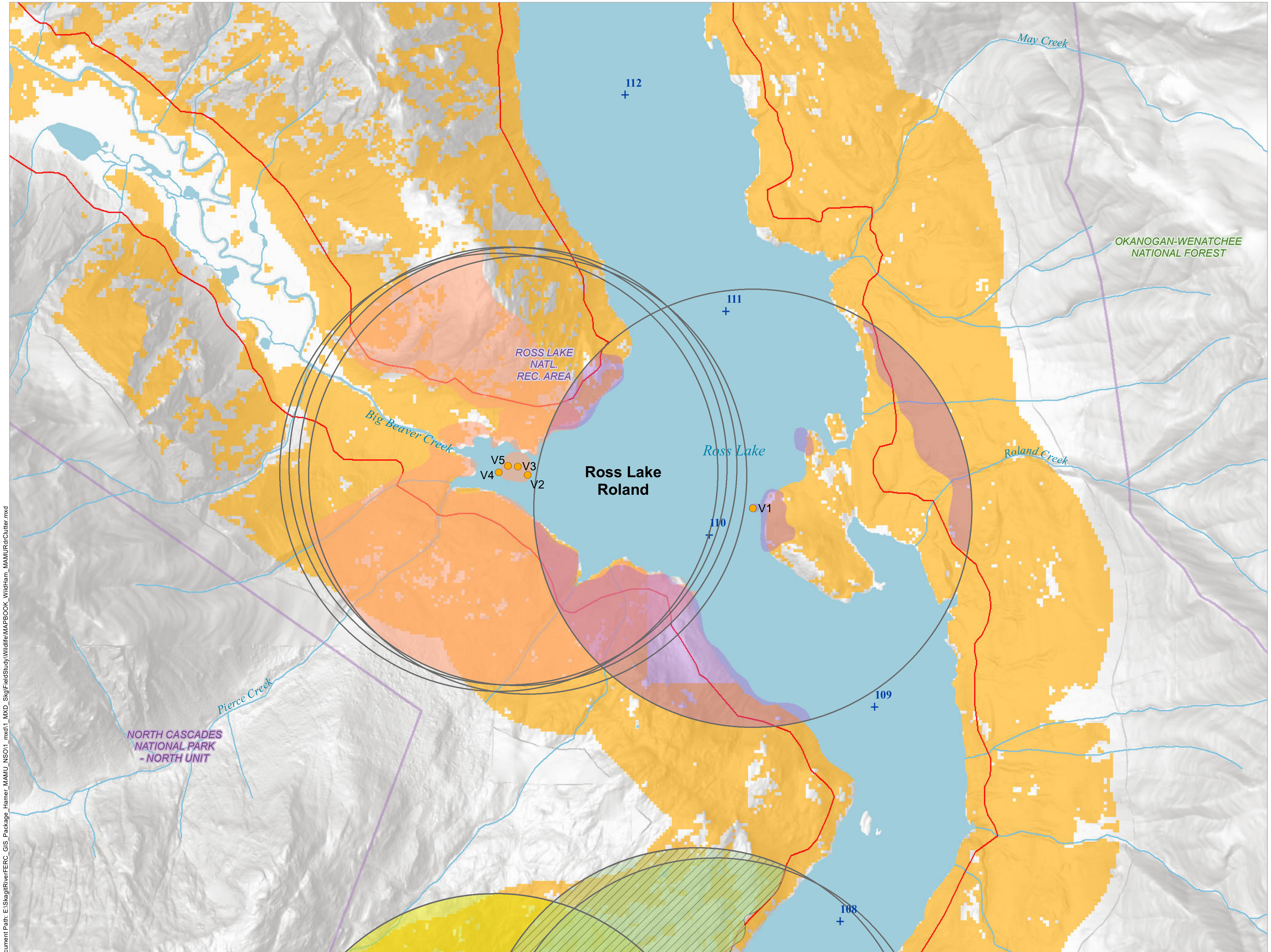
Document Path: E:\SkagitRiverFERC_GIS_Package_Hamer_MAMU_NSO\1_mxd\1_MXD_SkgFieldStudy\Wildlife\MAPBOOK_WildHam_MAMURdrClutter.mxd



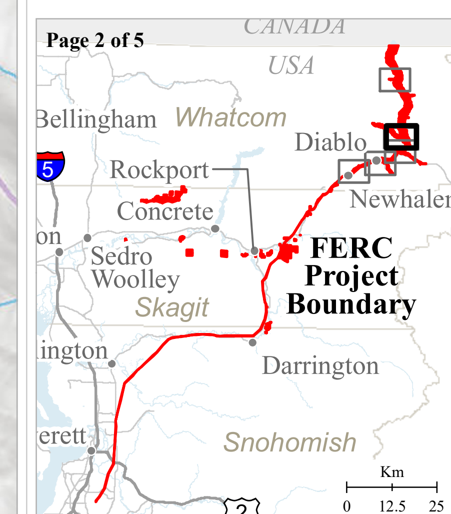
TR-05 MARBLED MURRELET STUDY RADAR CLUTTER MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Ross Lake Roland Visit 1 Clutter
- Ross Lake Roland Visit 2, 3, 4, & 5 Clutter
- Ross Lake Resort Visit 1 Clutter
- Ross Lake Resort Visit 2 Clutter
- Ross Lake Resort Visit 3, 4, & 5 Clutter
- Potentially Suitable Marbled Murrelet Nesting Habitat

*Clutter maps show representative areas of clutter at each survey site and were not mapped separately for individual survey visits if the radar location changed only slightly.

N

0 0.25 0.5 0.75
Kilometers



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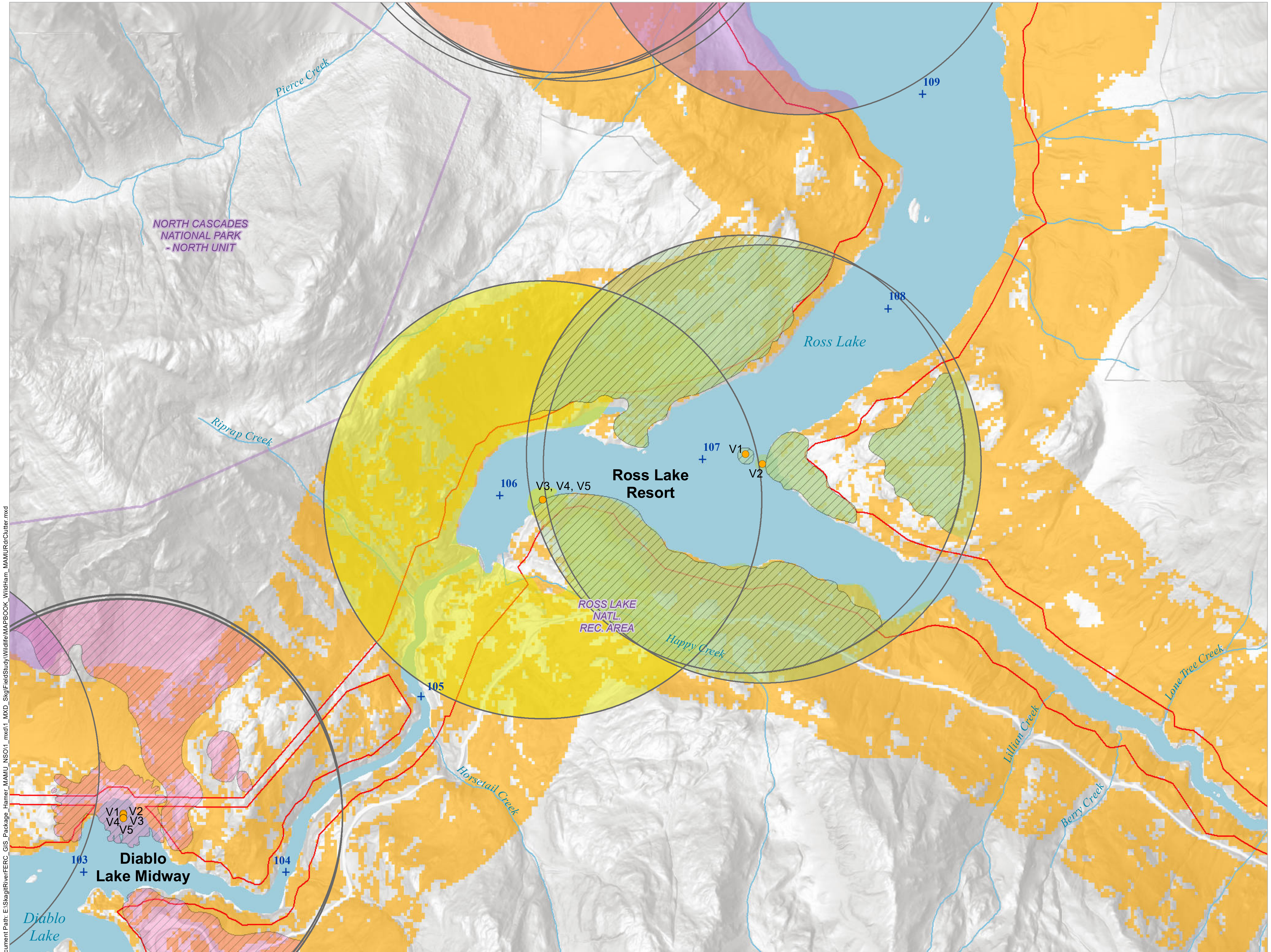

TR-05 MARBLED MURRELET STUDY RADAR CLUTTER MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Ross Lake Roland Visit 1 Clutter
- Ross Lake Roland Visit 2, 3, 4, & 5 Clutter
- Ross Lake Resort Visit 1 Clutter
- Ross Lake Resort Visit 2 Clutter
- Ross Lake Resort Visit 3, 4, & 5 Clutter
- Diablo Lake Midway Clutter
- Diablo Lake Sand Spit Clutter
- Potentially Suitable Marbled Murrelet Nesting Habitat

*Clutter maps show representative areas of clutter at each survey site and were not mapped separately for individual survey visits if the radar location changed only slightly.

N

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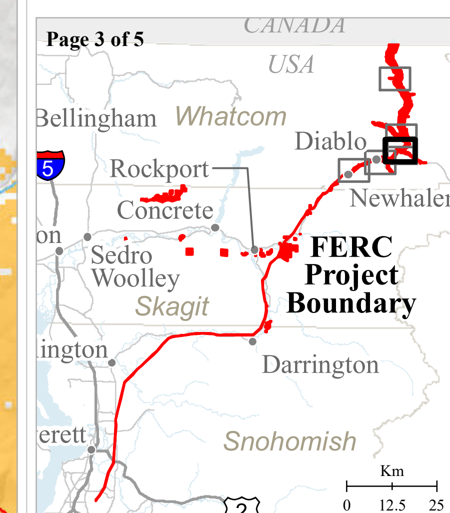
Kilometers



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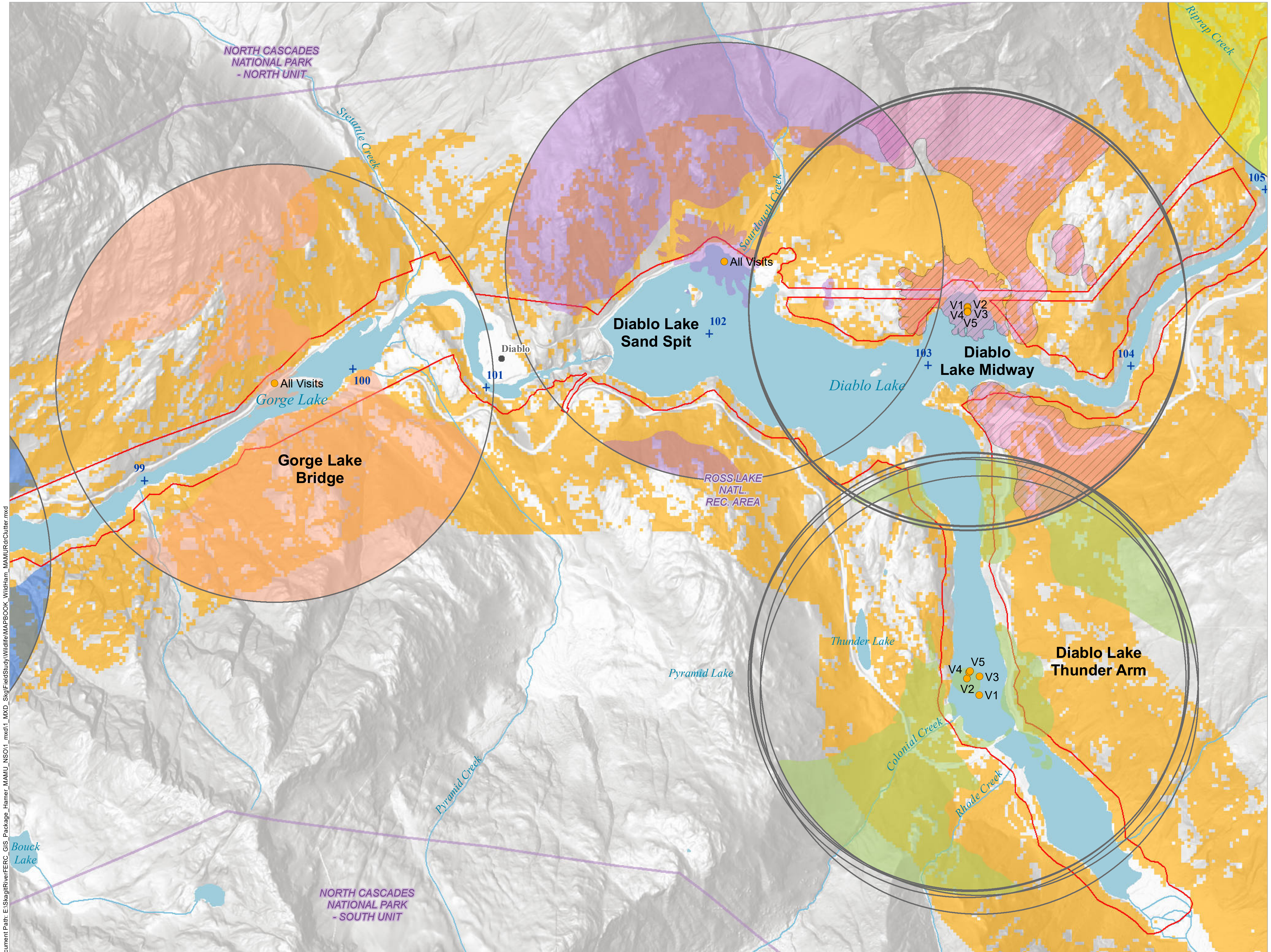

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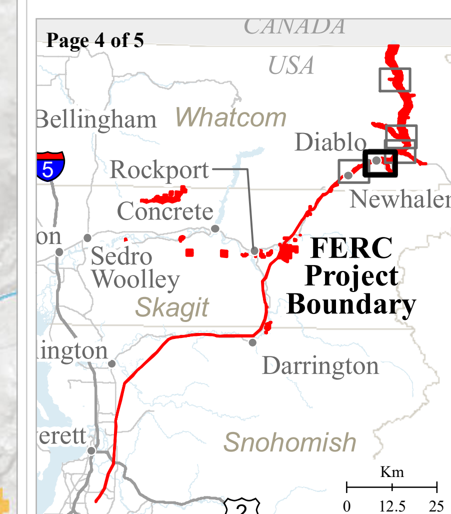
TR-05 MARBLED MURRELET STUDY RADAR CLUTTER MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Ross Lake Resort Visit 3, 4, & 5 Clutter
- Diablo Lake Midway Clutter
- Diablo Lake Sand Spit Clutter
- Gorge Lake Bridge Clutter
- Diablo Lake Thunder Arm Clutter
- Gorge Lake West End Clutter
- Potentially Suitable Marbled Murrelet Nesting Habitat

*Clutter maps show representative areas of clutter at each survey site and were not mapped separately for individual survey visits if the radar location changed only slightly.

0 0.25 0.5 0.75
Kilometers



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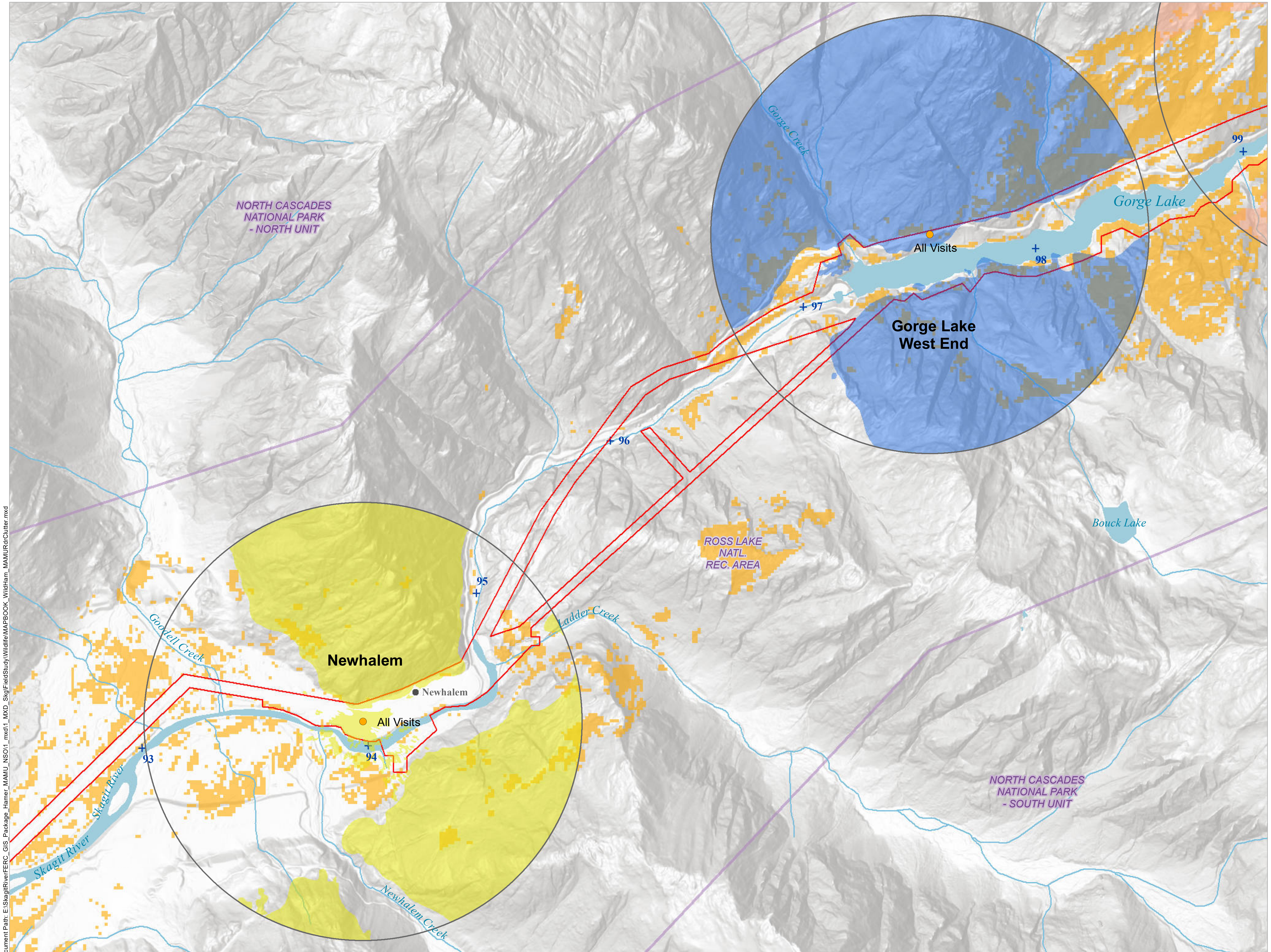


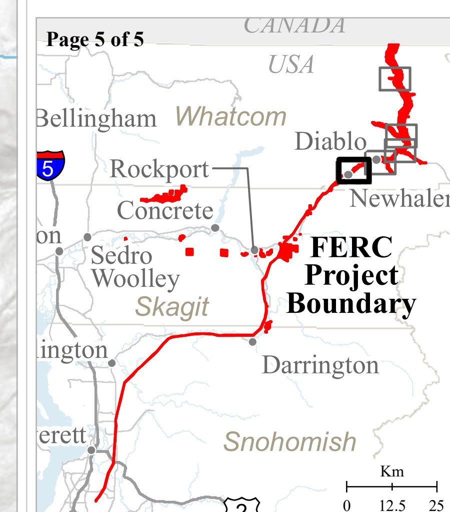
TR-05 MARBLED MURRELET STUDY RADAR CLUTTER MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Gorge Lake Bridge Clutter
- Gorge Lake West End Clutter
- Newhalem Clutter
- Potentially Suitable Marbled Murrelet Nesting Habitat

*Clutter maps show representative areas of clutter at each survey site and were not mapped separately for individual survey visits if the radar location changed only slightly.

N

0 0.25 0.5 0.75
Kilometers



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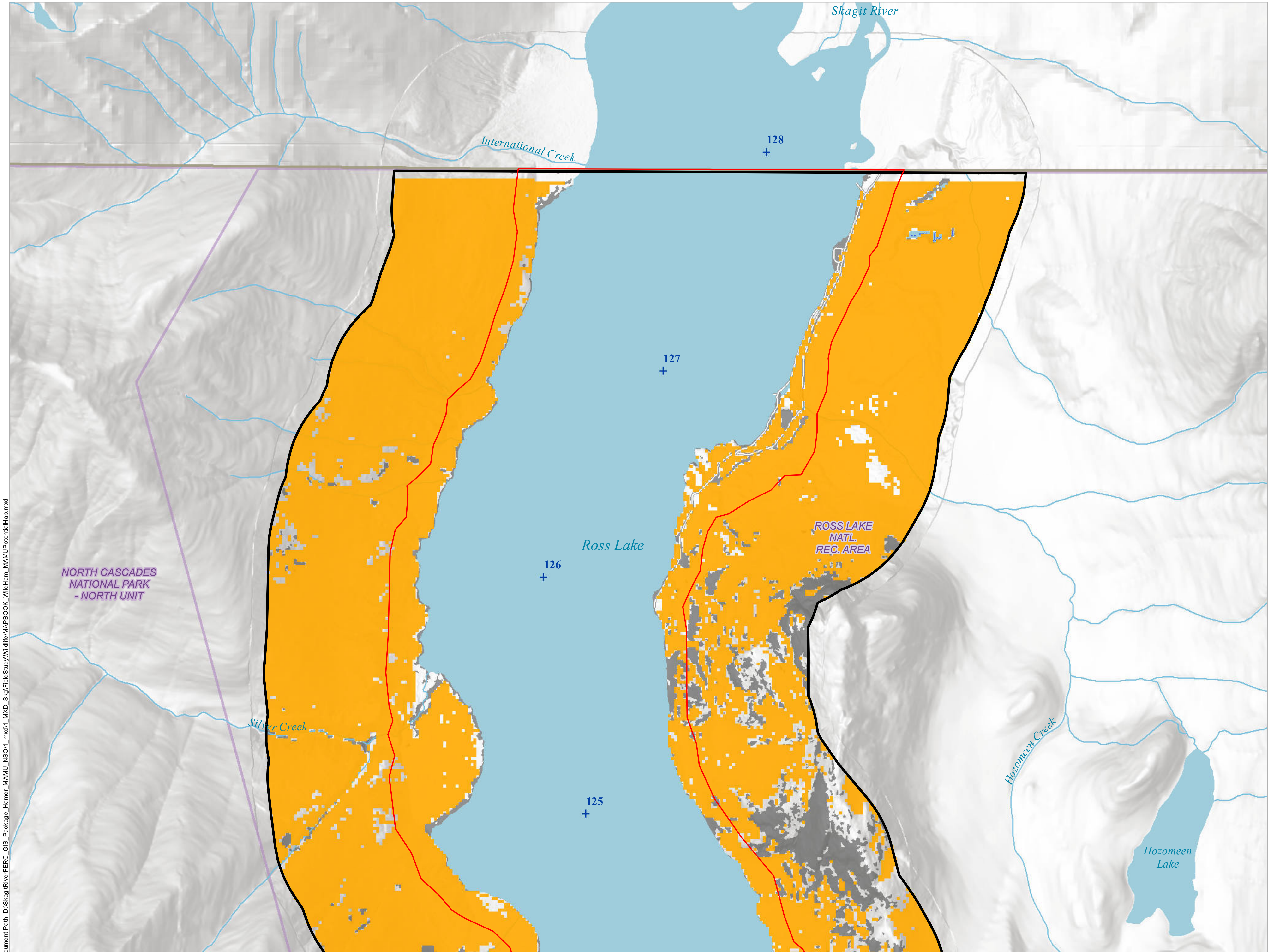
MARBLED MURRELET STUDY DRAFT REPORT

ATTACHMENT C

POTENTIALLY SUITABLE MARBLED MURRELET NESTING HABITAT MAPBOOK

TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

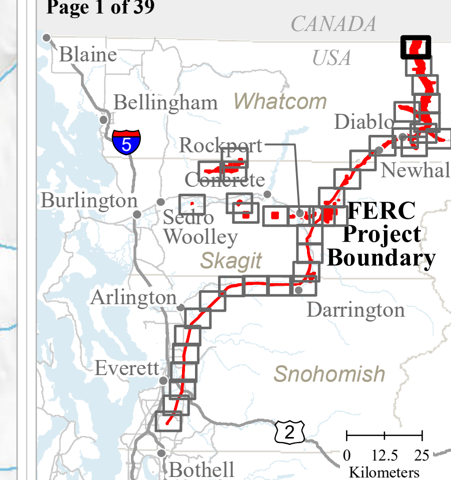
- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat



N

0 0.25 0.5
Kilometers

Page 1 of 39



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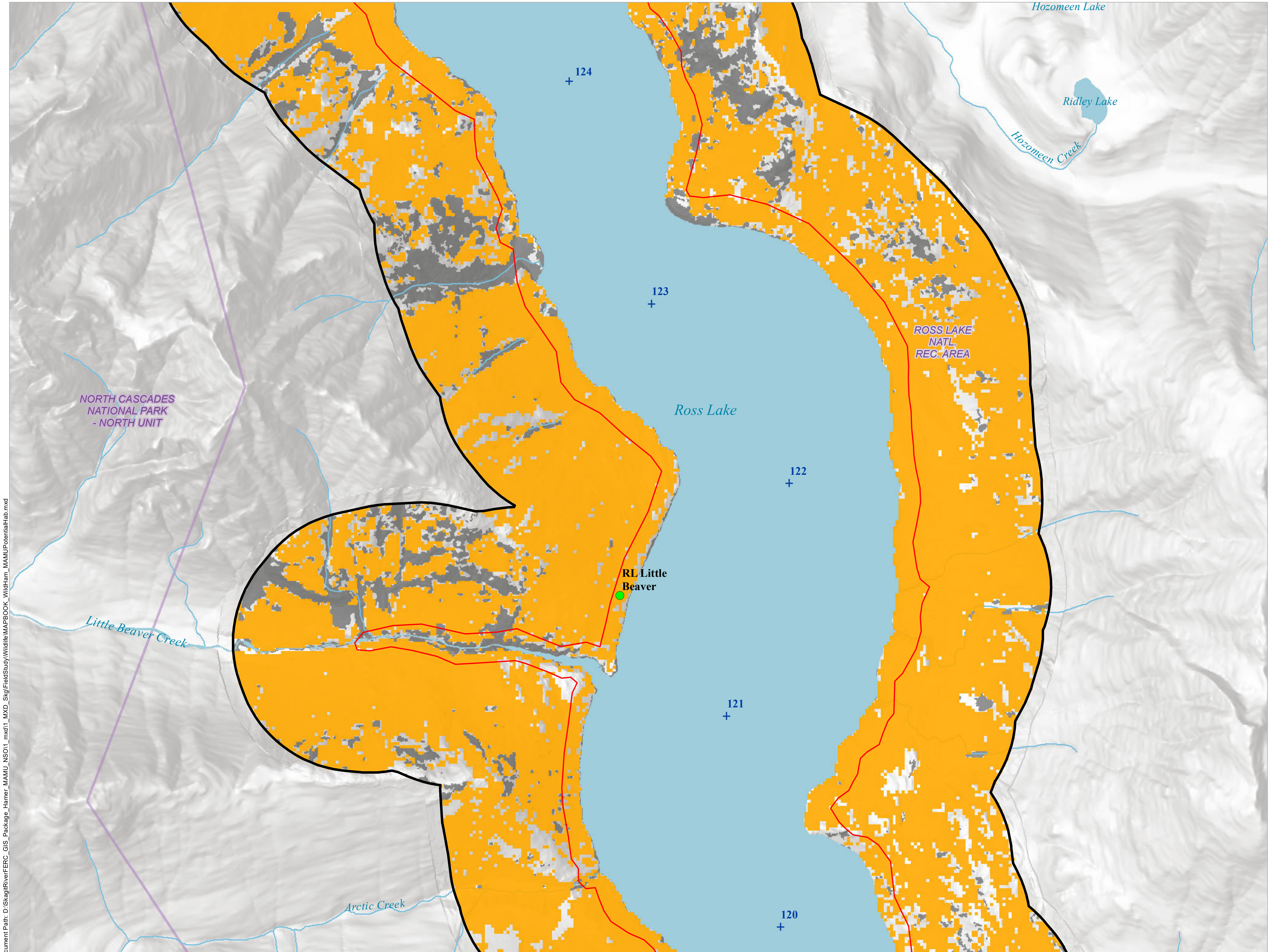
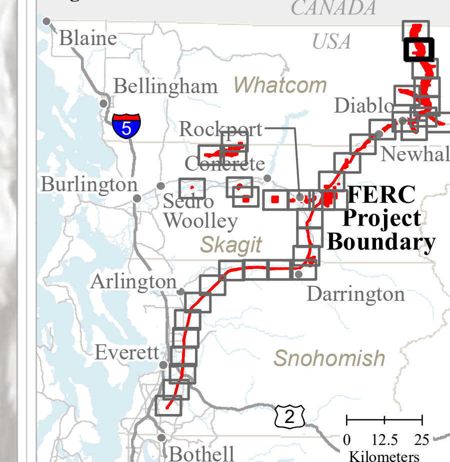
Document Path: D:\SkagitRiverFERC_GIS_Package_Hamer_MAMU_NSO1_mxd\1_MXD_SkgiFieldStudy\Wildlife\MAPBOOK_WildHam_MAMUPotentialHab.mxd

TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



FERC Project Boundary
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Marbled Murrelet Study Area
Non-forested Area
Habitat Plot (25m radius)
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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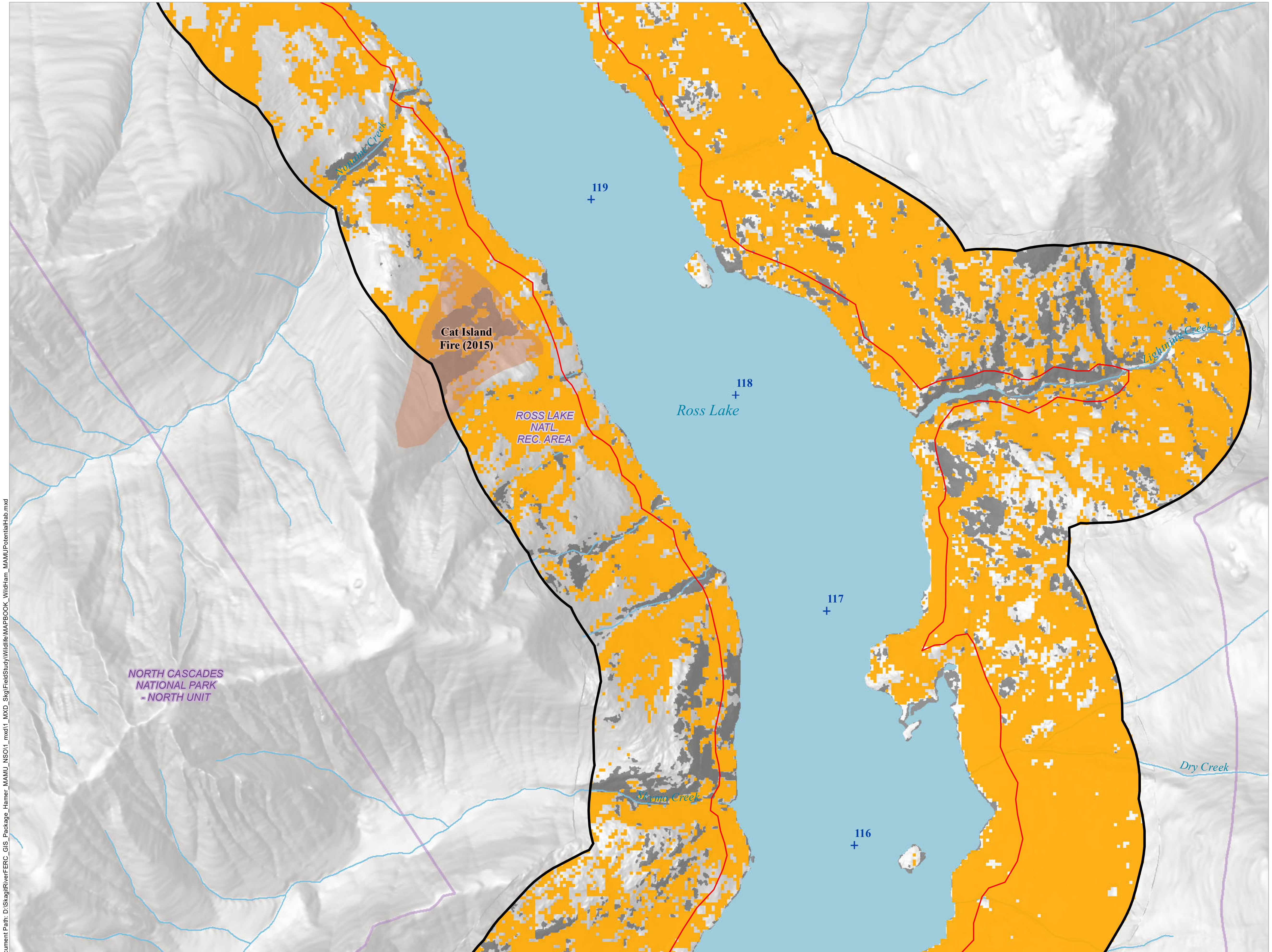
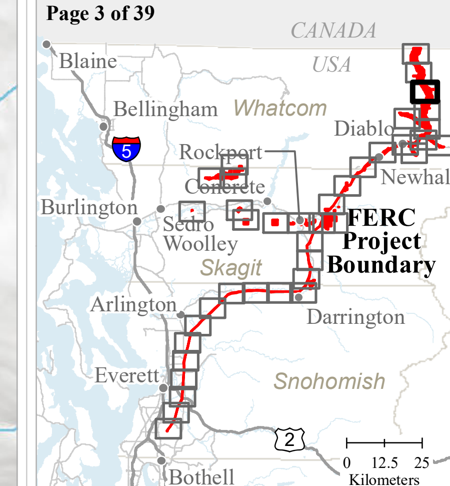


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers

Page 3 of 39



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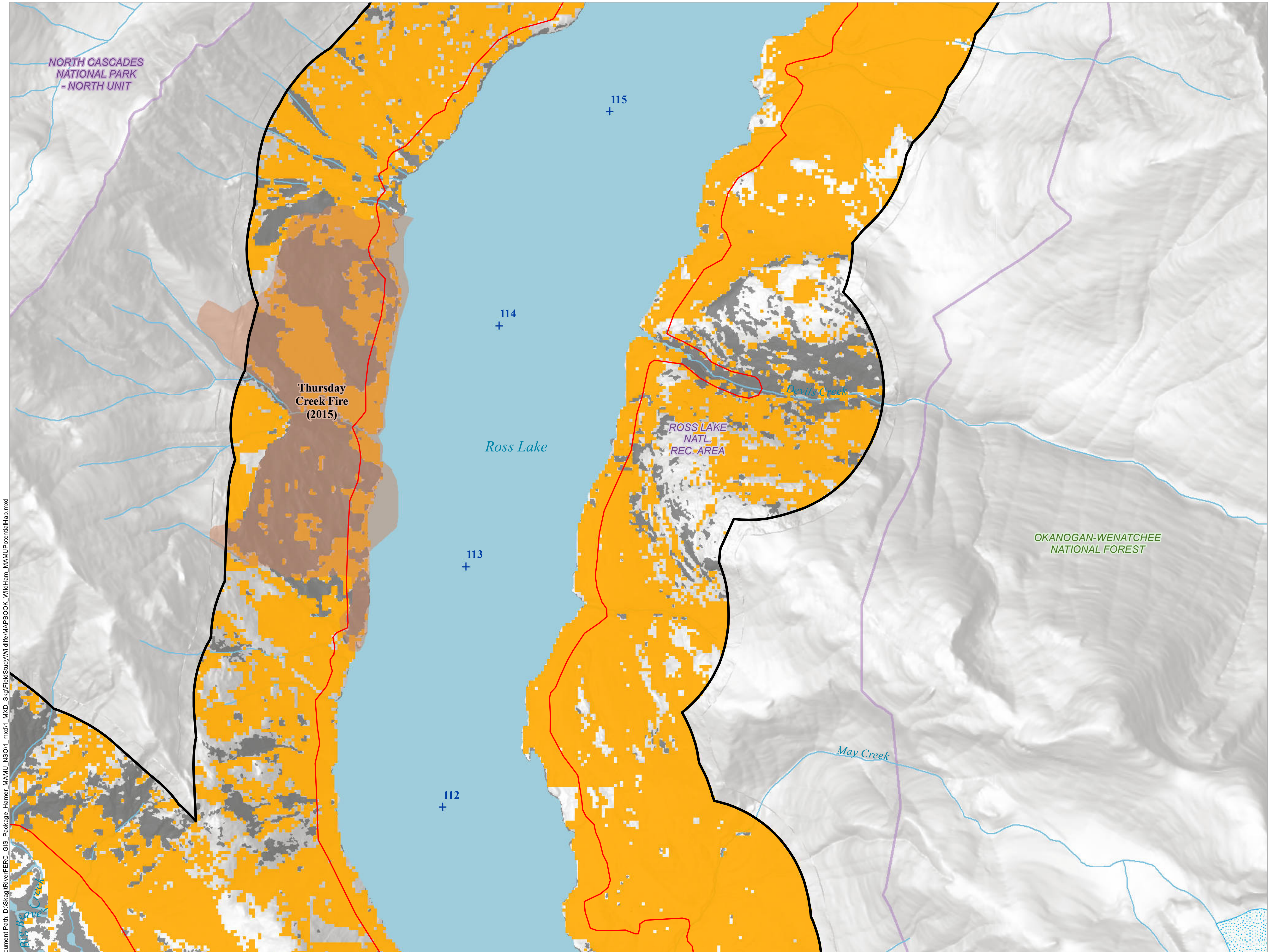
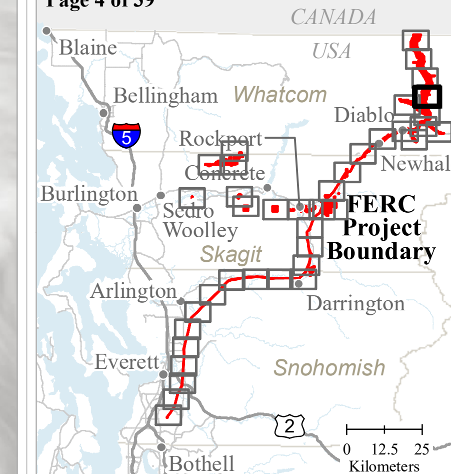
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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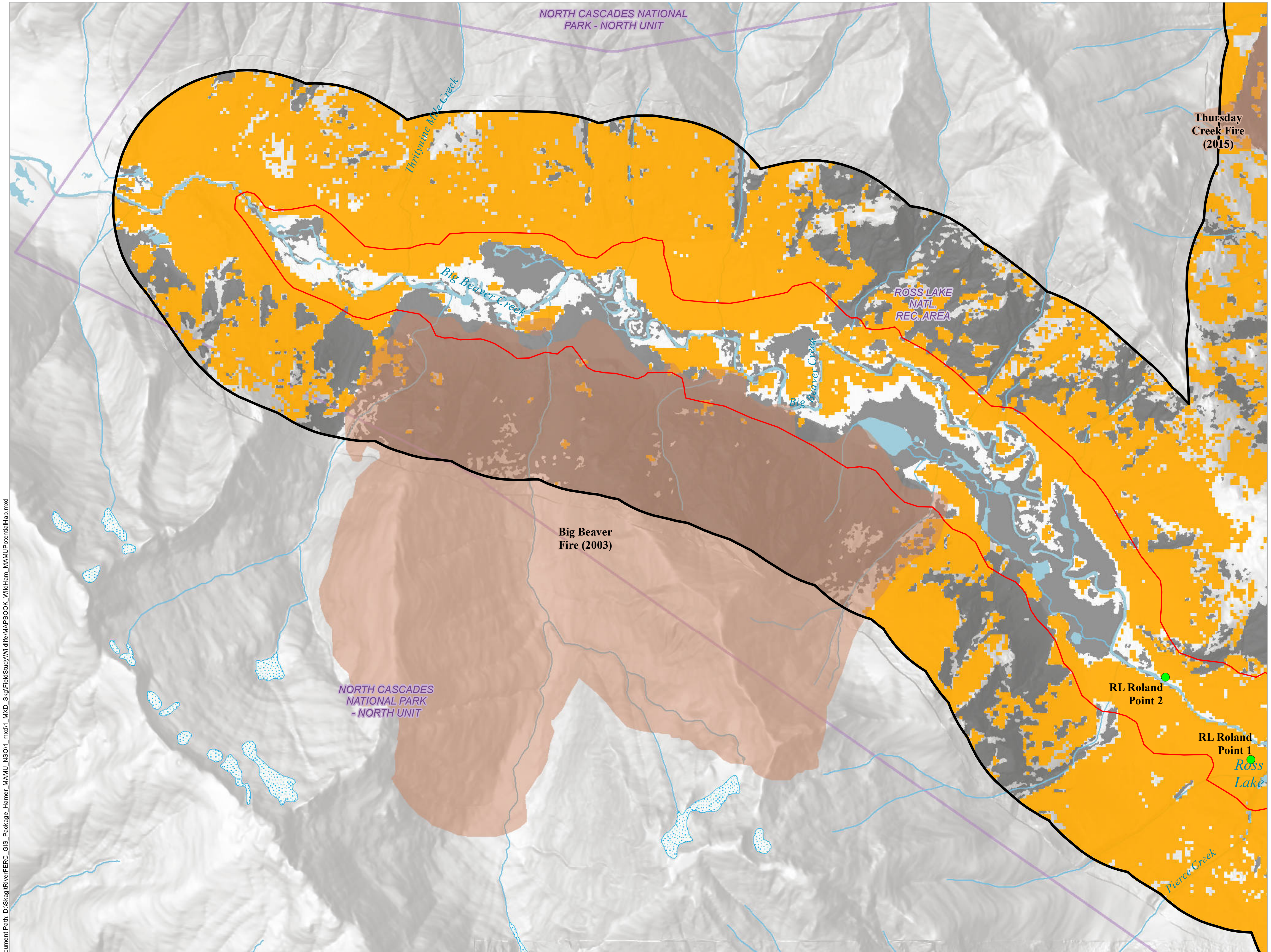
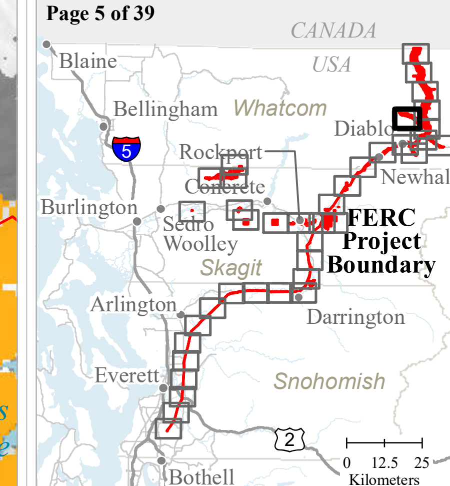


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Habitat Plot (25m radius)
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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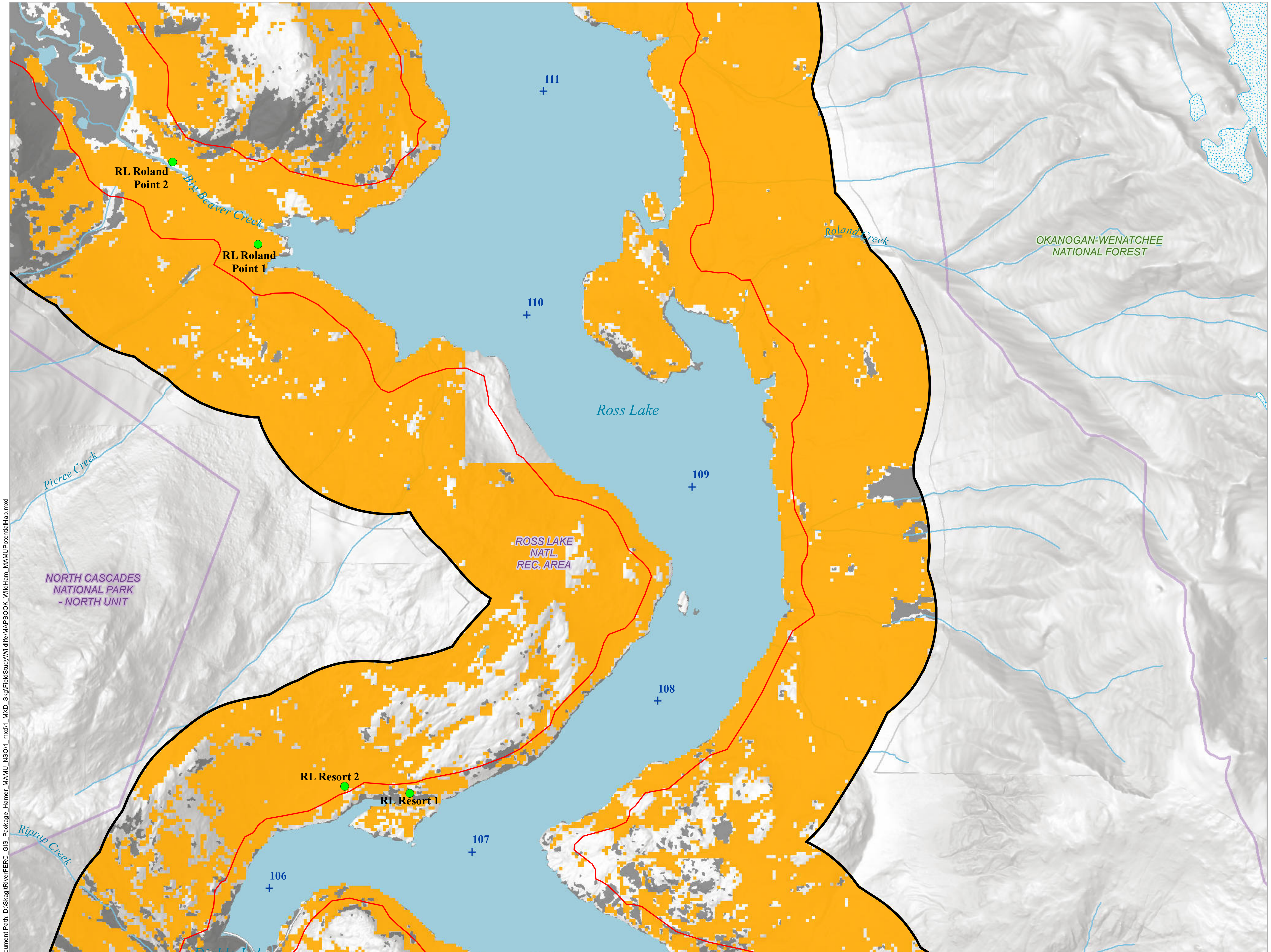

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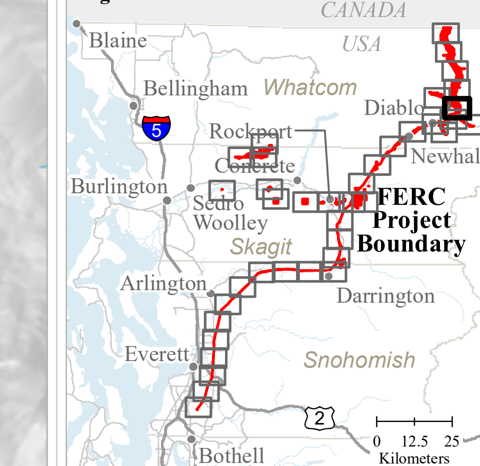
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Habitat Plot (25m radius)
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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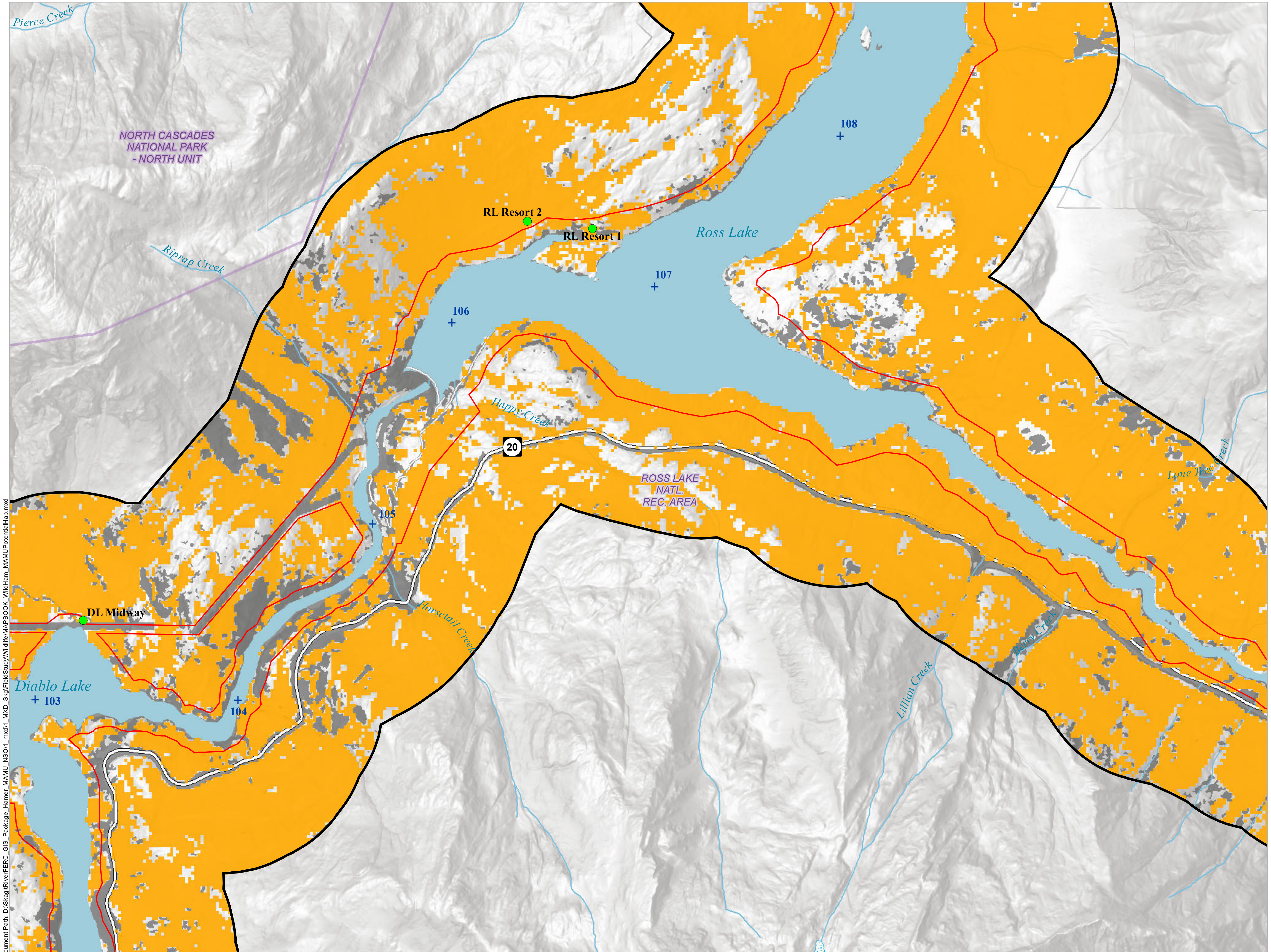
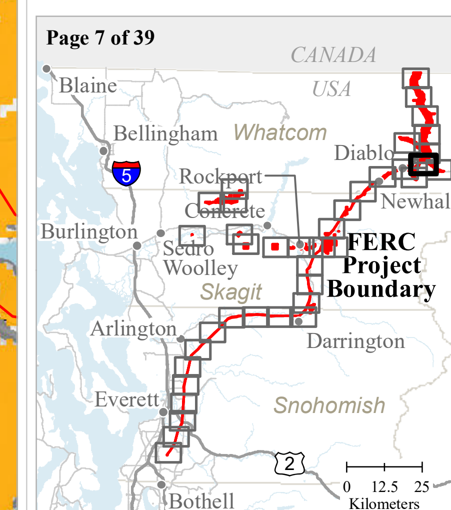
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Habitat Plot (25m radius)
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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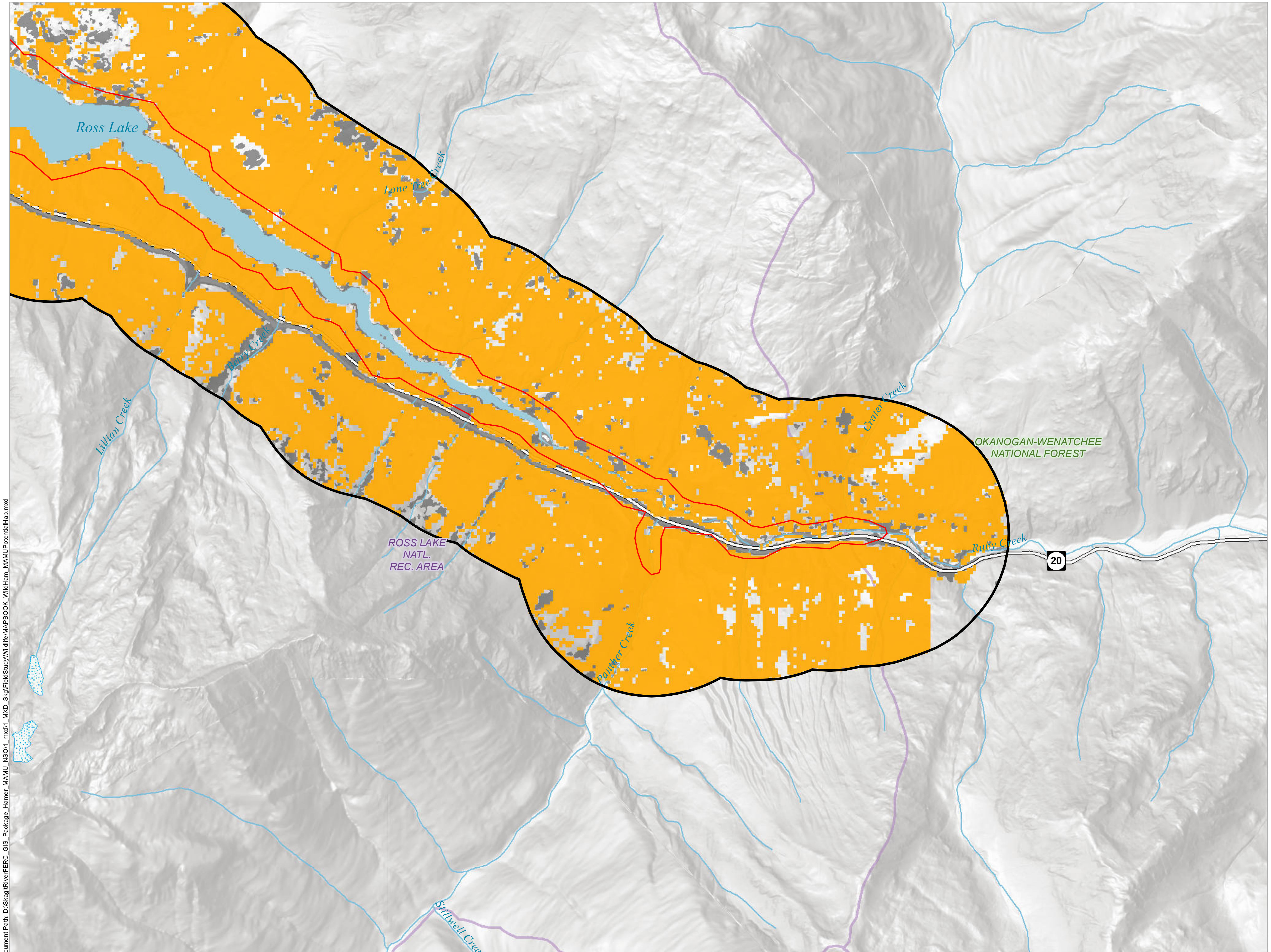
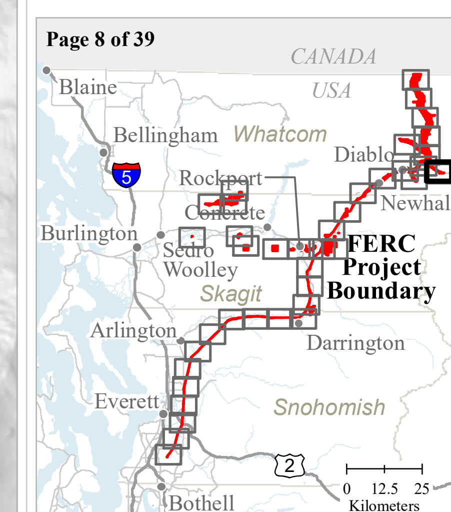
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



- FERC Project Boundary
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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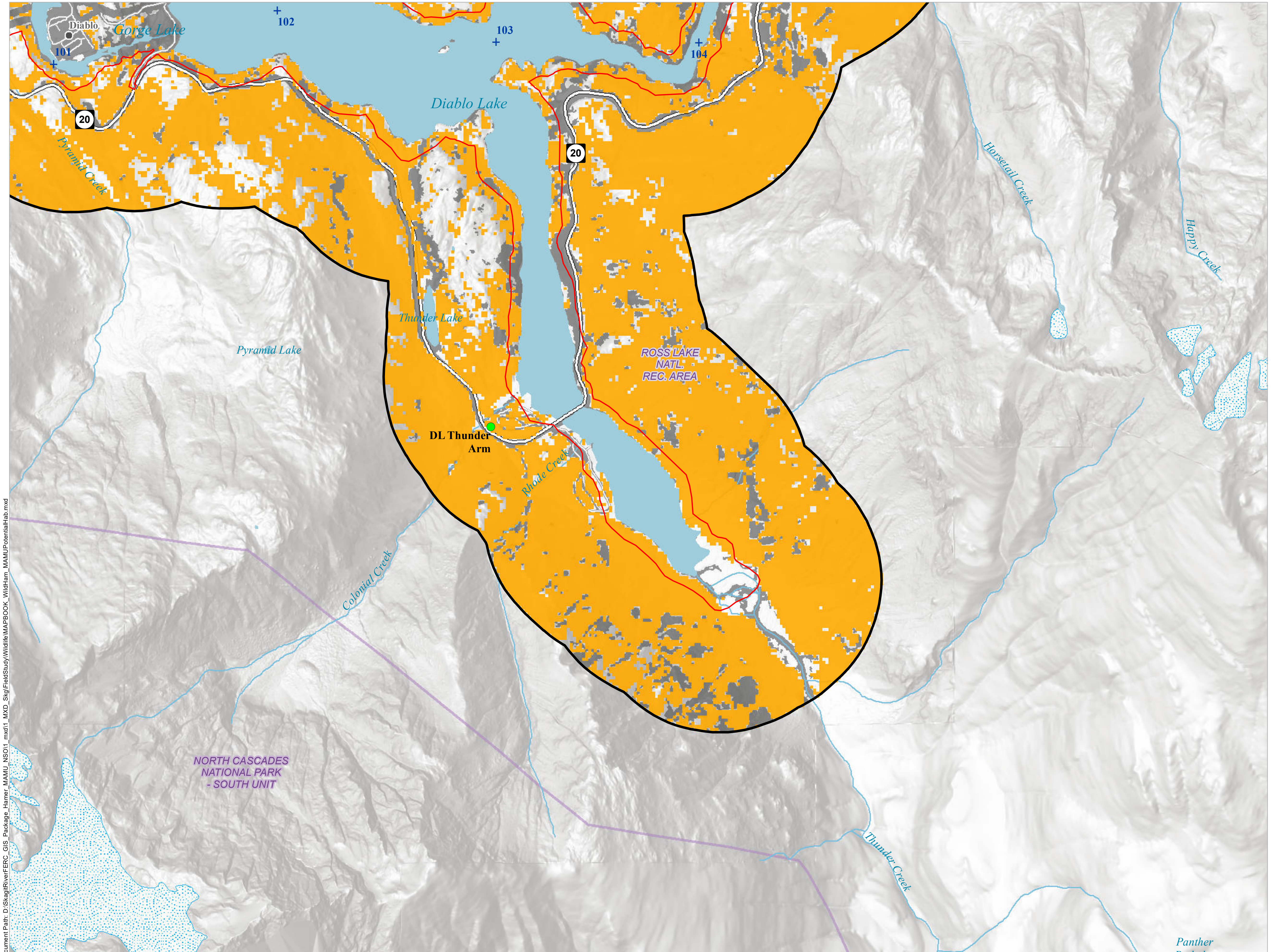
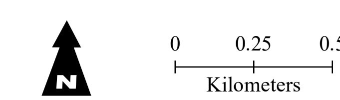
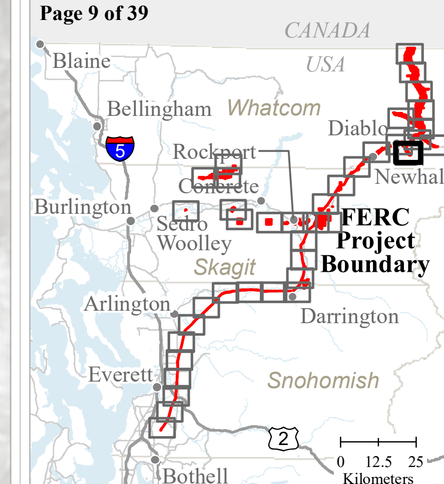
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



FERC Project Boundary
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Marbled Murrelet Study Area
Non-forested Area
Habitat Plot (25m radius)
Potentially Suitable Marbled Murrelet Nesting Habitat





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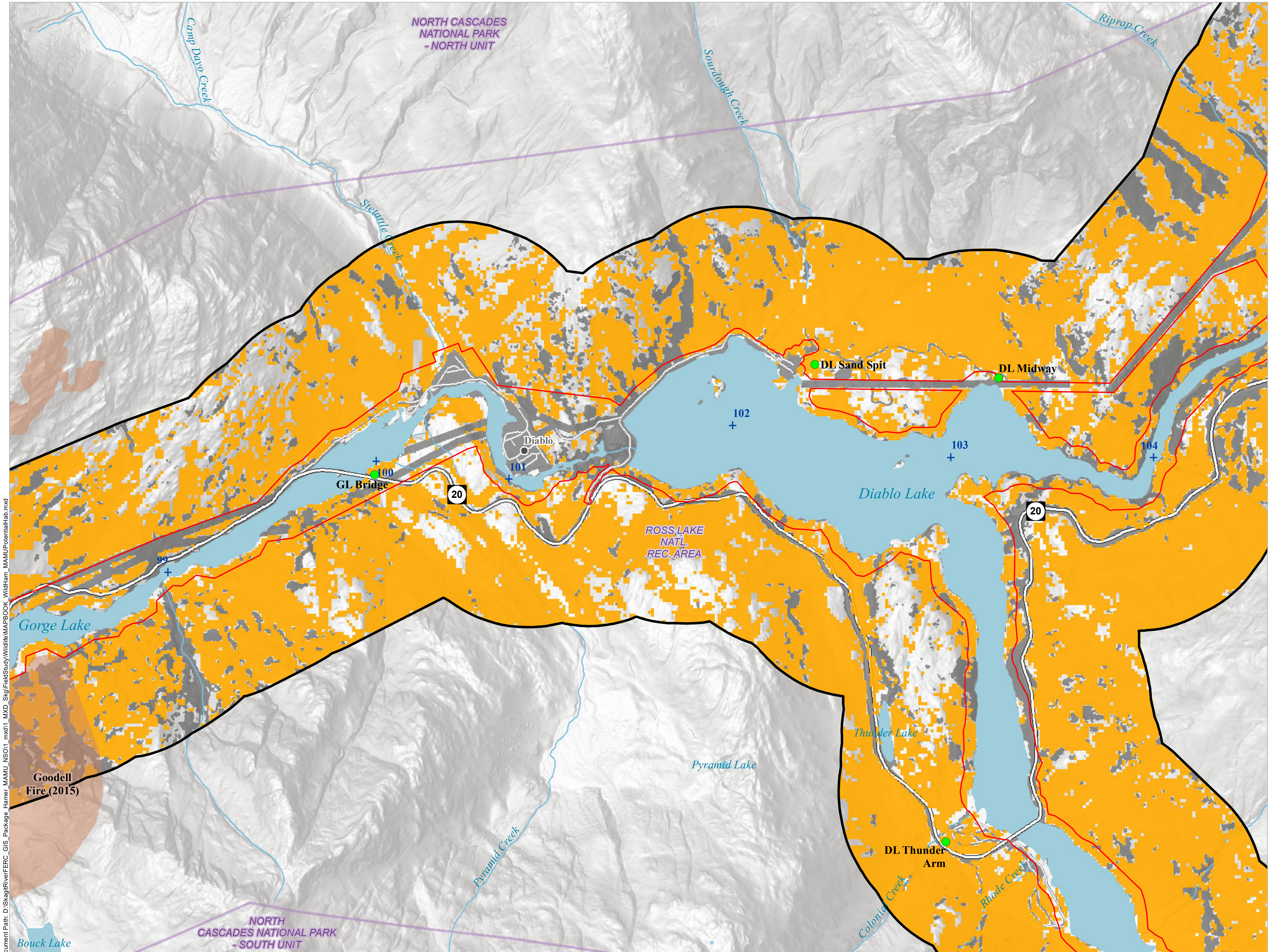
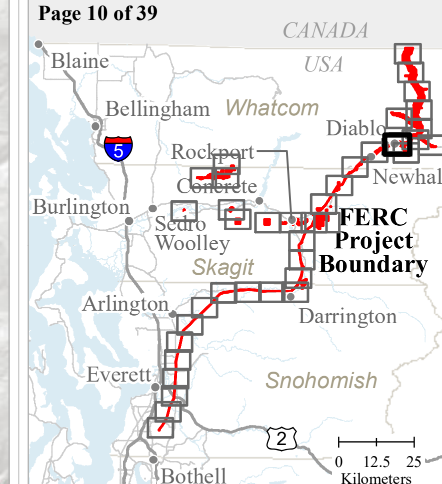
Data Source: [DNR, Hamer, HDR].

TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Habitat Plot (25m radius)
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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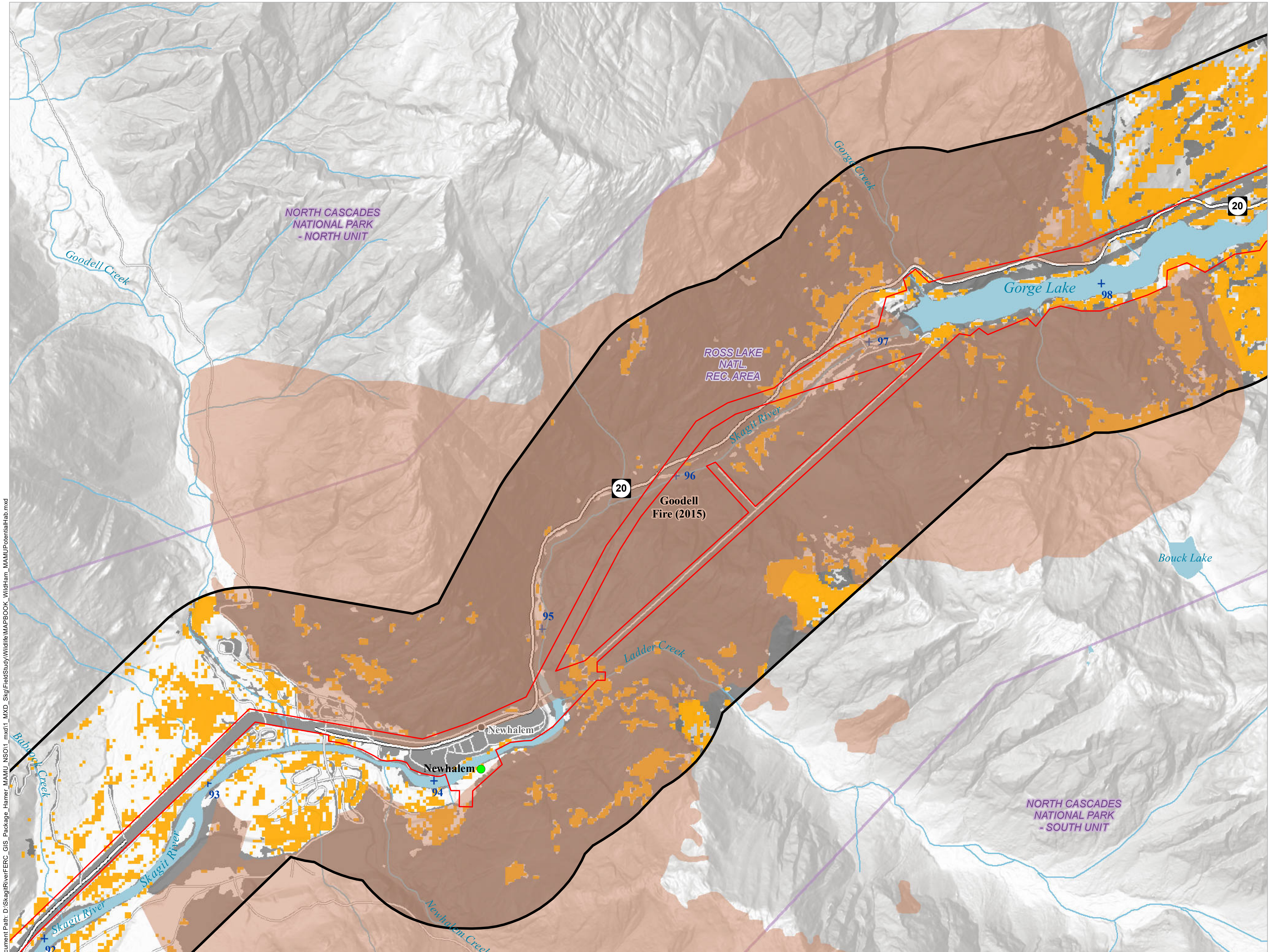
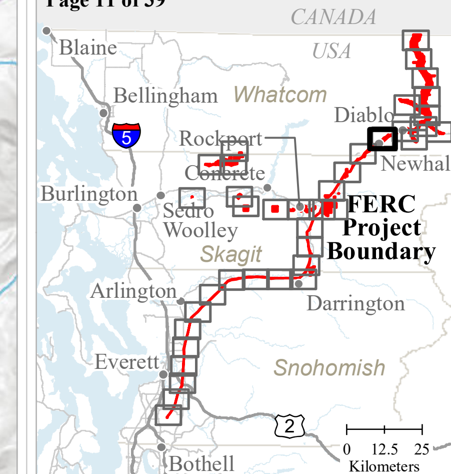
- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Habitat Plot (25m radius)
- Potentially Suitable Marbled Murrelet Nesting Habitat





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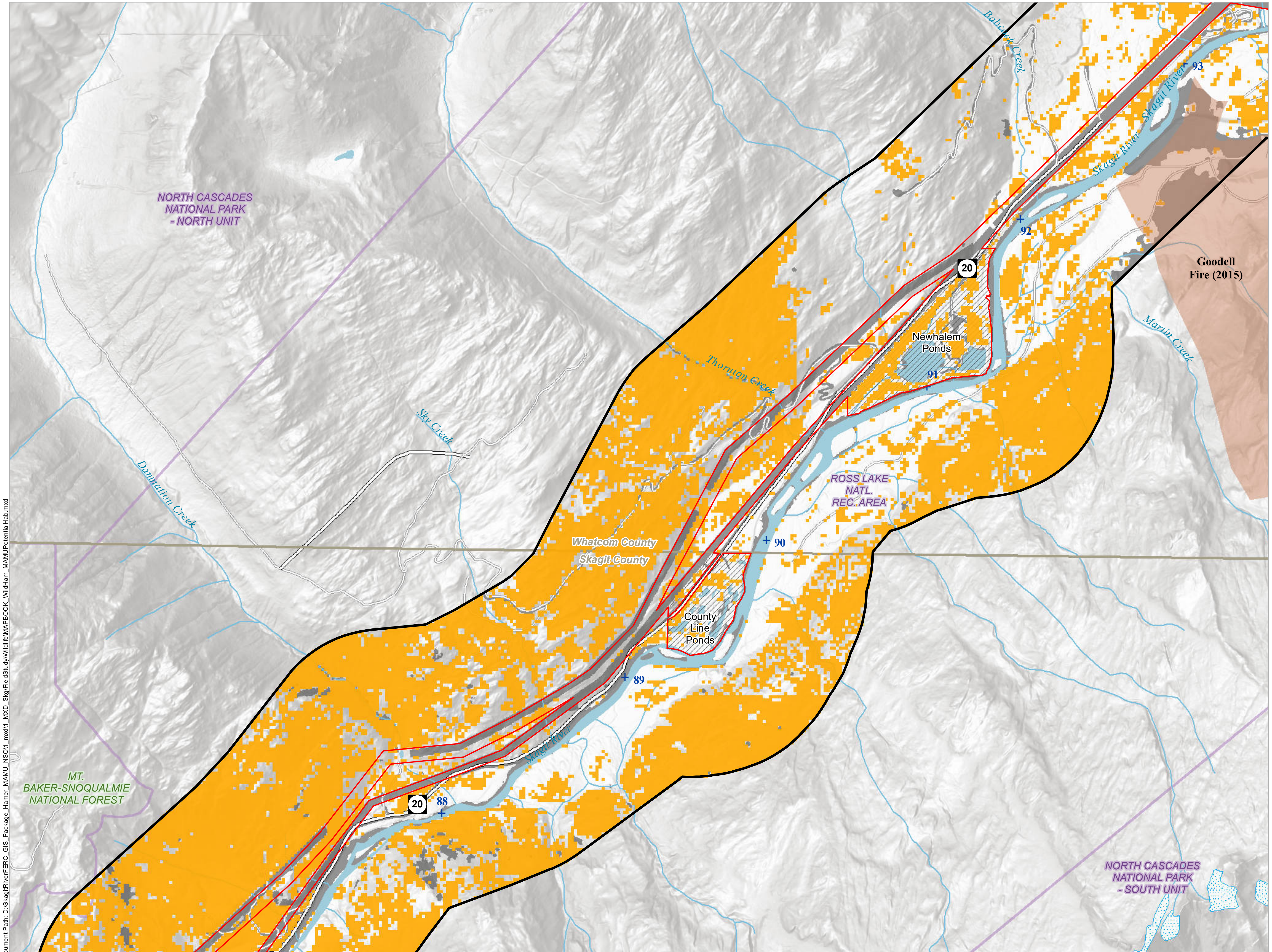
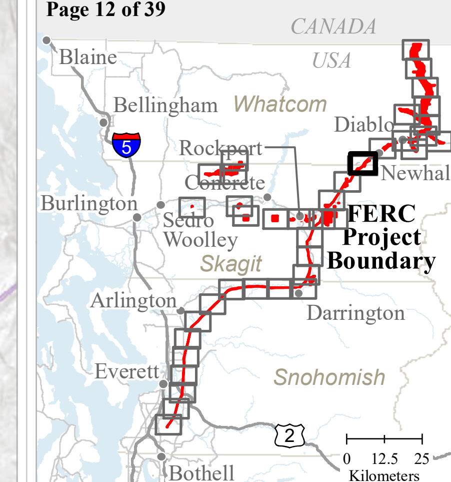


- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Marbled Murrelet Study Area
- Recently Burned Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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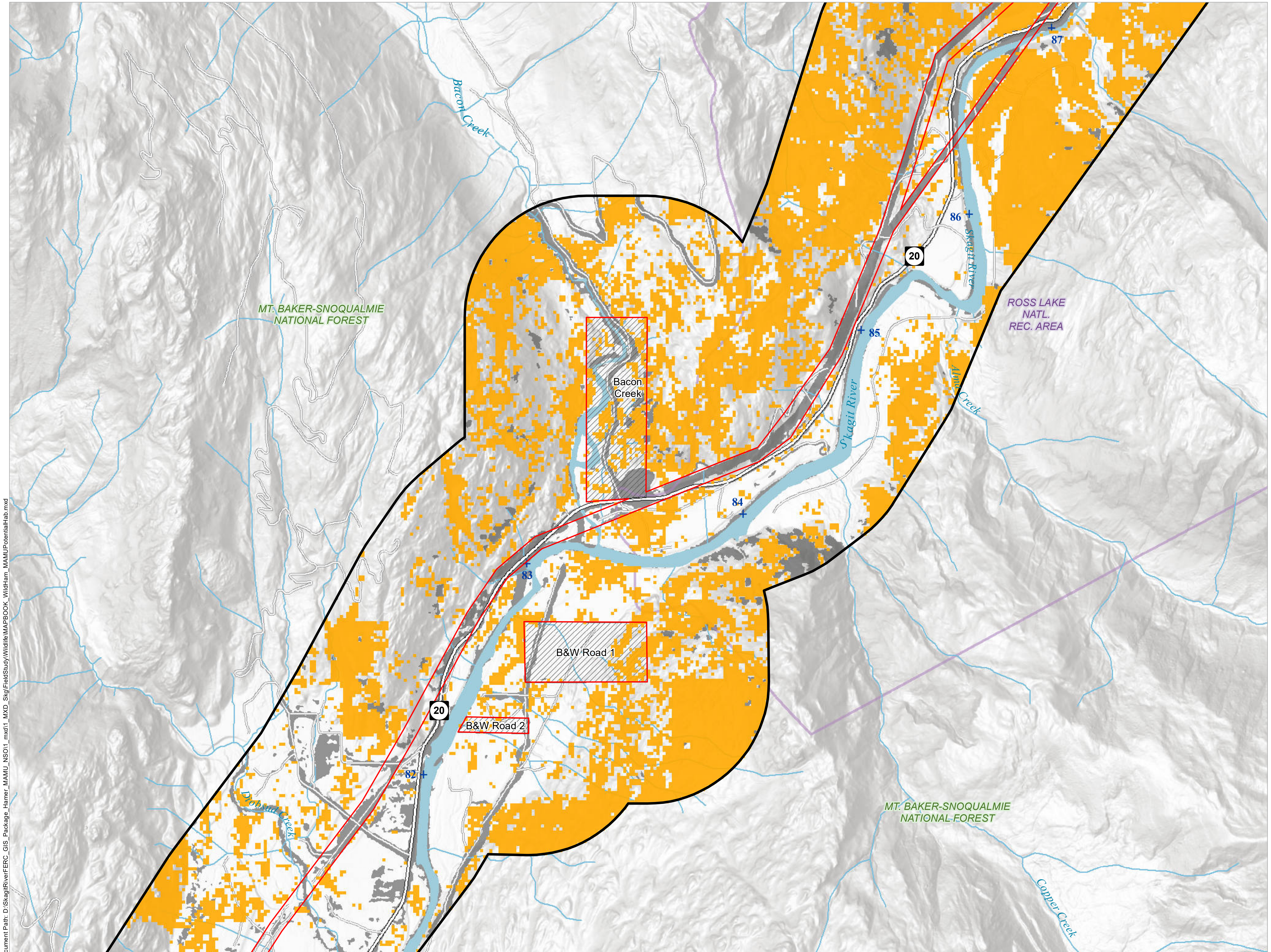

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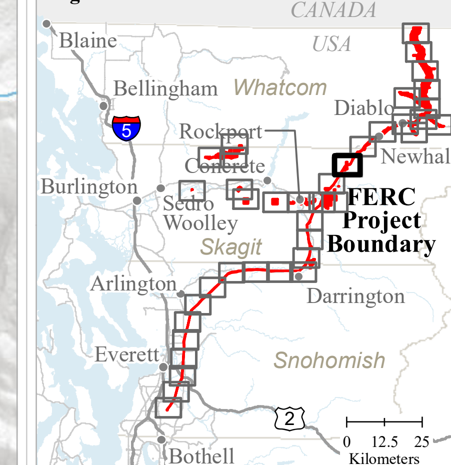
0 0.25 0.5
Kilometers



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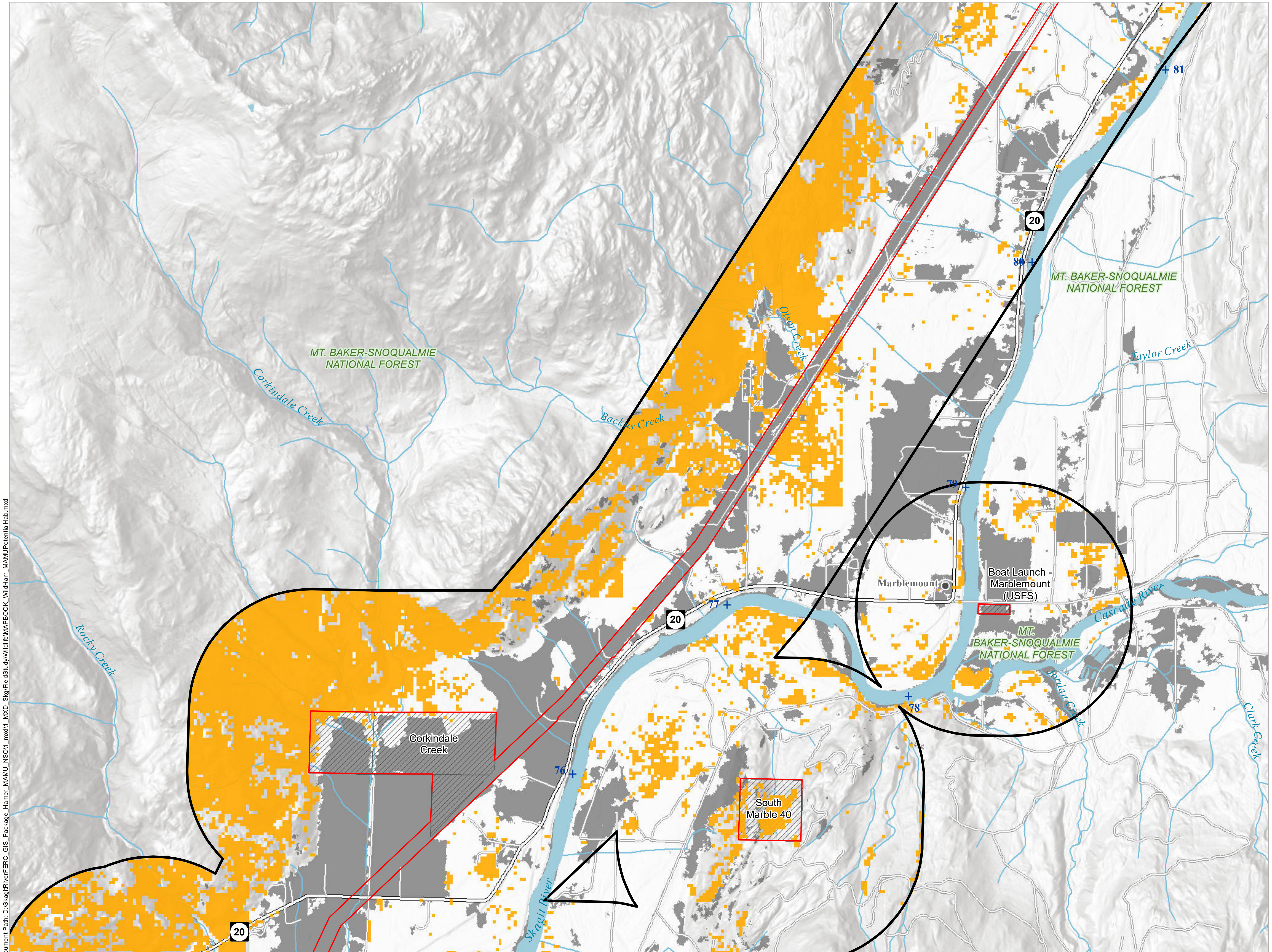

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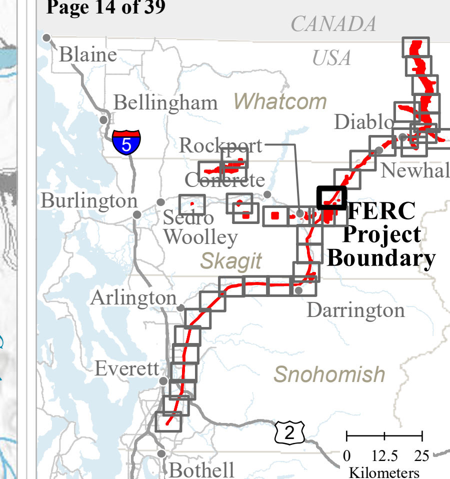
0 0.25 0.5
Kilometers



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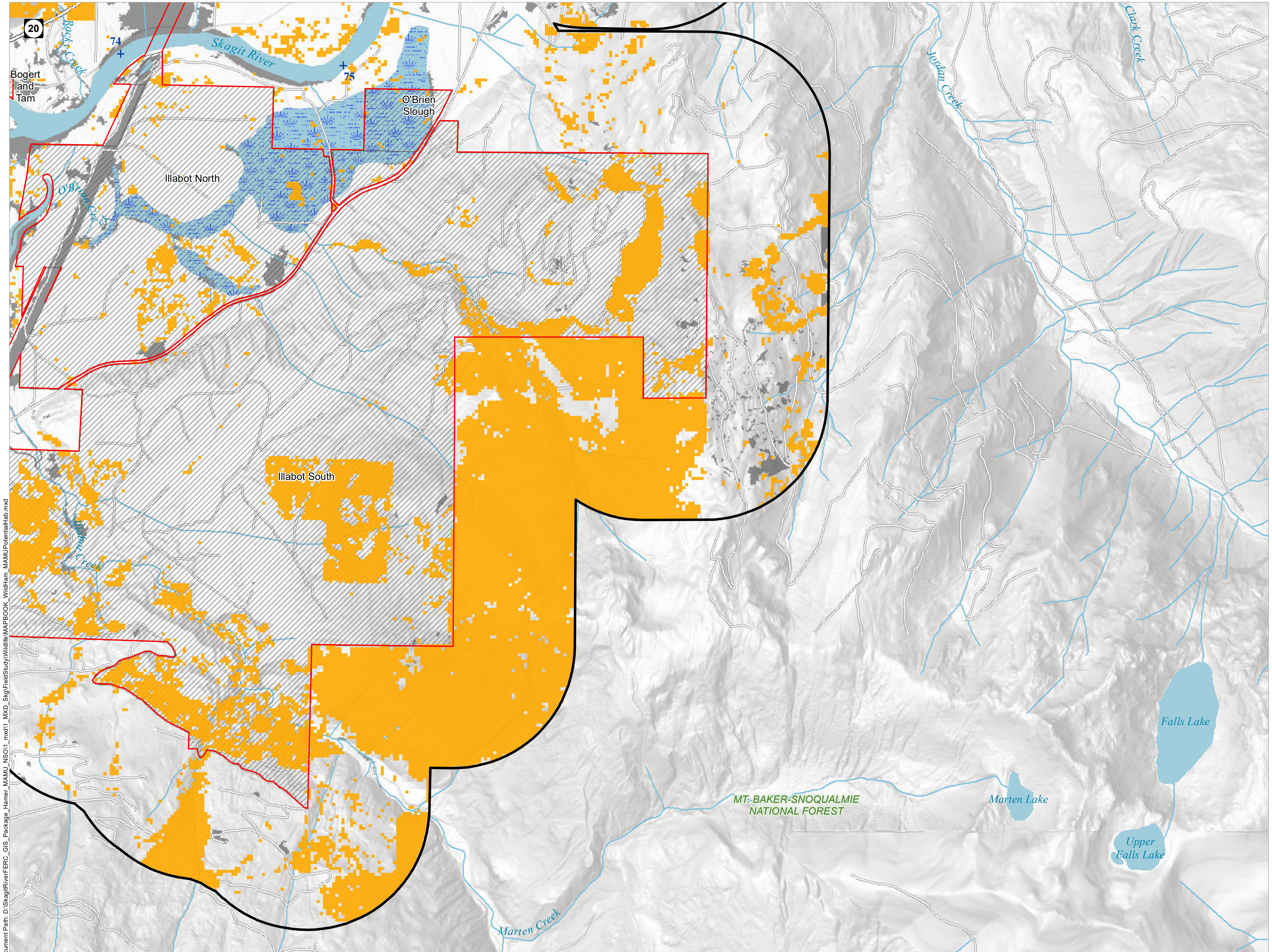

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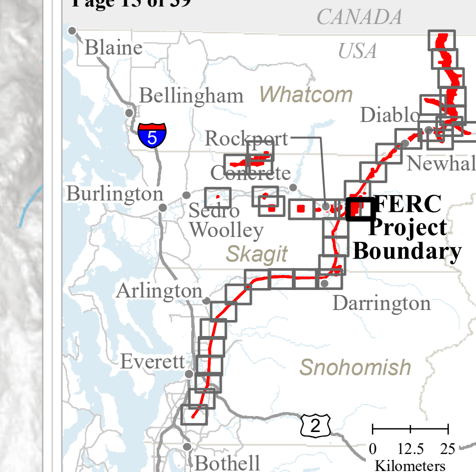
- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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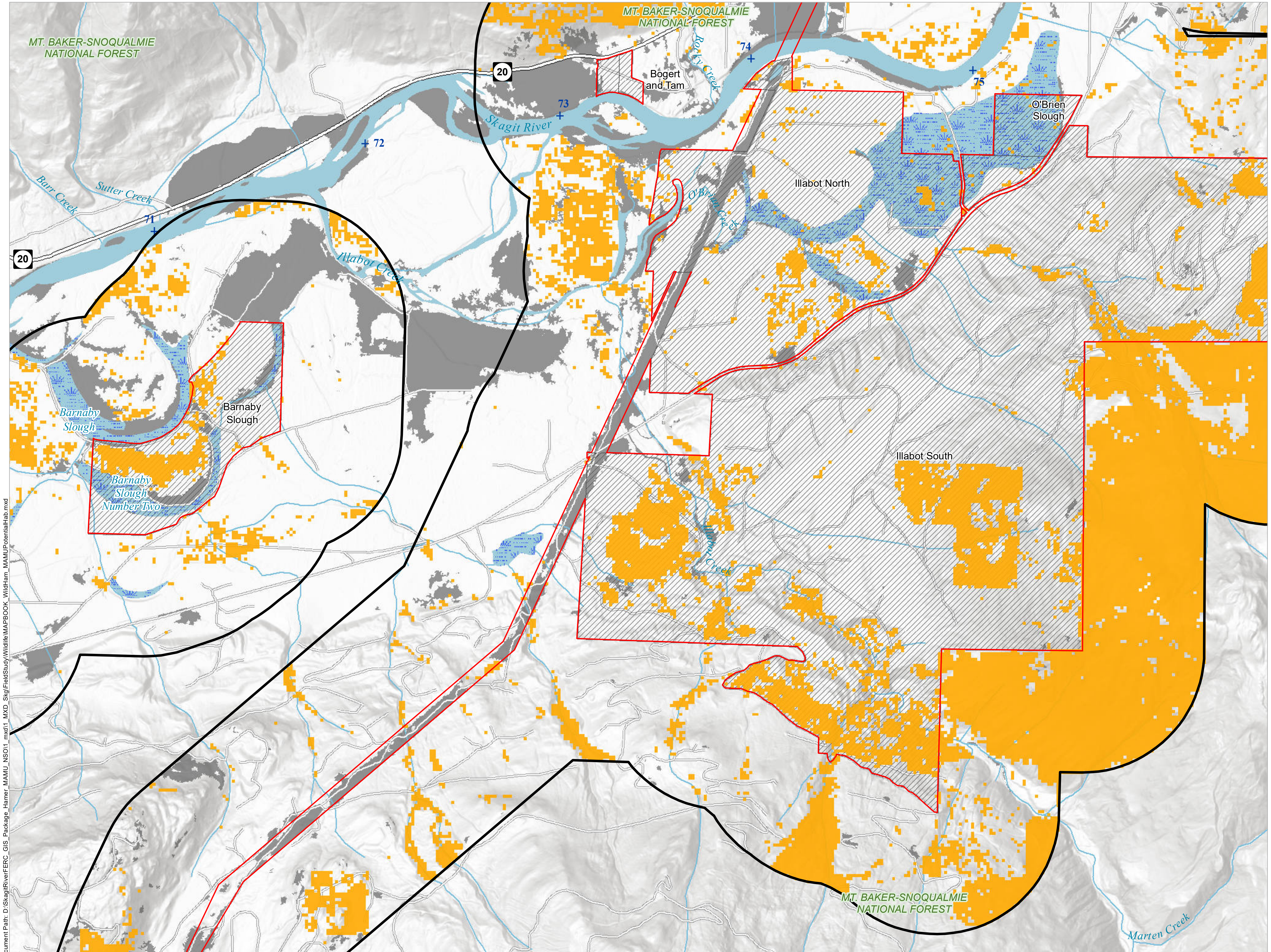

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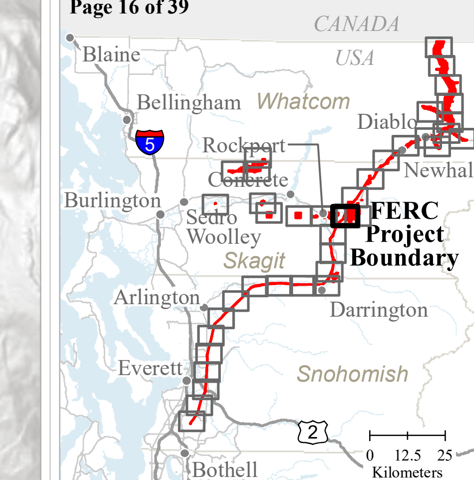
0 0.25 0.5
Kilometers



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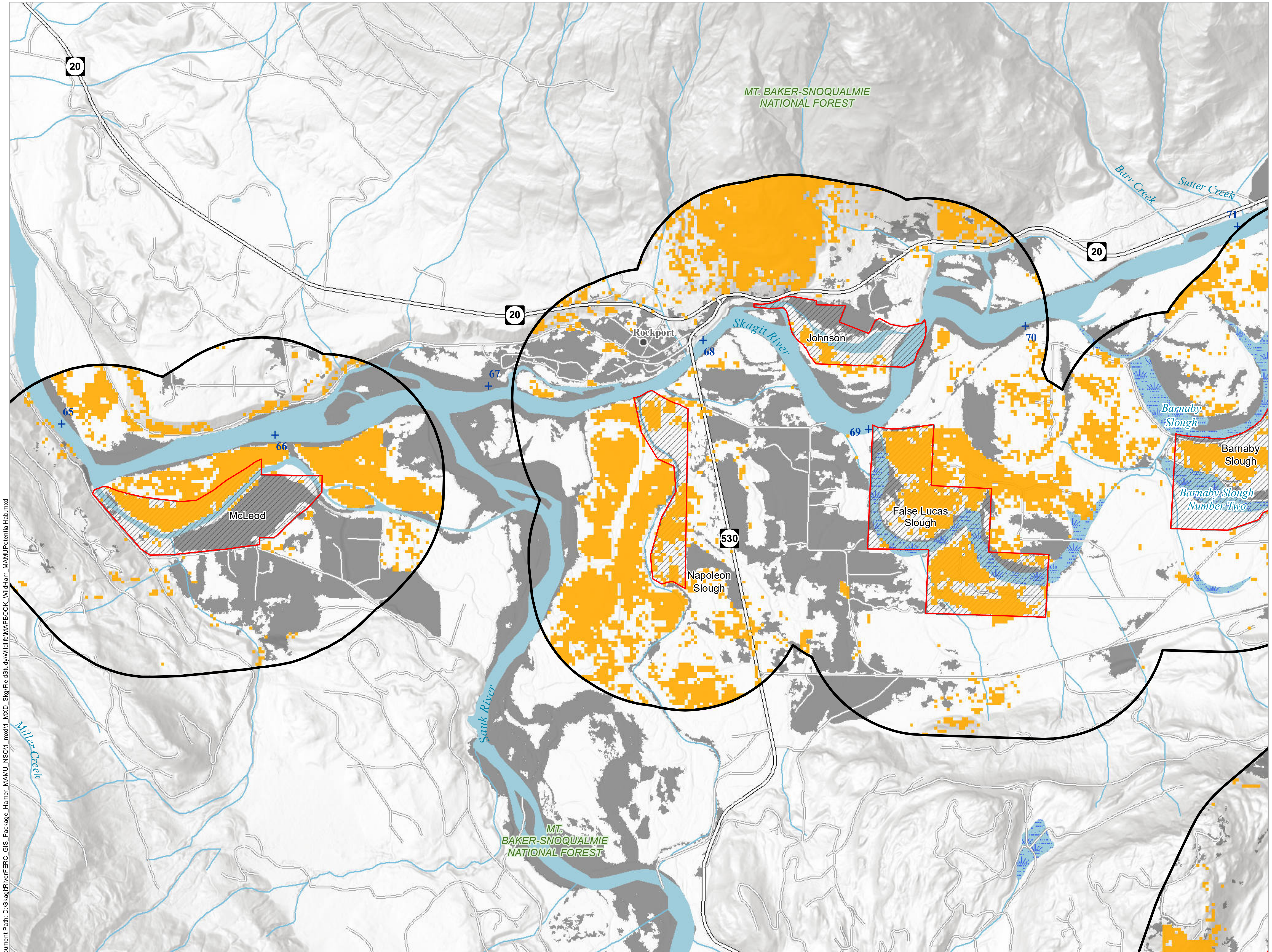
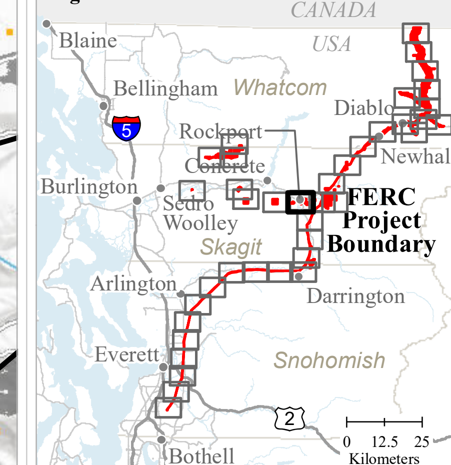


FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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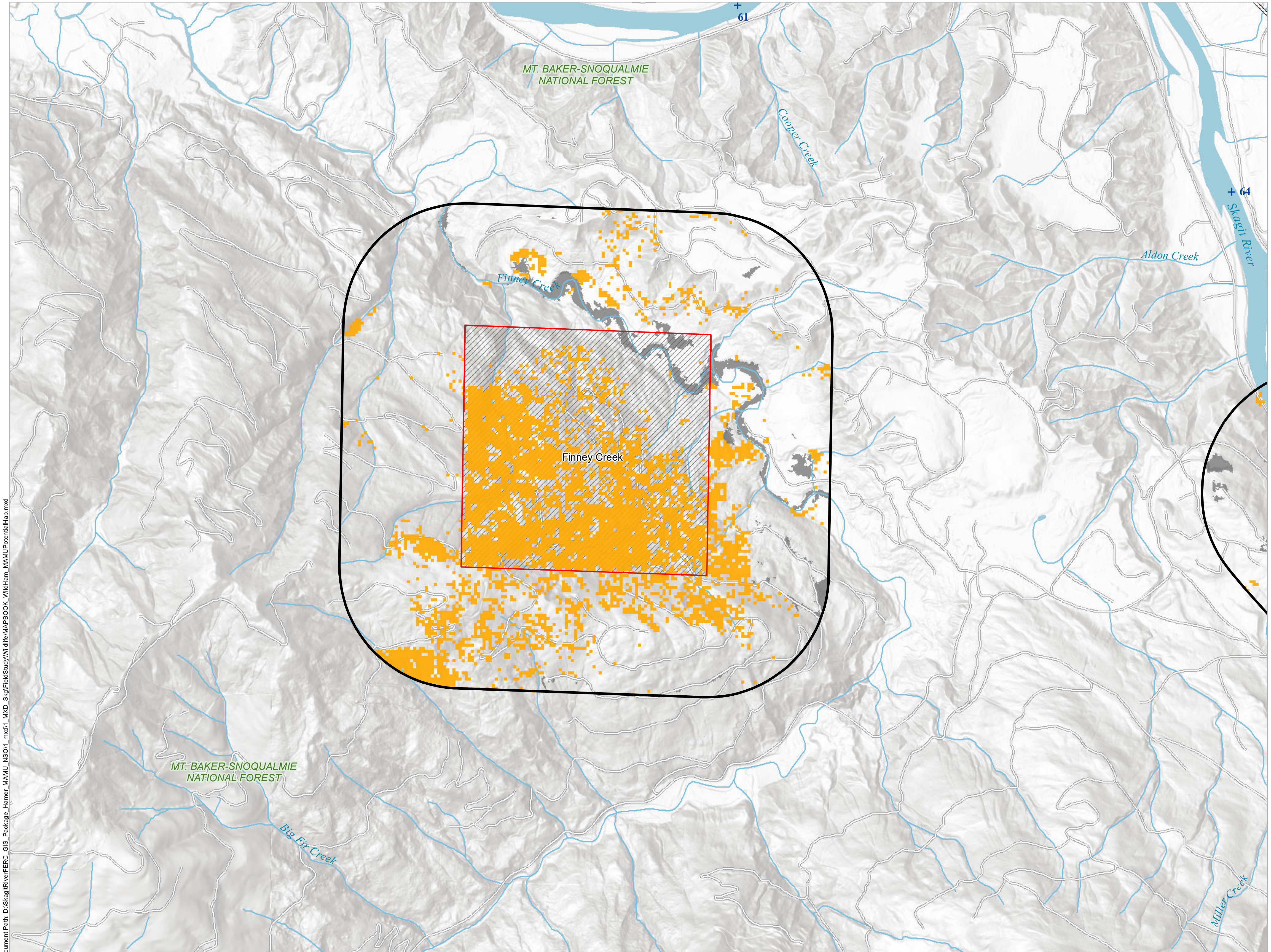
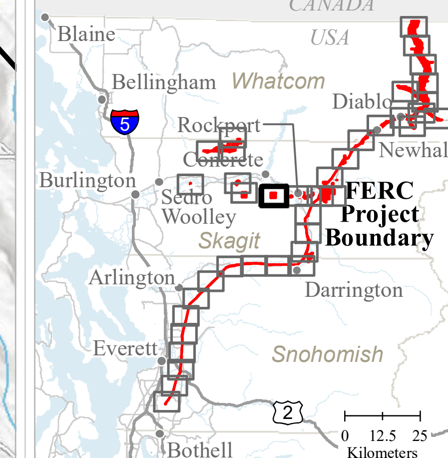


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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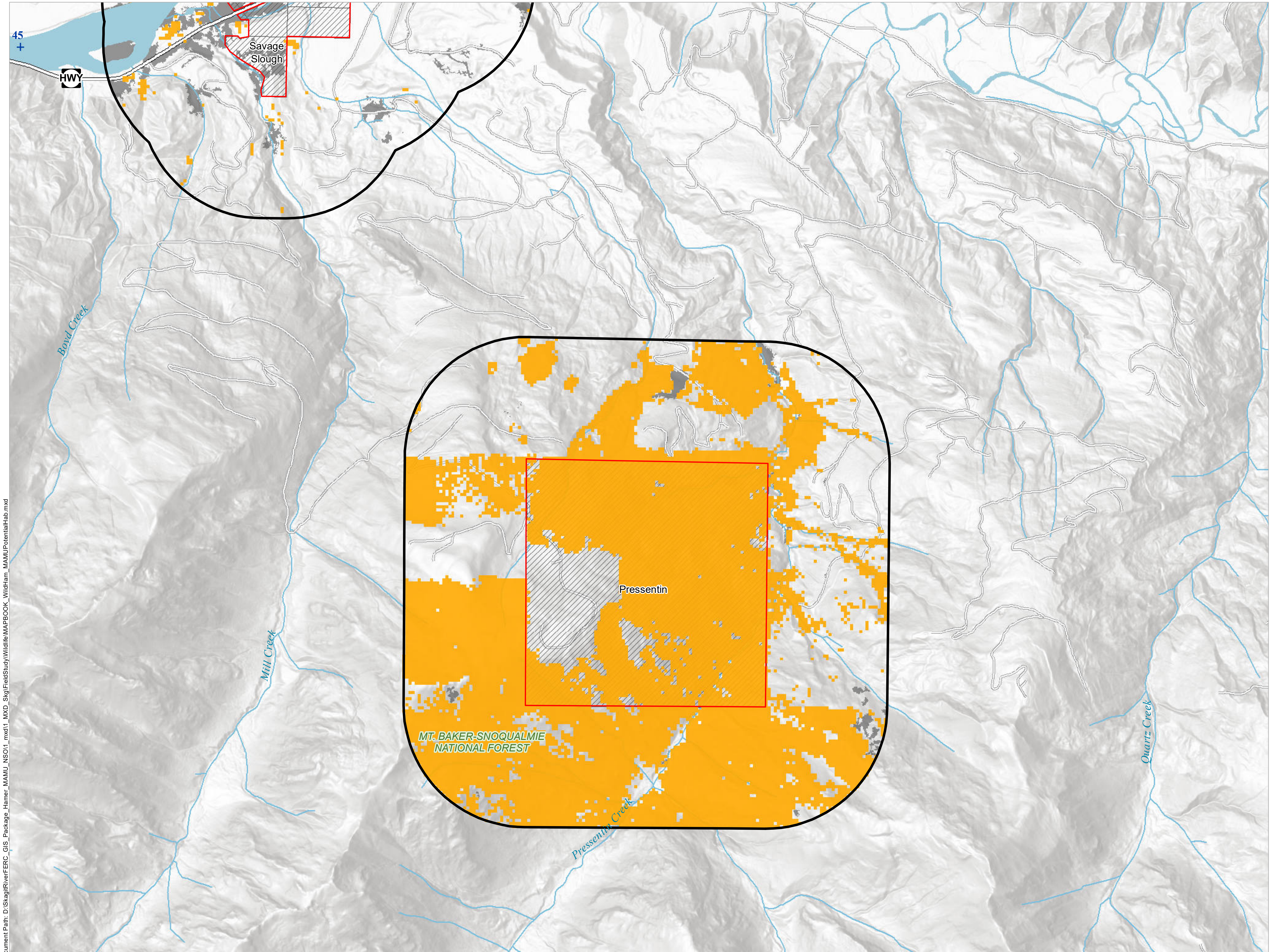

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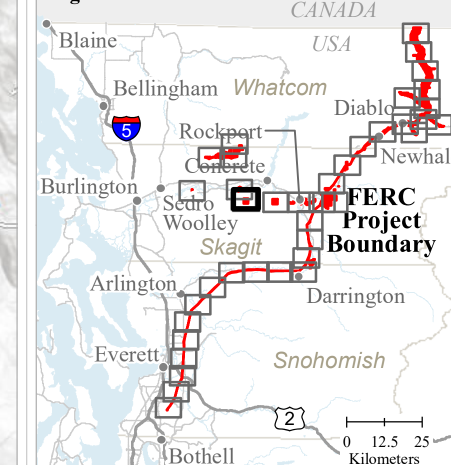
FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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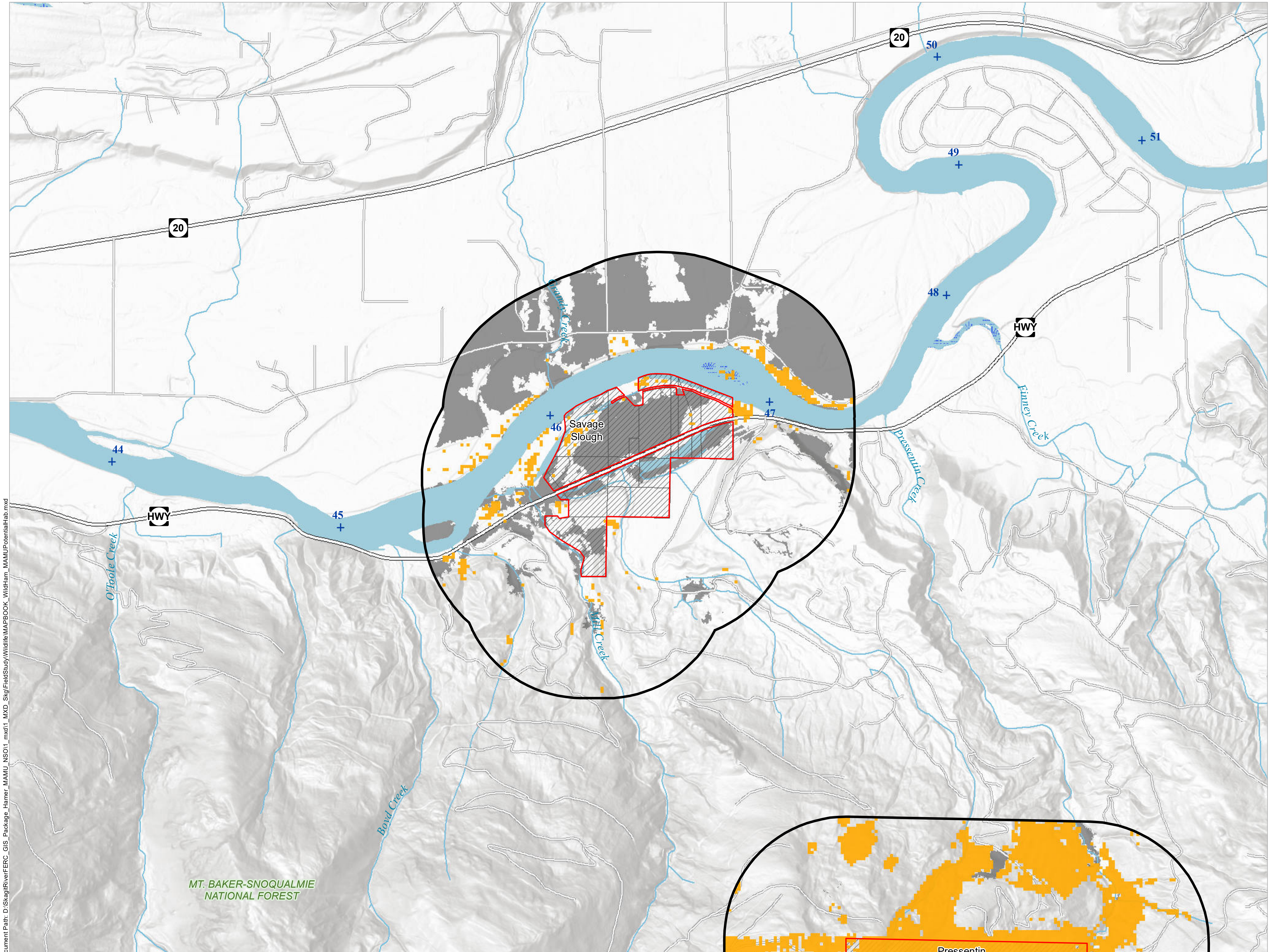
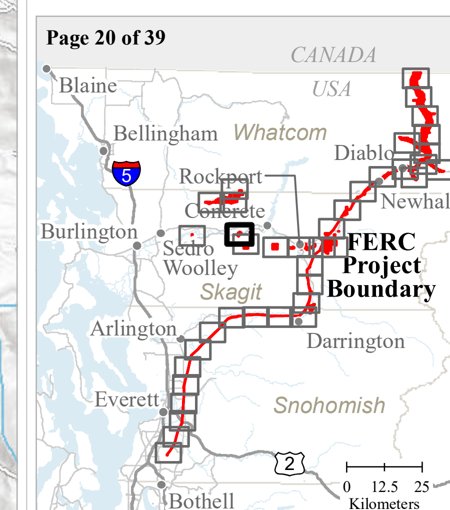


FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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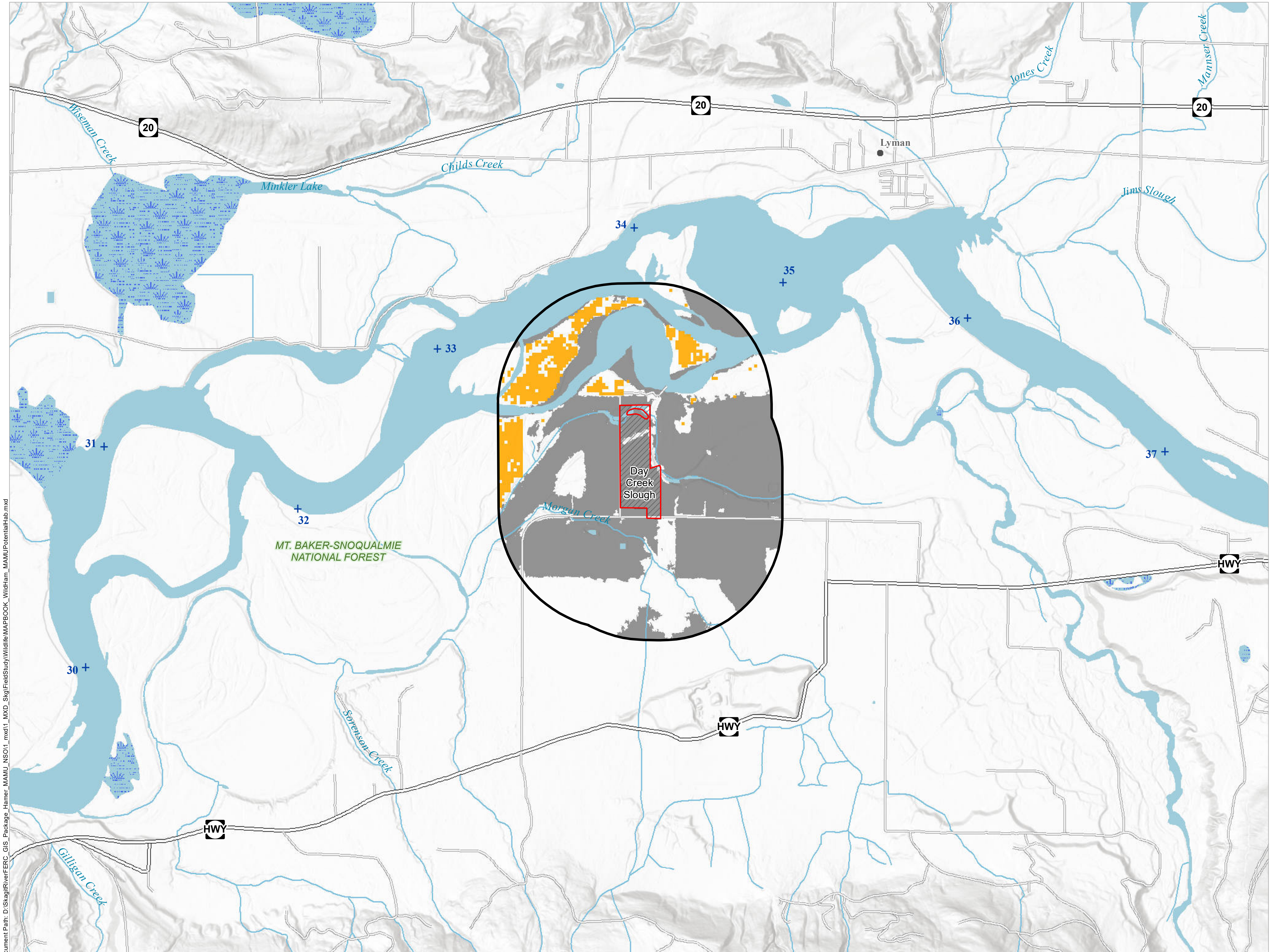

- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Marbled Murrelet Study Area
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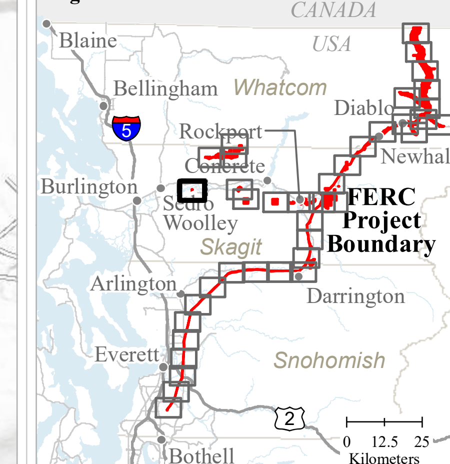
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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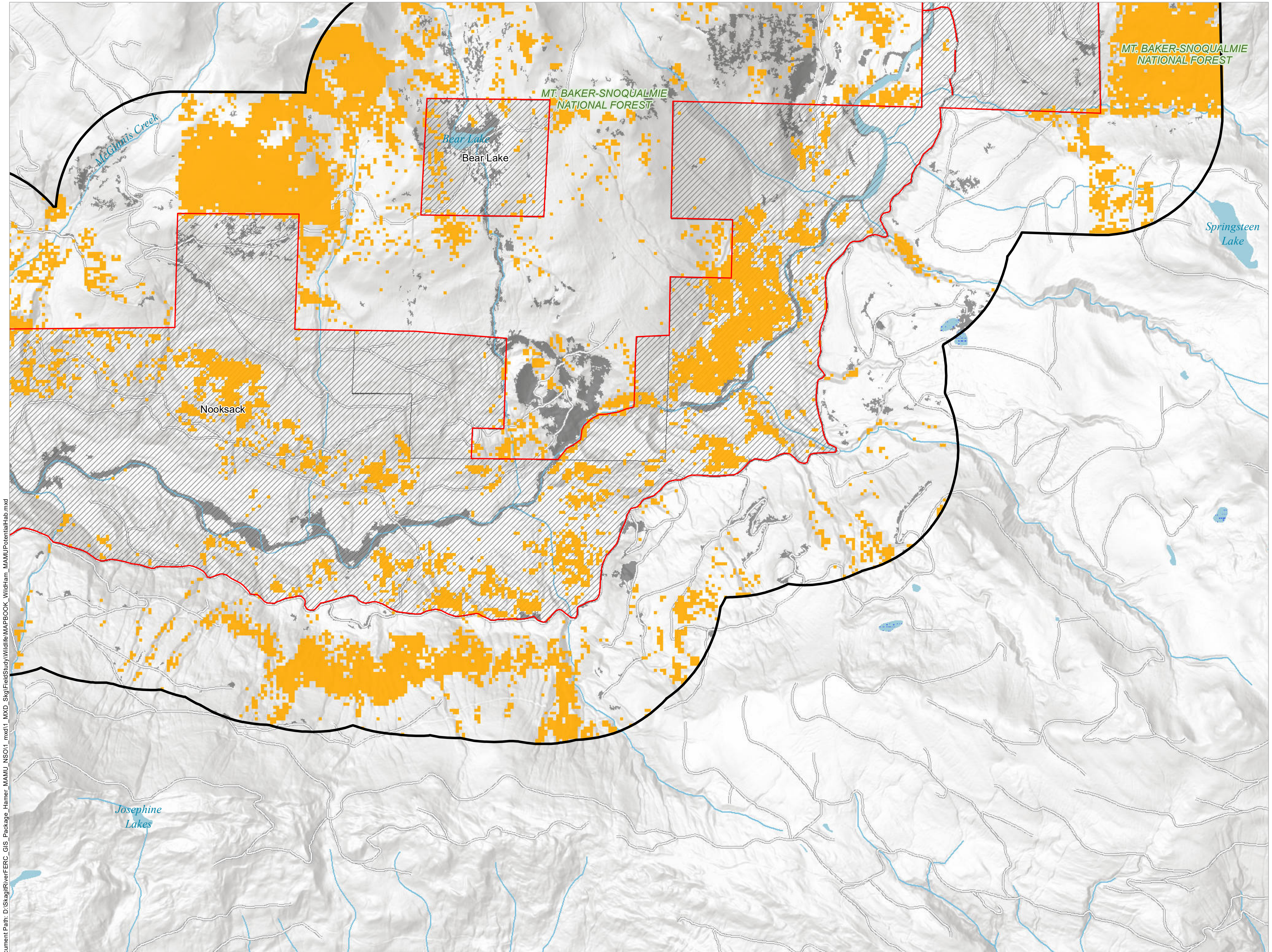
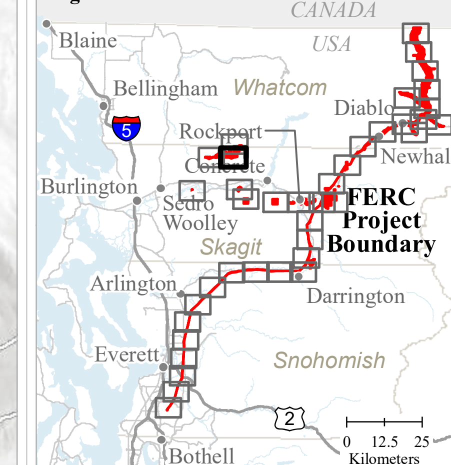


FERC Project Boundary
Mitigation Parcel
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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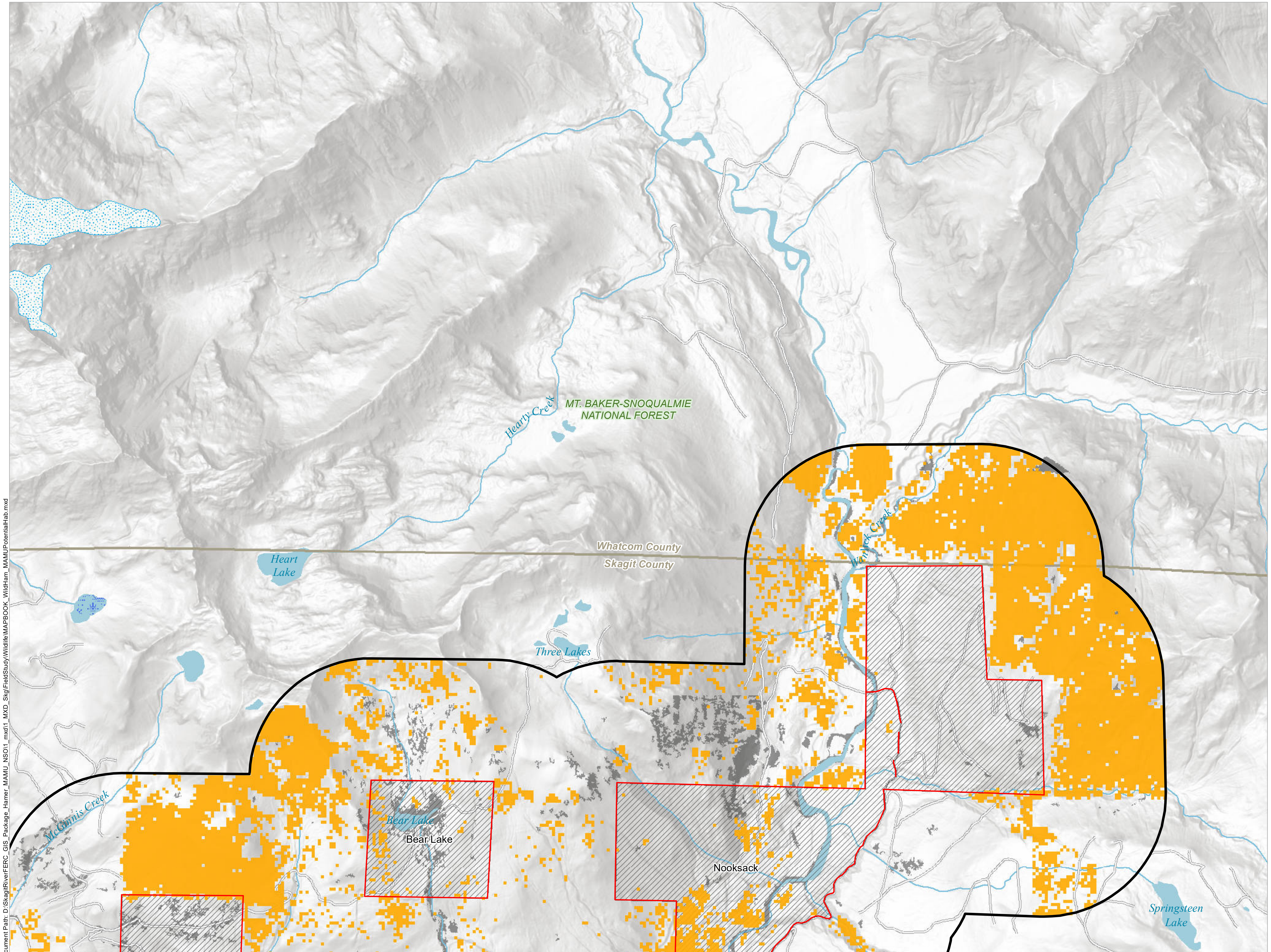

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- FERC Project Boundary
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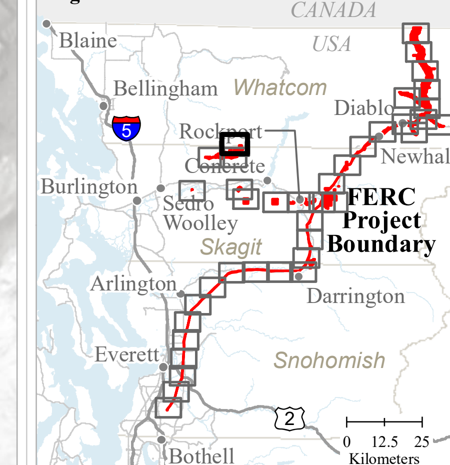
0 0.25 0.5
Kilometers



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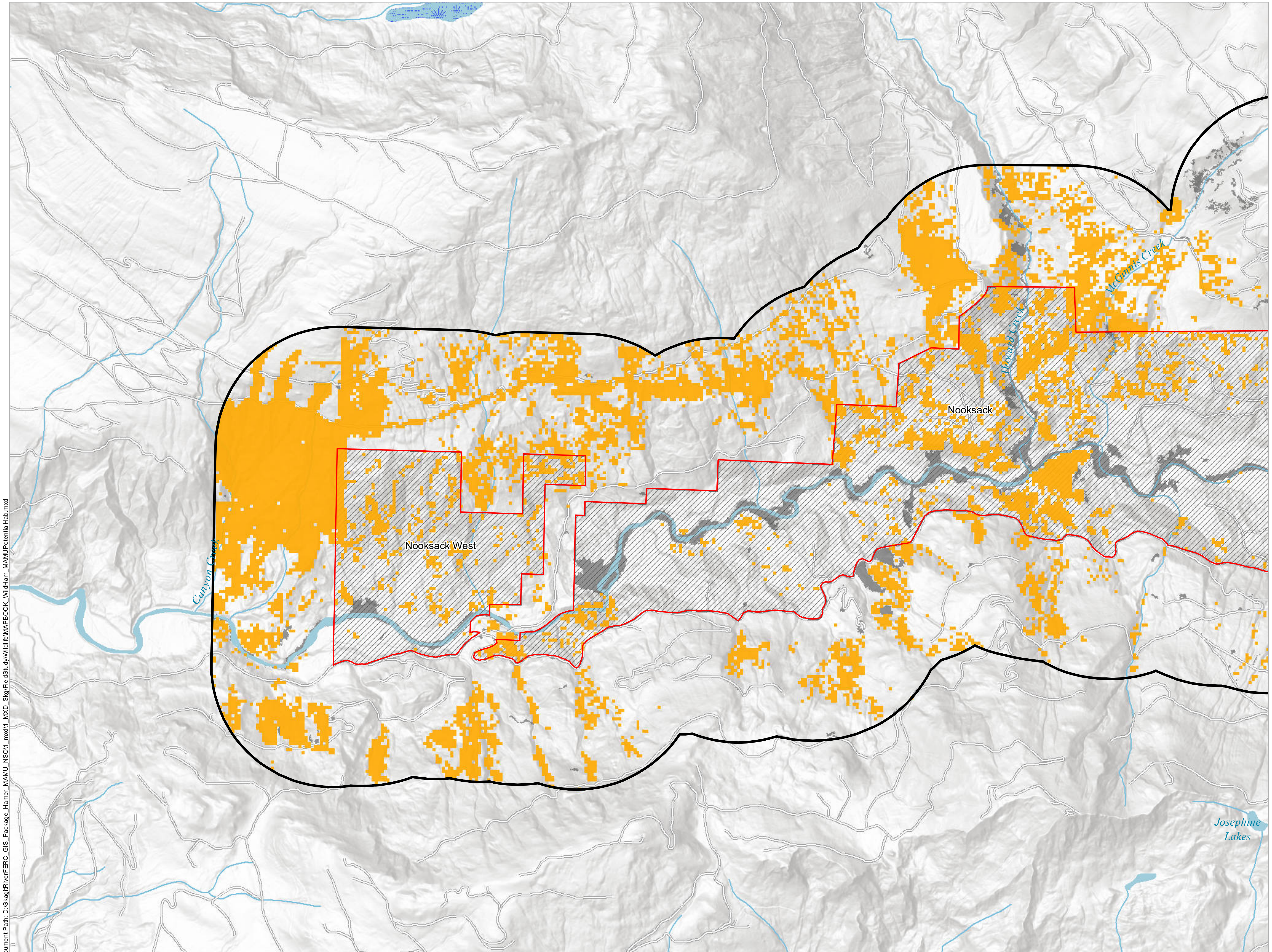

TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
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- Marbled Murrelet Study Area
- Non-forested Area
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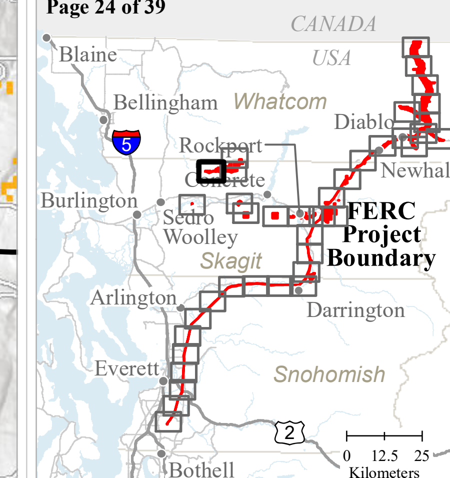
N

0 0.25 0.5
Kilometers



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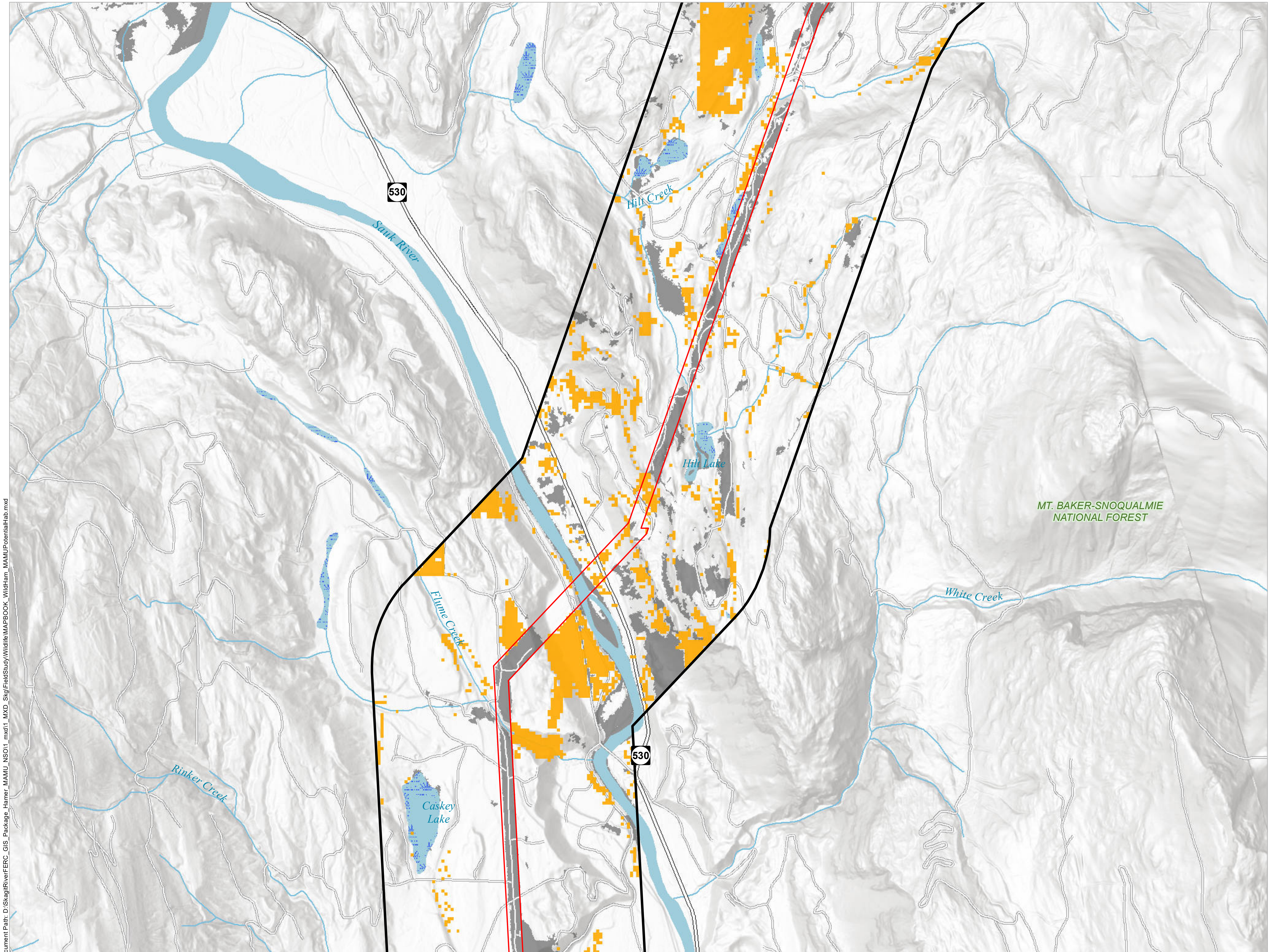

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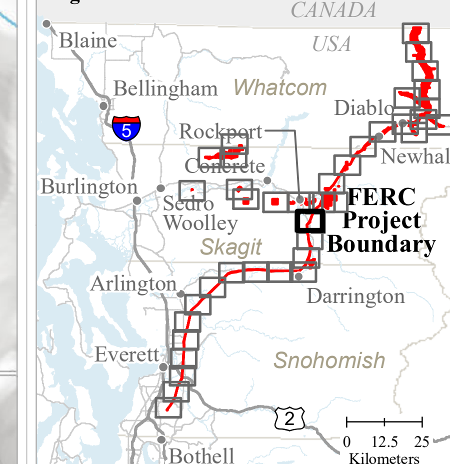
Kilometers



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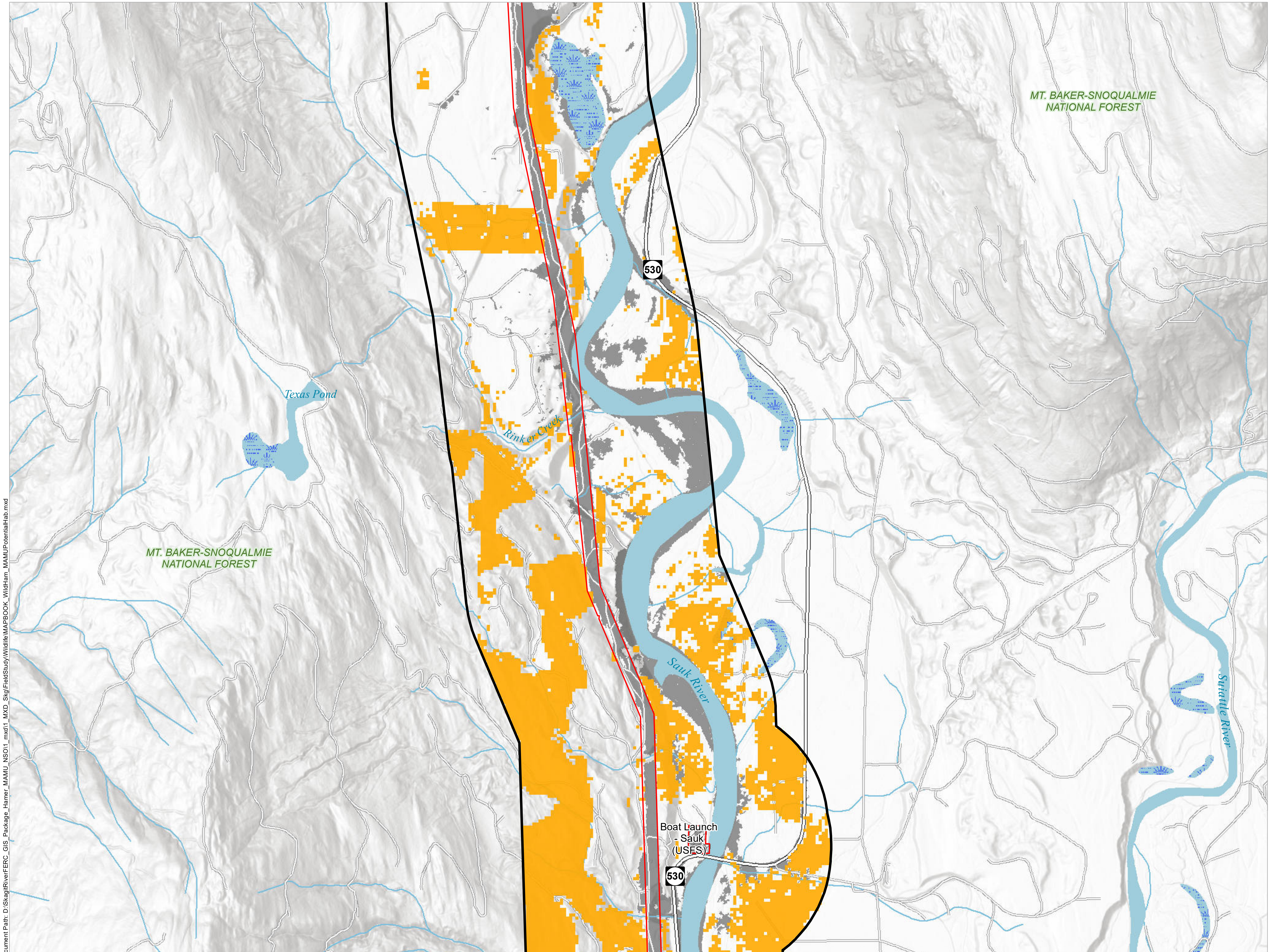

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- FERC Project Boundary
- Mitigation Parcel
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

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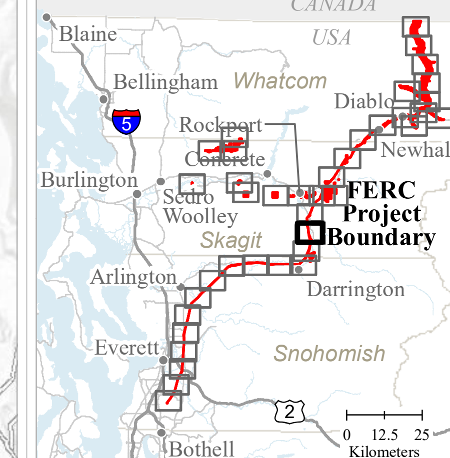
0 0.25 0.5
Kilometers



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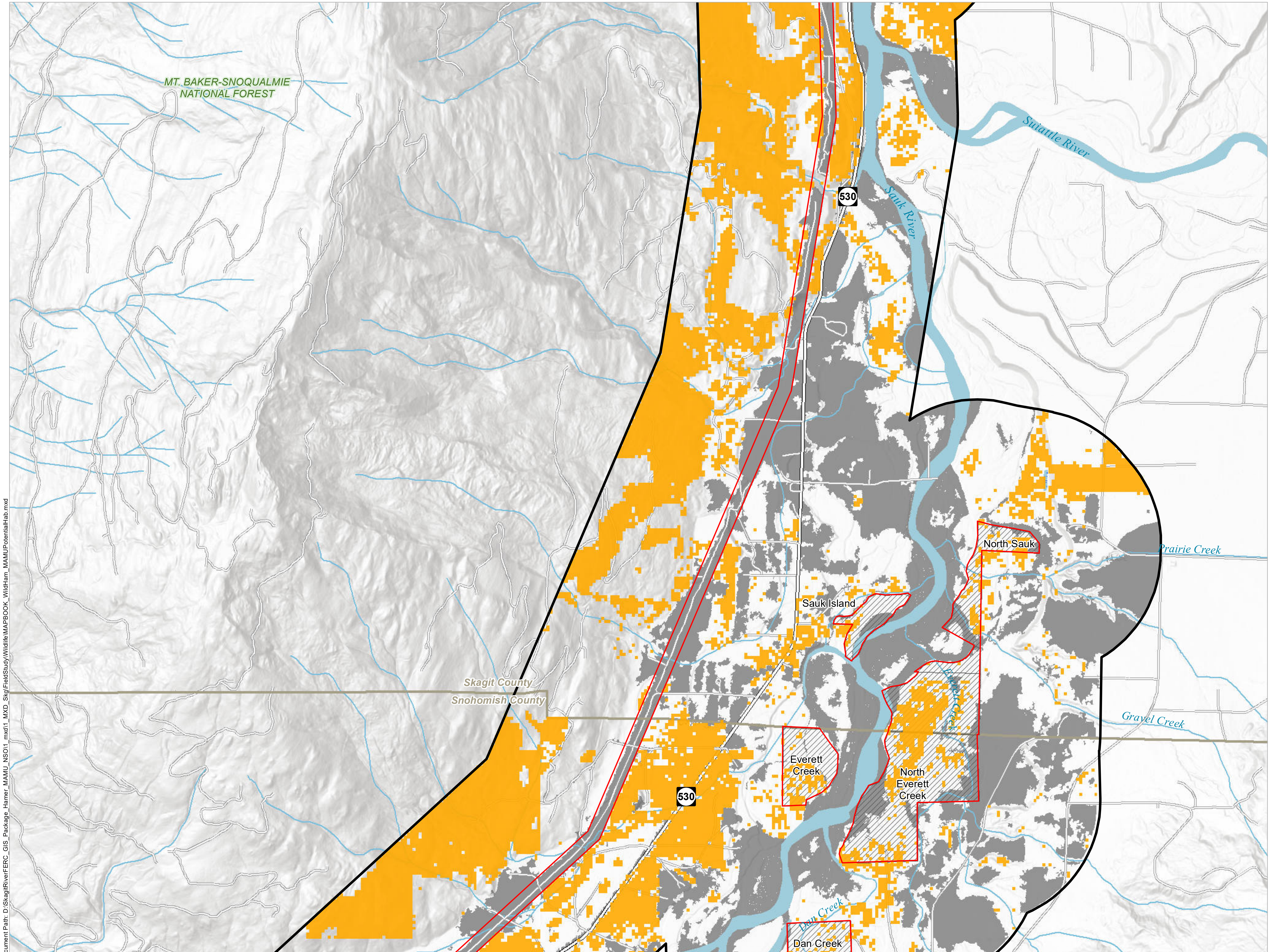

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- Mitigation Parcel
- Marbled Murrelet Study Area
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0 0.25 0.5
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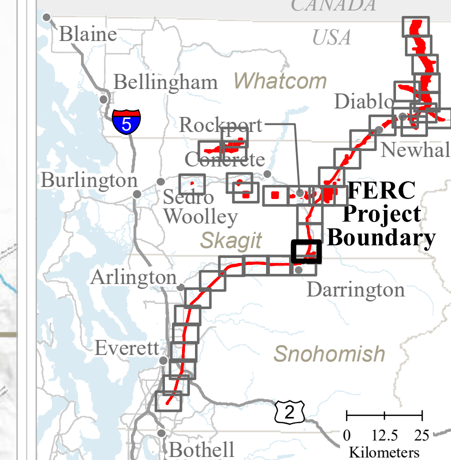

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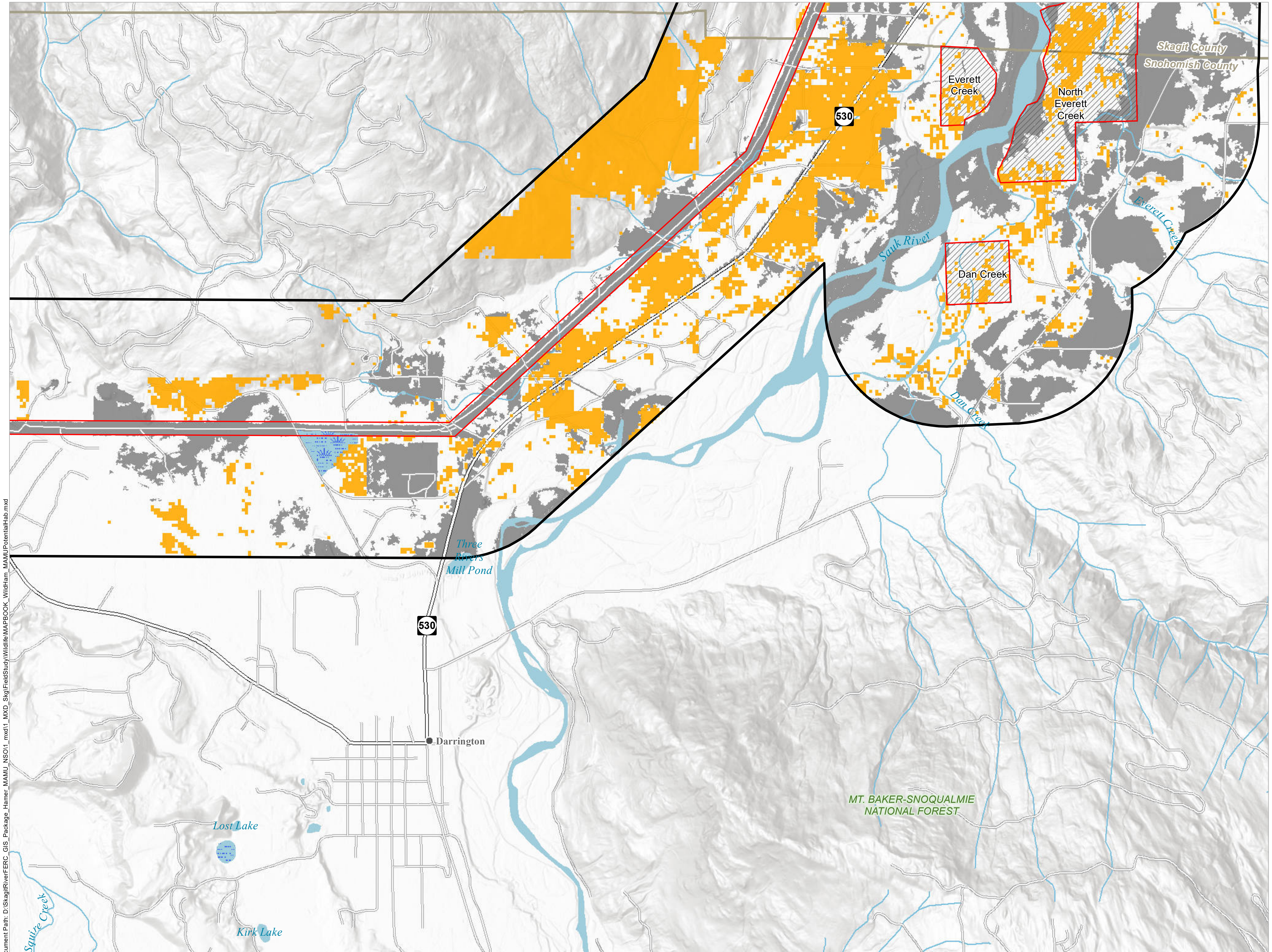
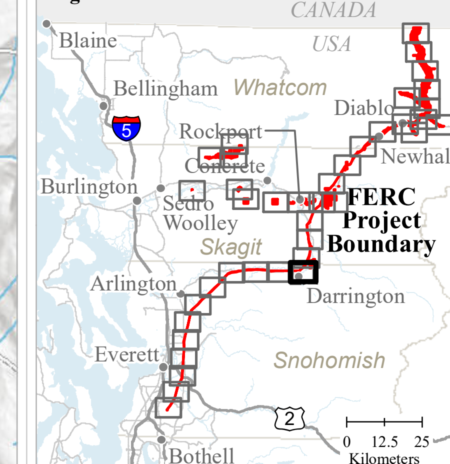


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Mitigation Parcel
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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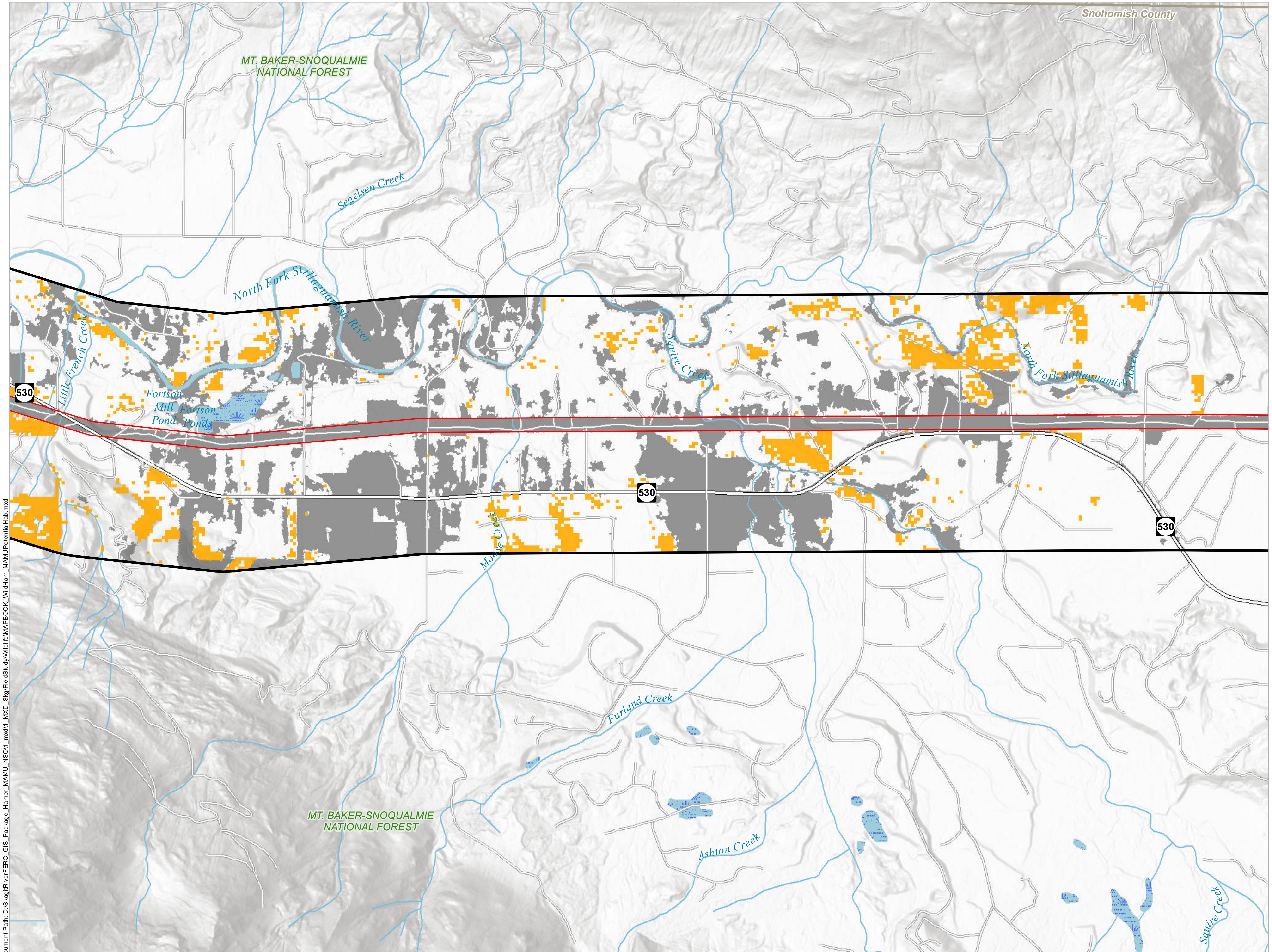
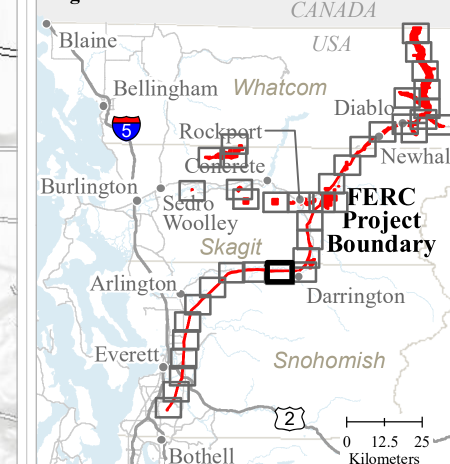


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

FERC Project Boundary
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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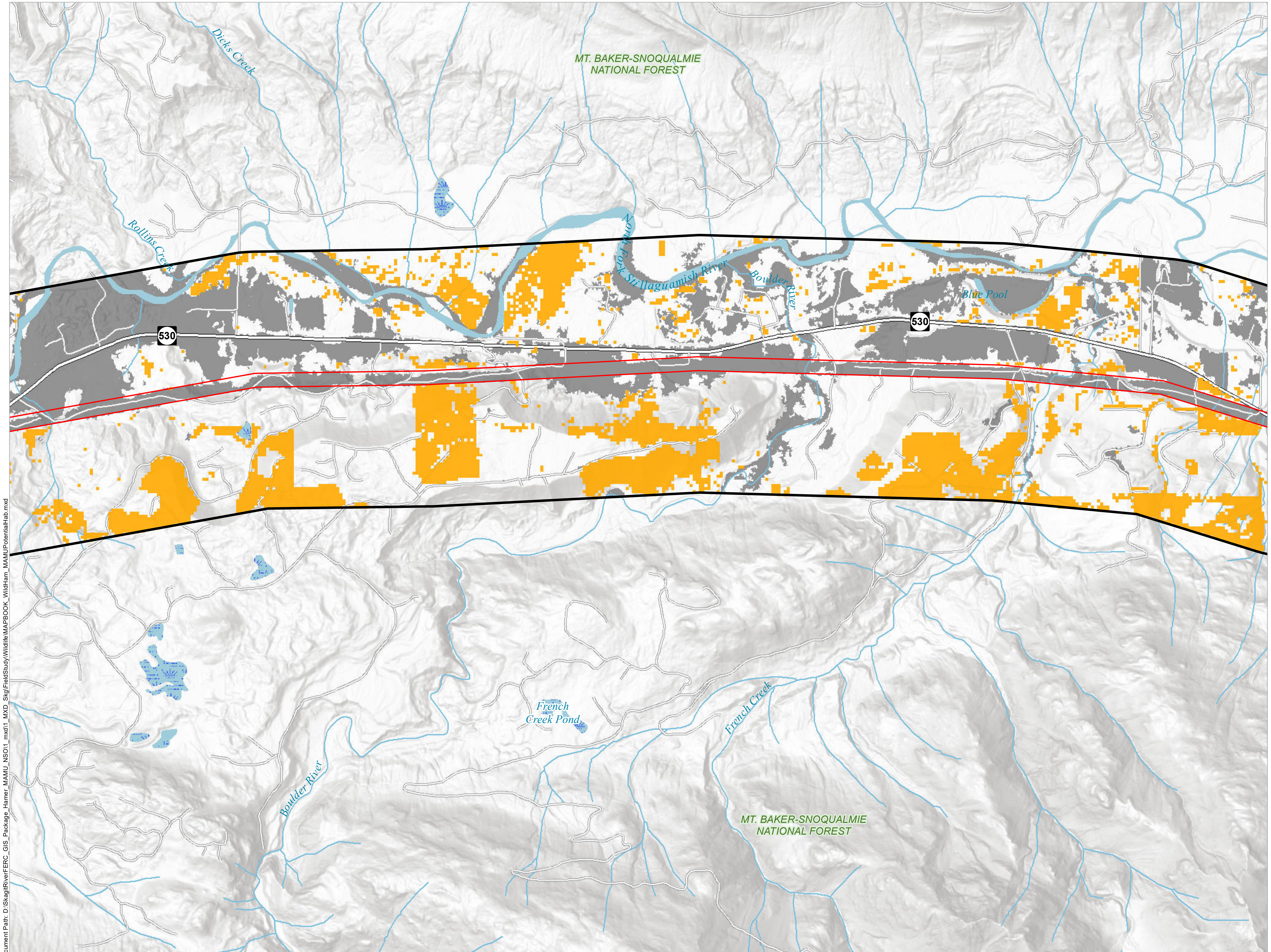
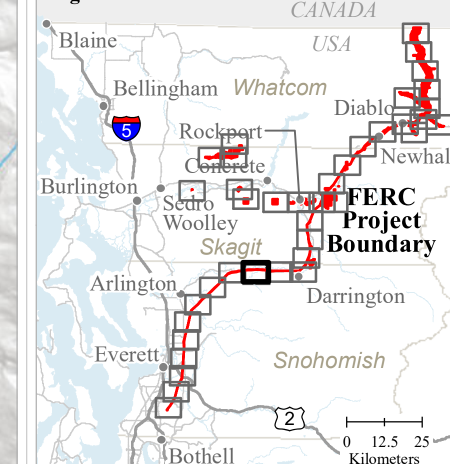
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



FERC Project Boundary
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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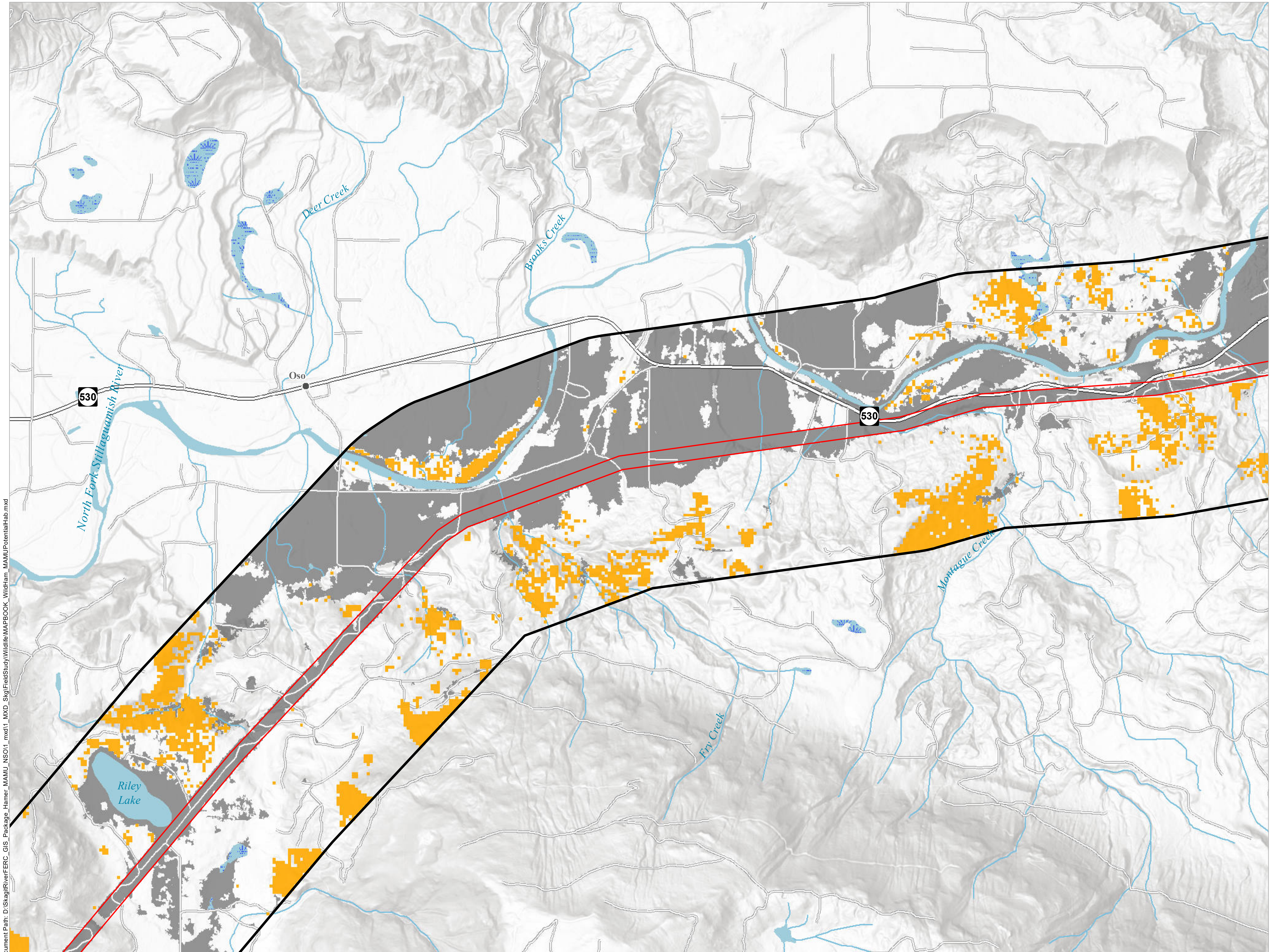
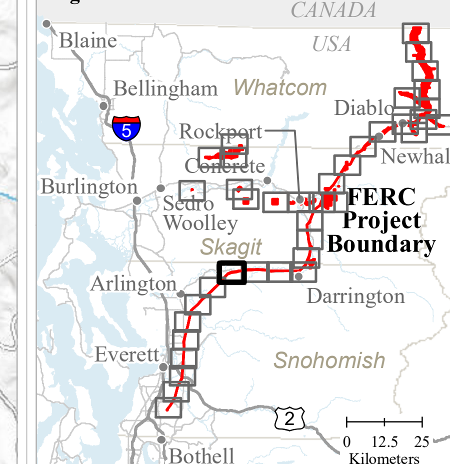


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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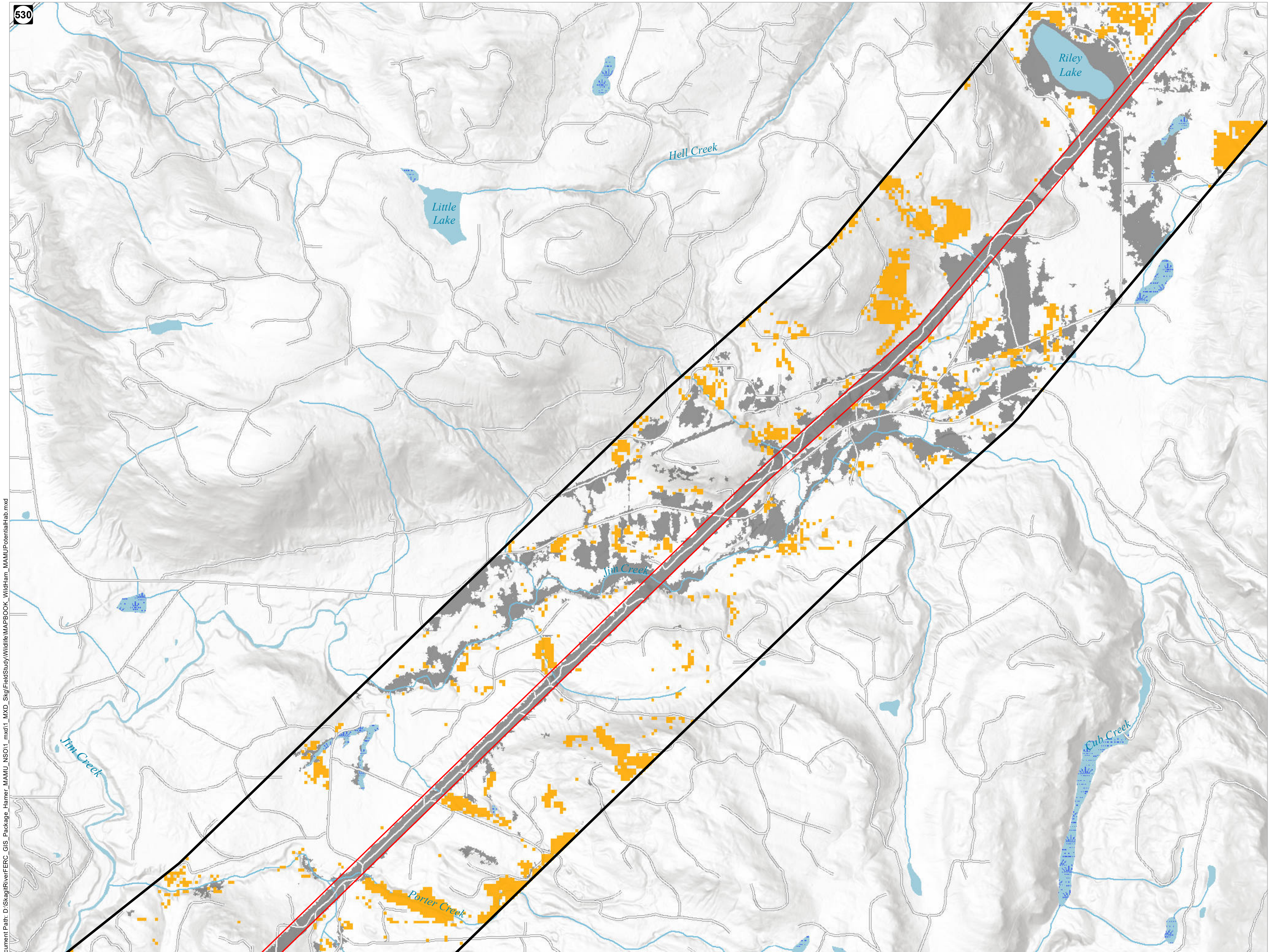
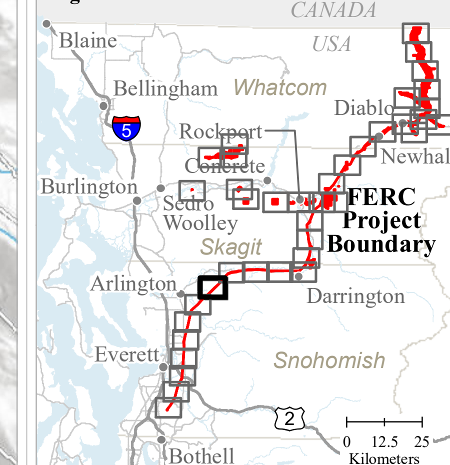


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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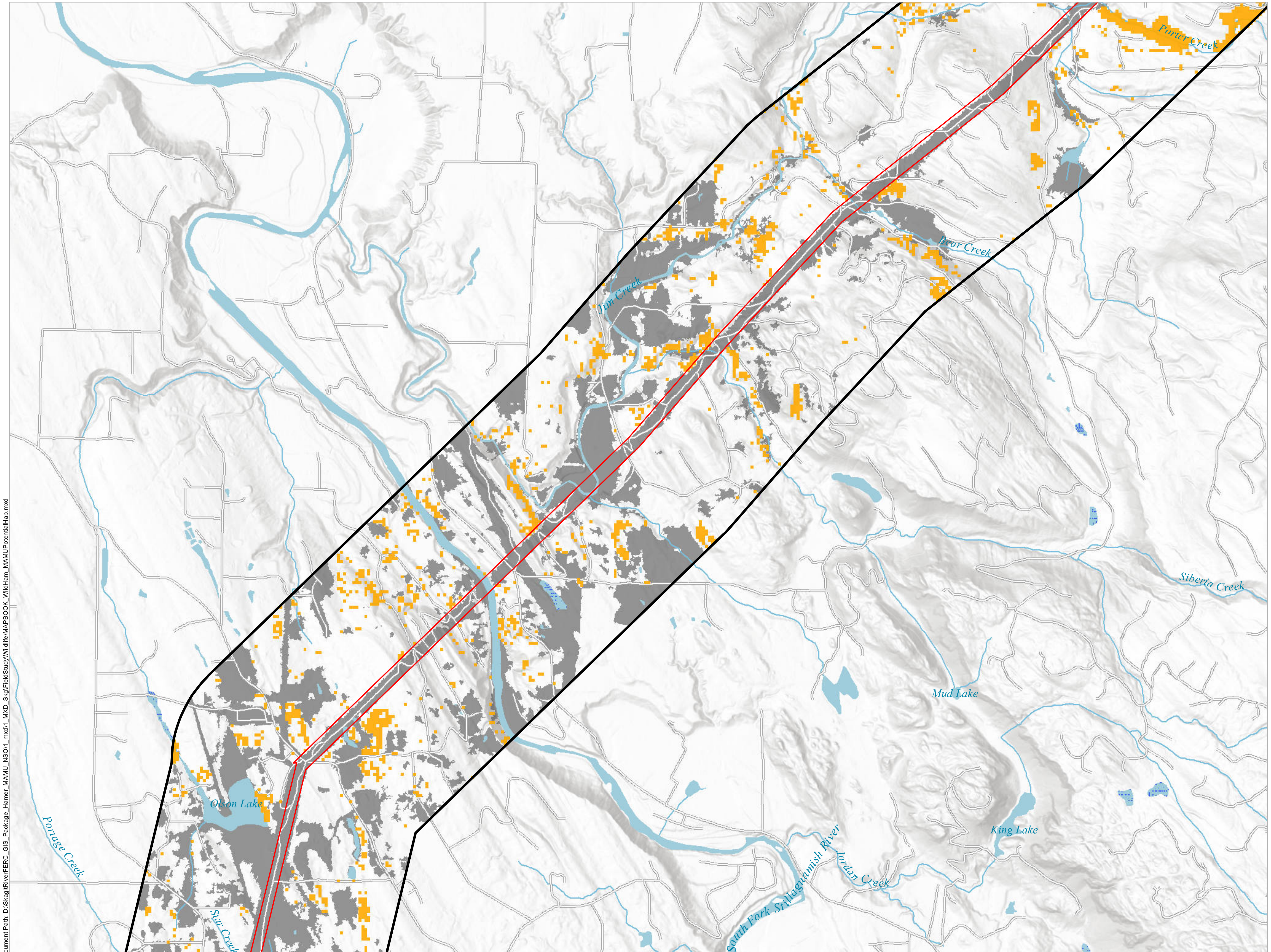
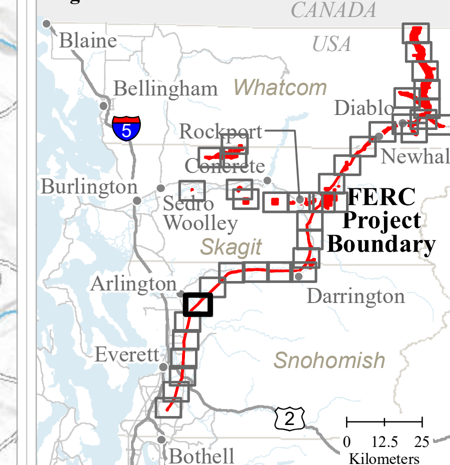


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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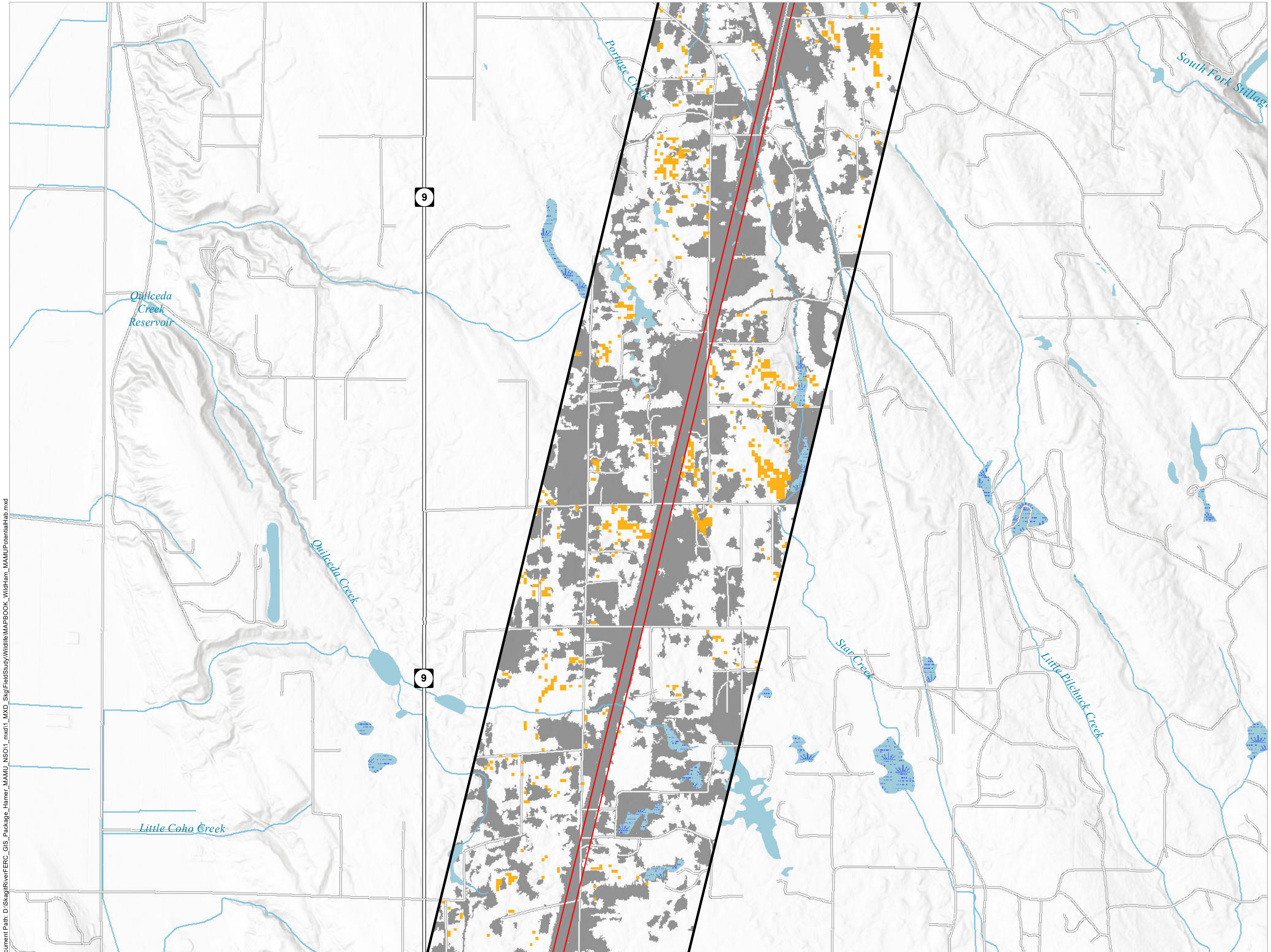

TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers

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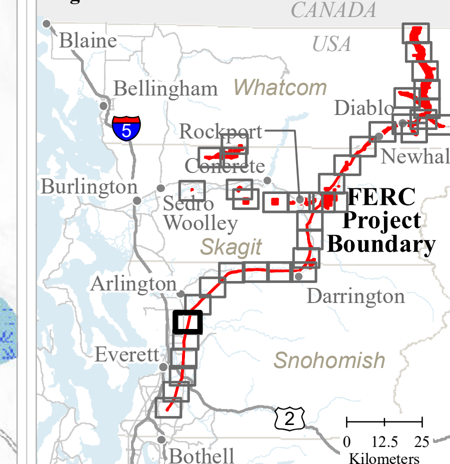

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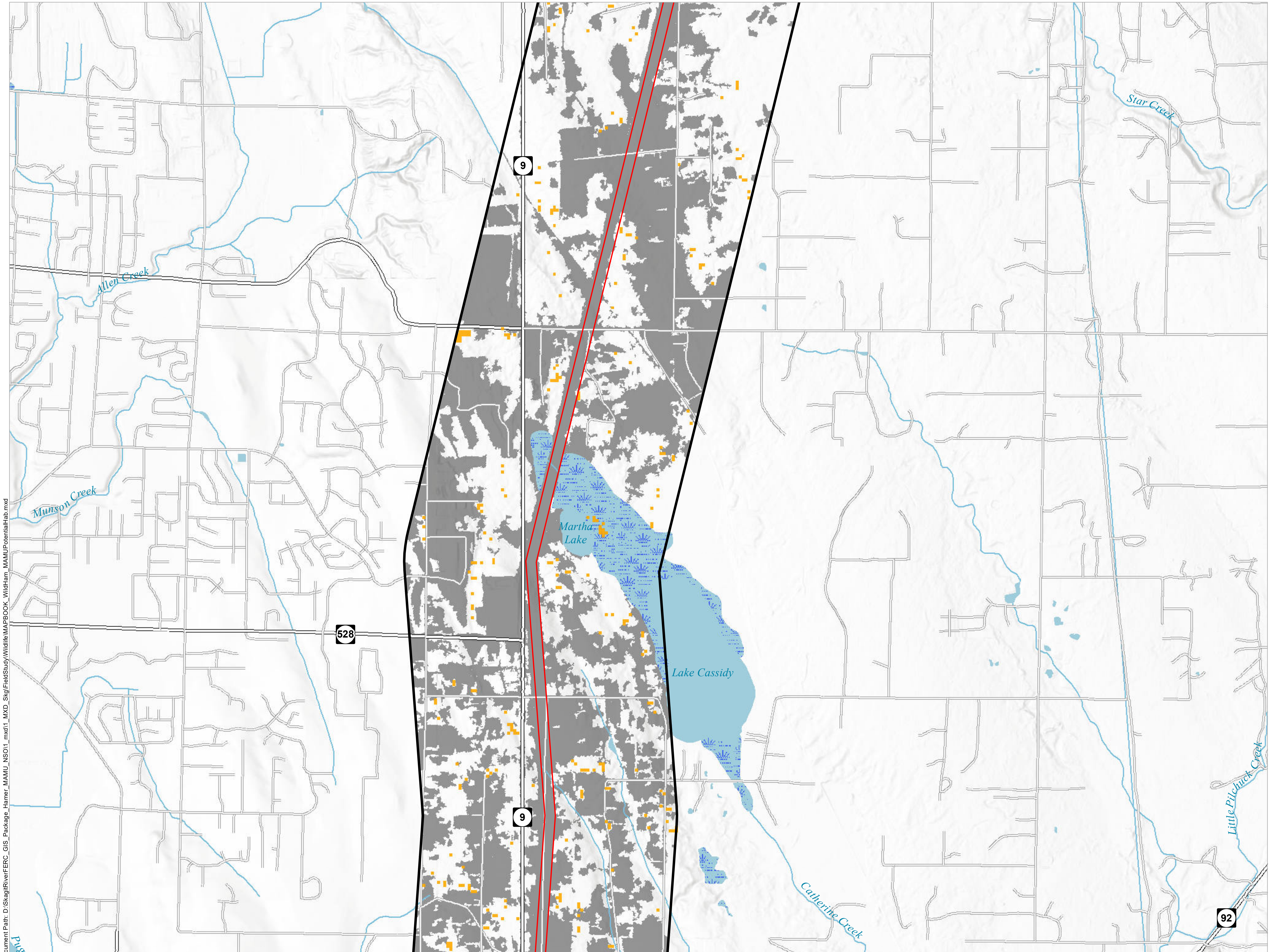

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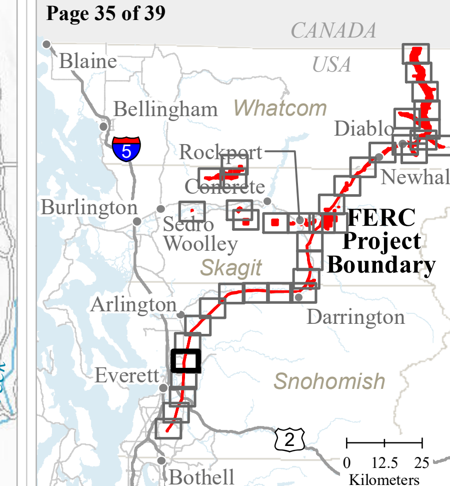
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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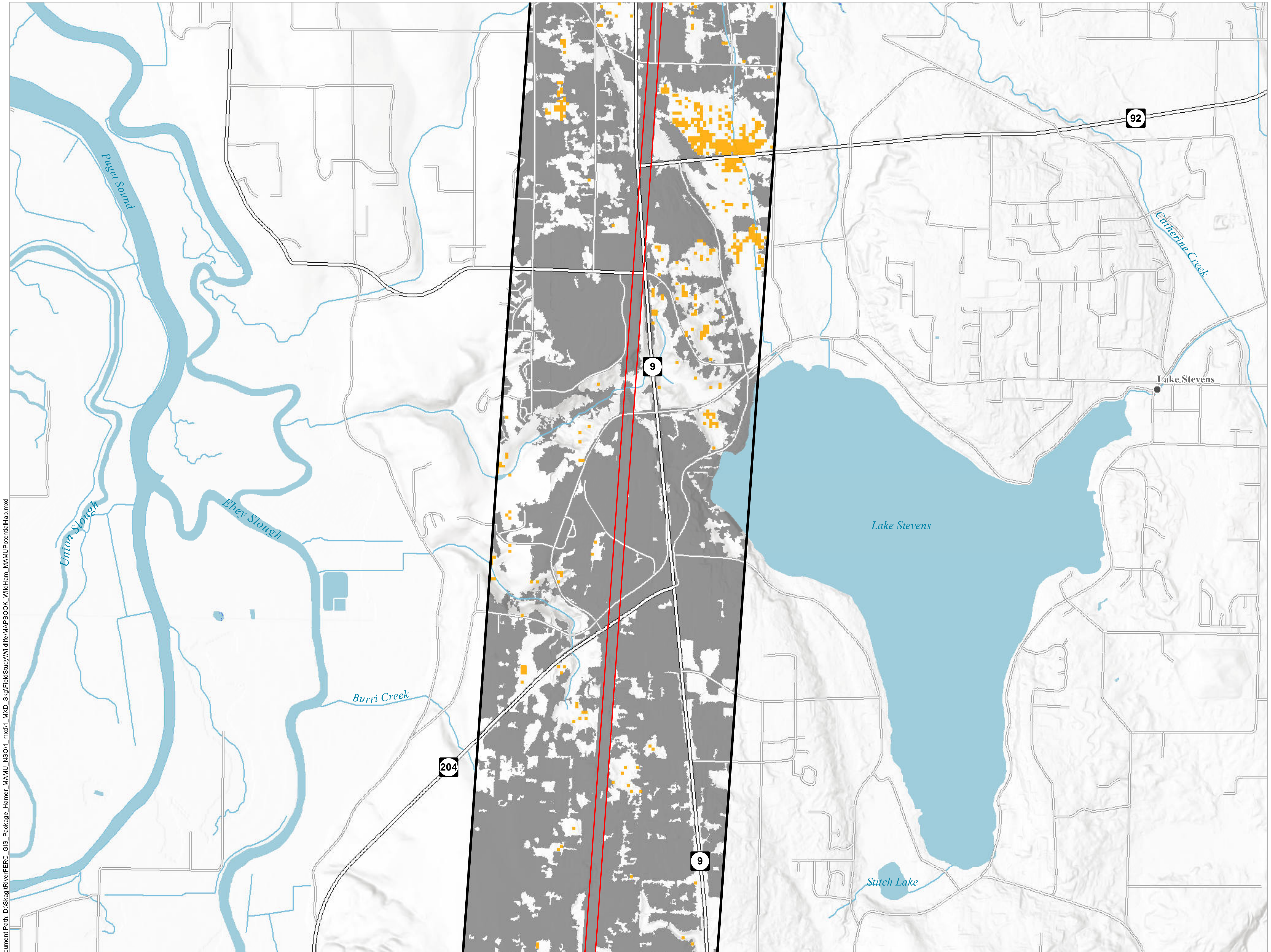
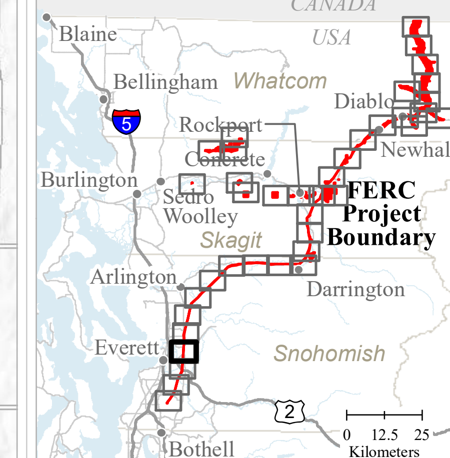
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK



- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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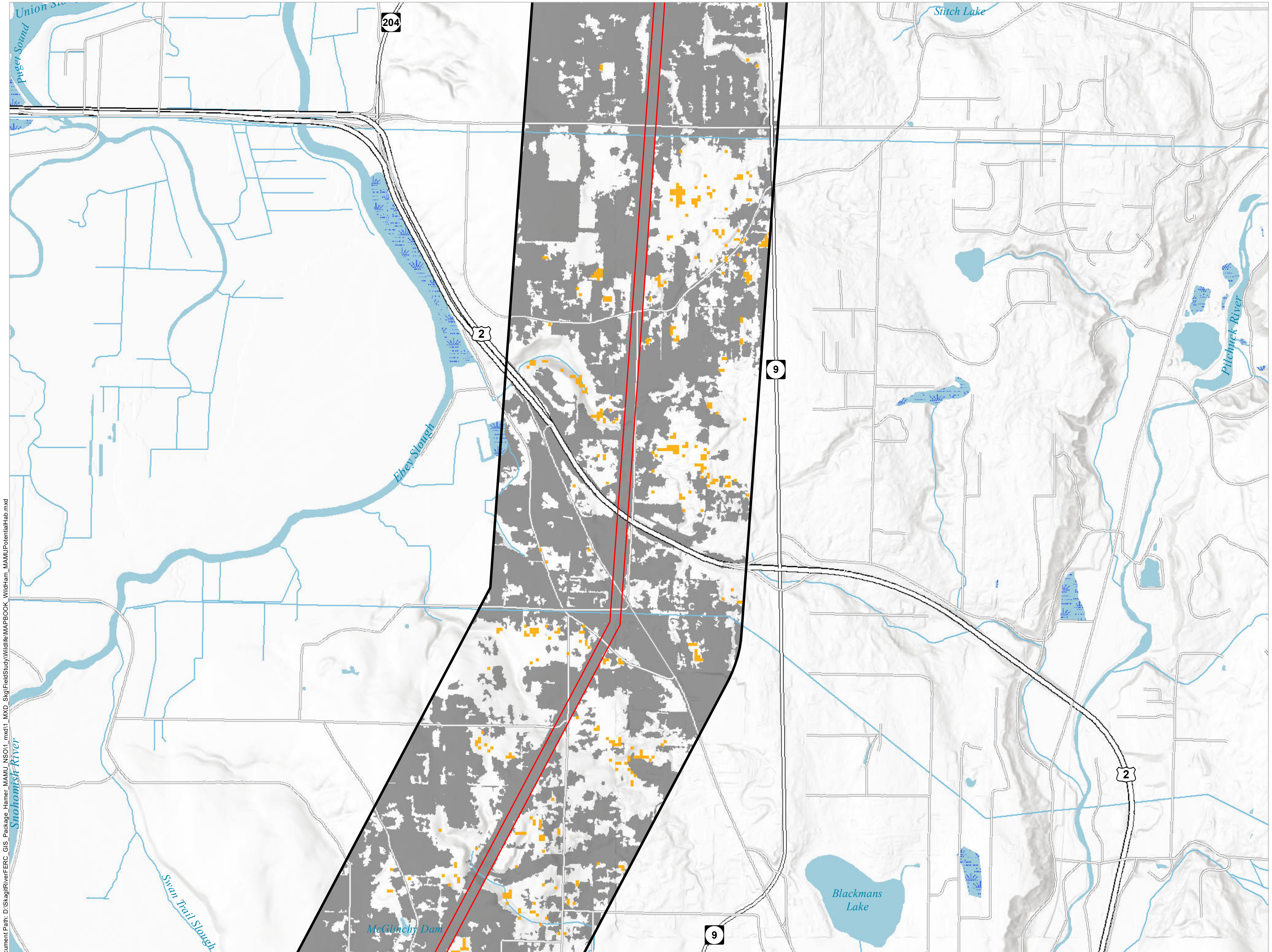
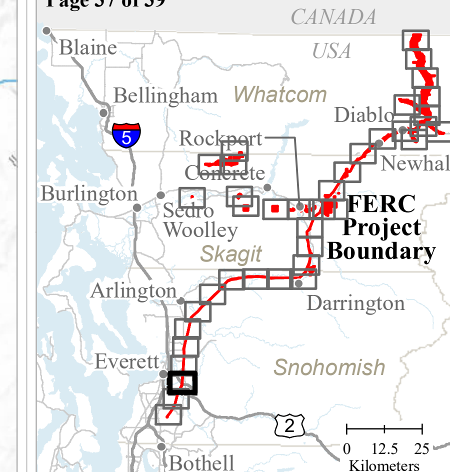


- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

N

0 0.25 0.5
Kilometers



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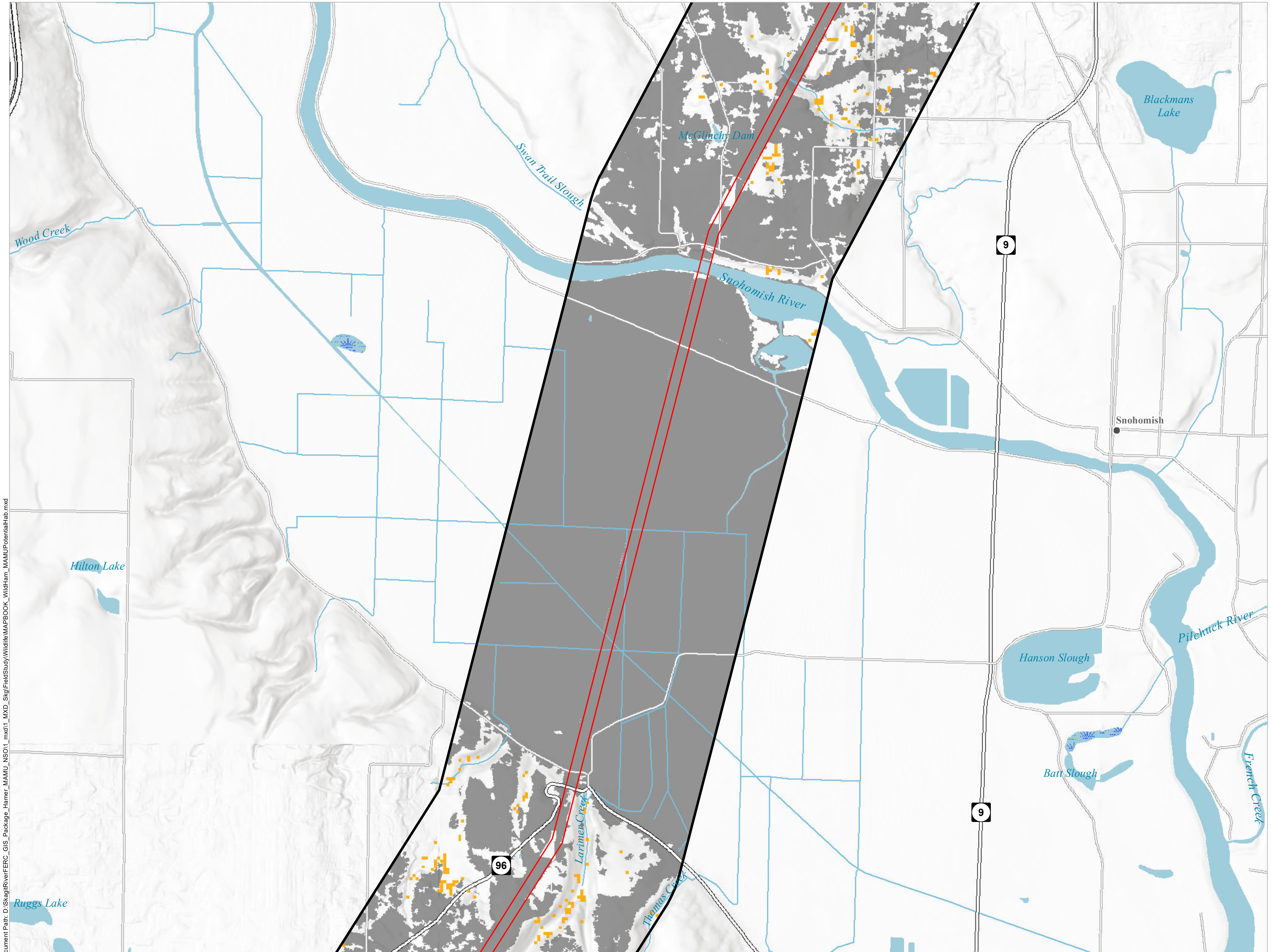
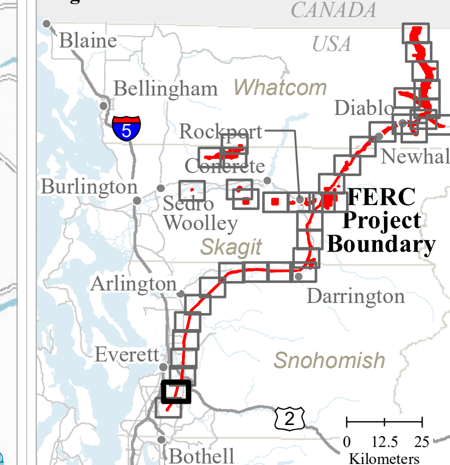


TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

FERC Project Boundary
Marbled Murrelet Study Area
Non-forested Area
Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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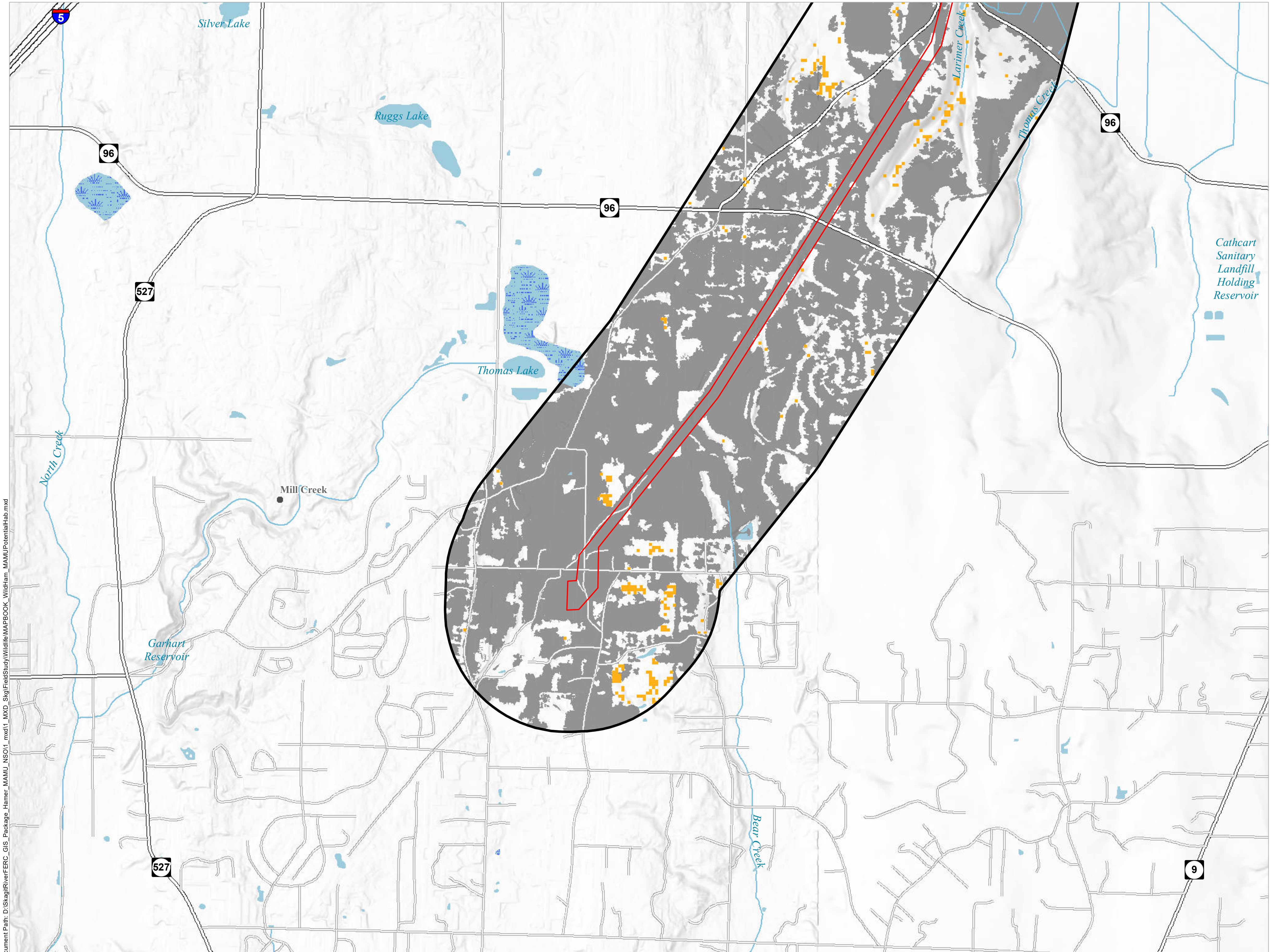

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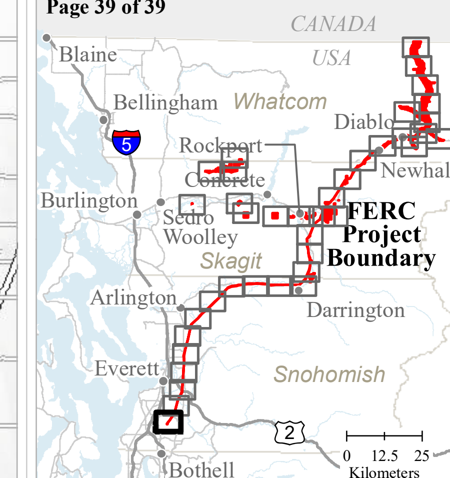
TR-05 MARBLED MURRELET STUDY POTENTIALLY SUITABLE NESTING HABITAT MAPBOOK

- FERC Project Boundary
- Marbled Murrelet Study Area
- Non-forested Area
- Potentially Suitable Marbled Murrelet Nesting Habitat

0 0.25 0.5
Kilometers



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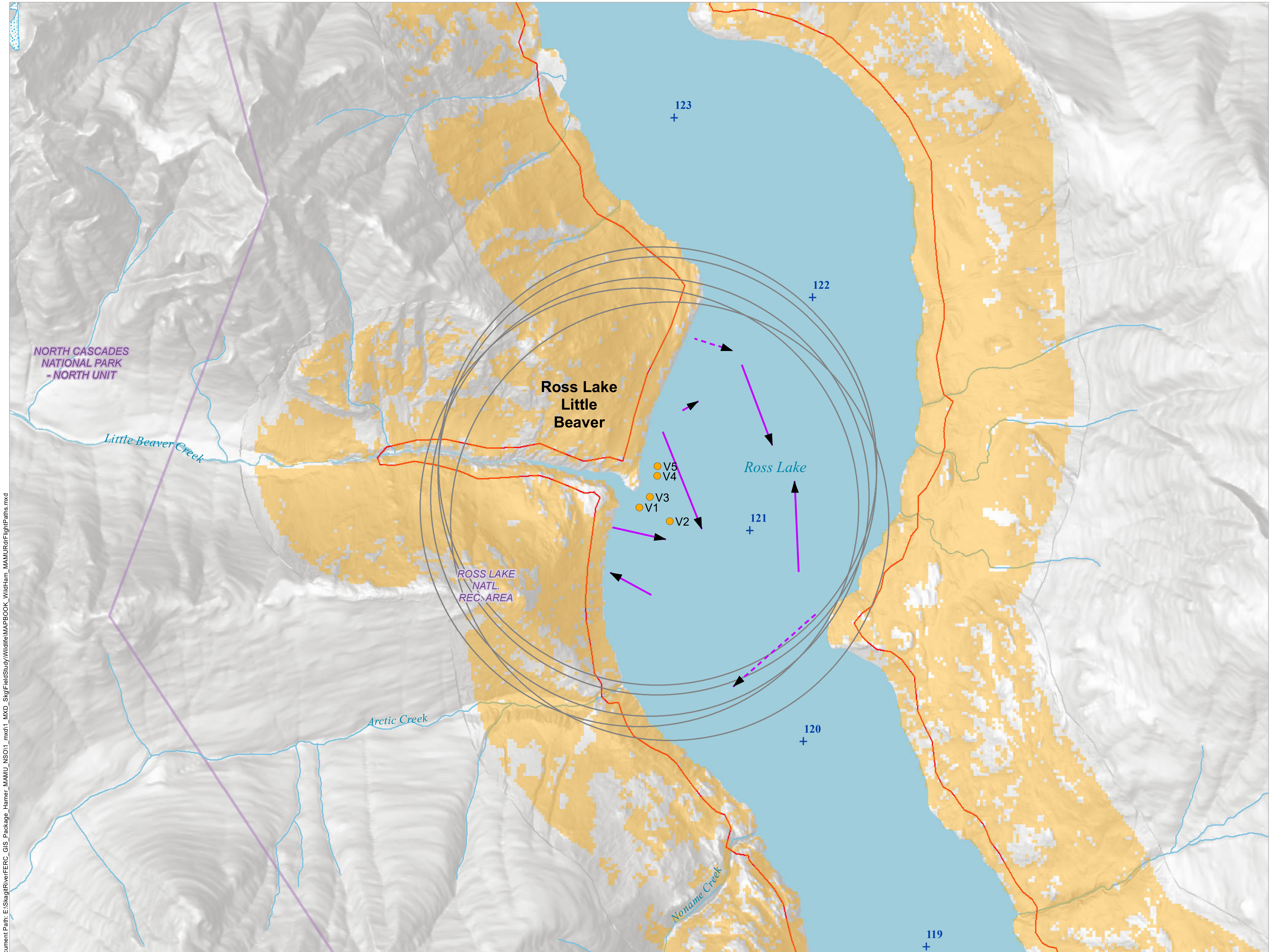
MARBLED MURRELET STUDY DRAFT REPORT

ATTACHMENT D

MURRELET-TYPE TARGET FLIGHT PATHS OBSERVED DURING RADAR SURVEYS MAPBOOK



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TR-05 MARBLED MURRELET STUDY FLIGHT PATHS DETECTED DURING RADAR SURVEYS MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Potentially Suitable Marbled Murrelet Nesting Habitat

Murrelet-type Target Flight Path Pre-Sunrise:

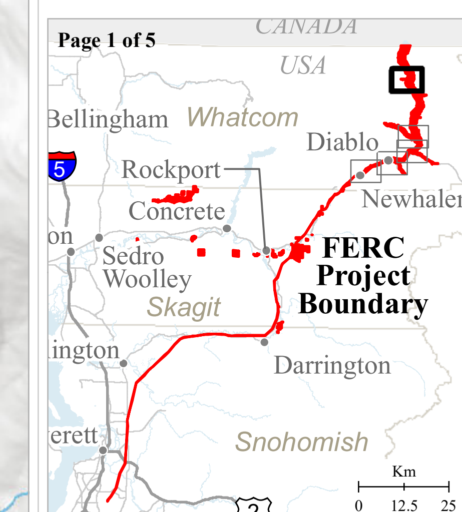
- Ross Lake Little Beaver

Murrelet-type Target Flight Path Post-Sunrise:

- Ross Lake Little Beaver

N

0 0.25 0.5 0.75
Kilometers



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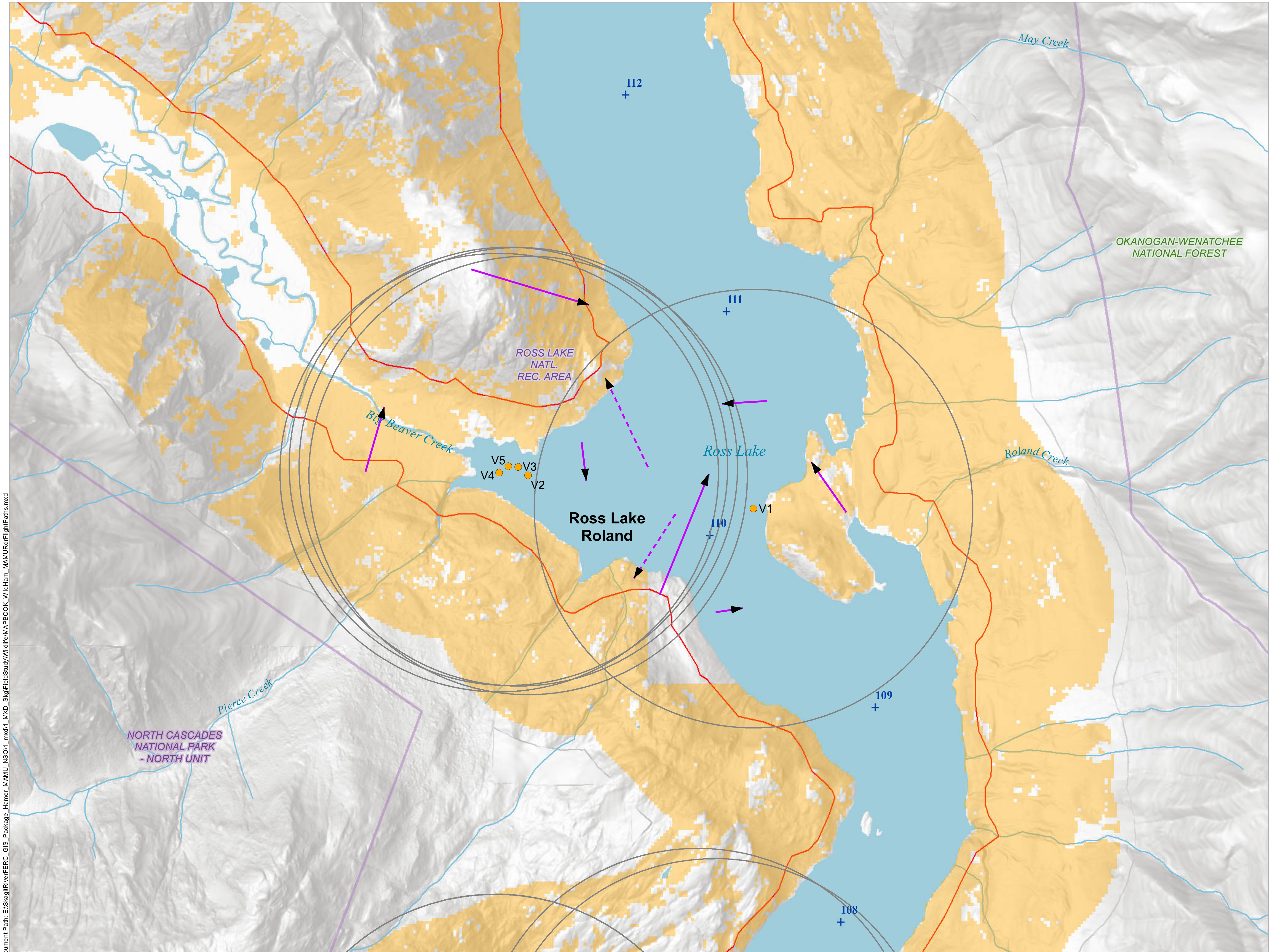
TR-05 MARBLED MURRELET STUDY FLIGHT PATHS DETECTED DURING RADAR SURVEYS MAPBOOK



- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Potentially Suitable Marbled Murrelet Nesting Habitat

Murrelet-type Target Flight Path Pre-Sunrise:

- Ross Lake Roland

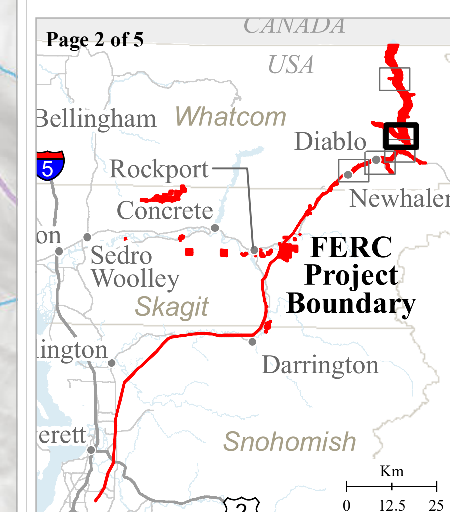
Murrelet-type Target Flight Path Post-Sunrise:

- Ross Lake Roland

N

0 0.25 0.5 0.75 Kilometers

Page 2 of 5



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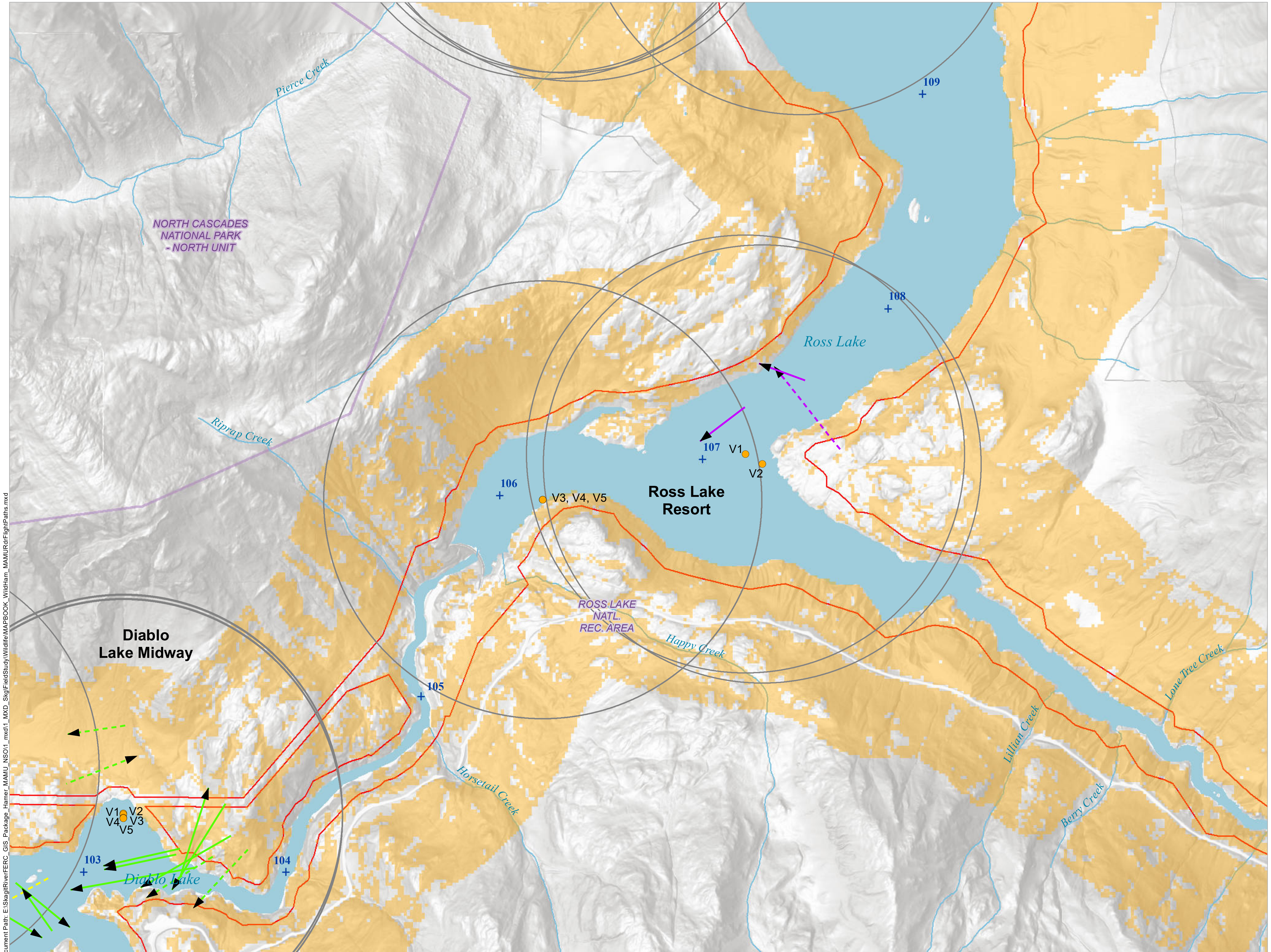
TR-05 MARBLED MURRELET STUDY FLIGHT PATHS DETECTED DURING RADAR SURVEYS MAPBOOK



FERC Project Boundary

Project River Miles (PRM)

National Park / National Recreation Area Boundary

Radar Survey Site

Radar Range (3 km diameter)

Potentially Suitable Marbled Murrelet Nesting Habitat

Murrelet-type Target Flight Path Pre-Sunrise:

Diablo Lake Midway

Ross Lake Resort

Murrelet-type Target Flight Path Post-Sunrise:

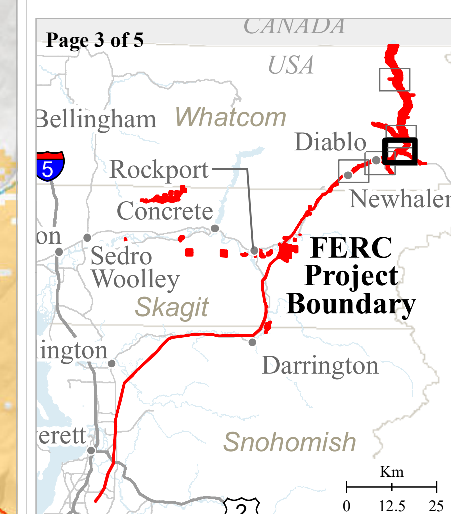
Diablo Lake Midway

Diablo Lake Sand Spit

Ross Lake Resort

0 0.25 0.5 0.75
Kilometers

Page 3 of 5



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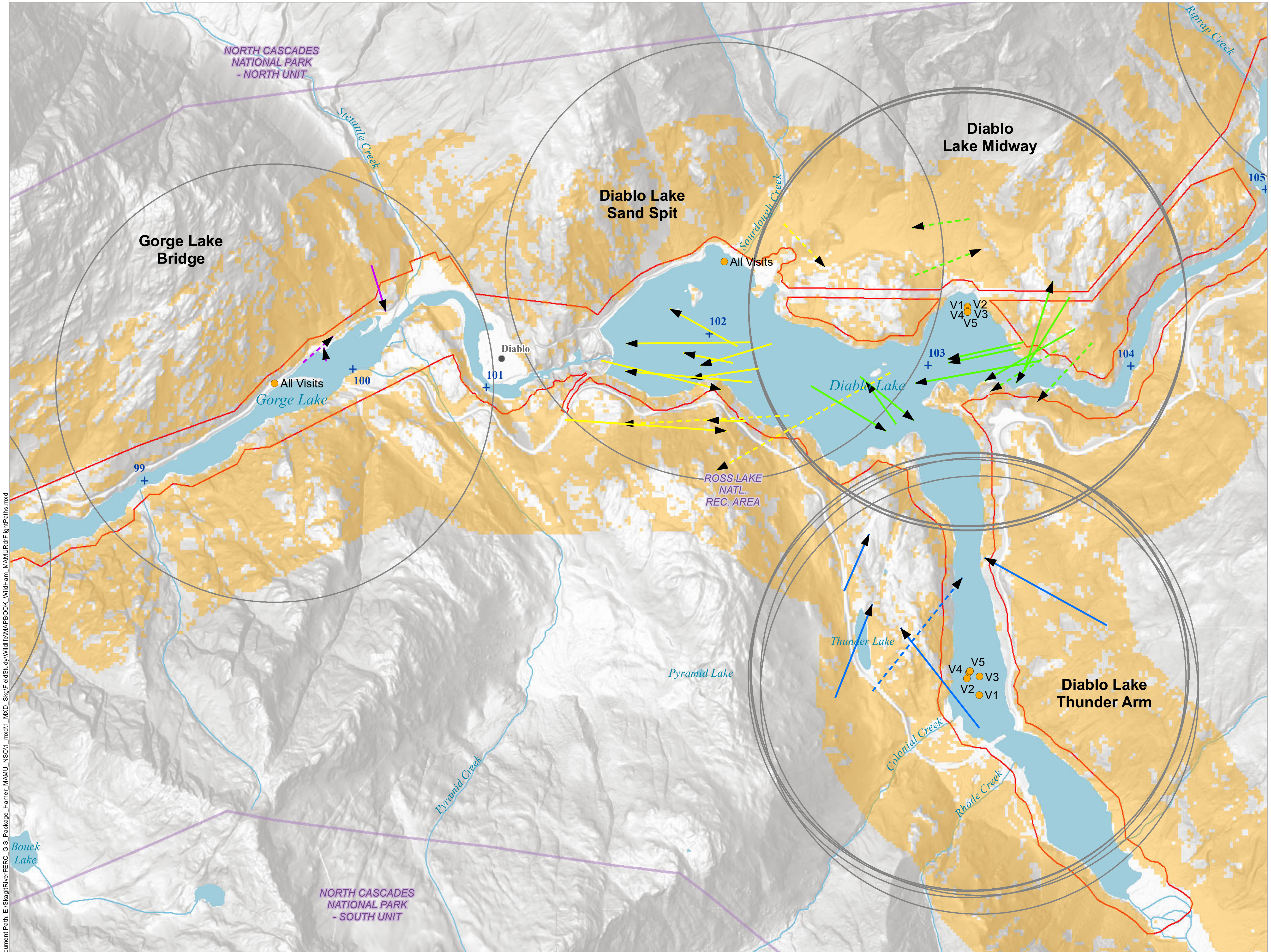

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TR-05 MARBLED MURRELET STUDY FLIGHT PATHS DETECTED DURING RADAR SURVEYS MAPBOOK

- FERC Project Boundary
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Radar Survey Site
- Radar Range (3 km diameter)
- Potentially Suitable Marbled Murrelet Nesting Habitat

Murrelet-type Target Flight Path Pre-Sunrise:

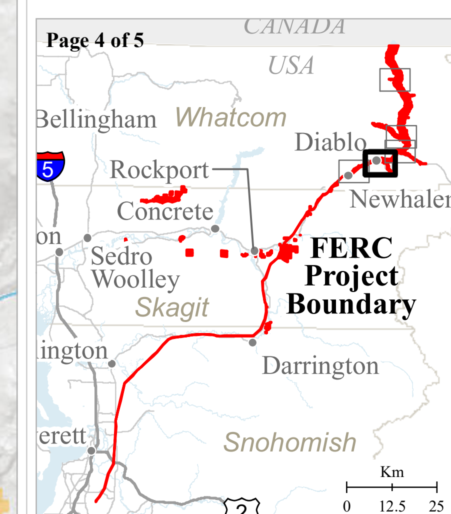
- Diablo Lake Midway
- Diablo Lake Sand Spit
- Diablo Lake Thunder Arm
- Gorge Lake Bridge

Murrelet-type Target Flight Path Post-Sunrise:

- Diablo Lake Midway
- Diablo Lake Sand Spit
- Diablo Lake Thunder Arm
- Gorge Lake Bridge

0 0.375 0.75
Kilometers

Page 4 of 5



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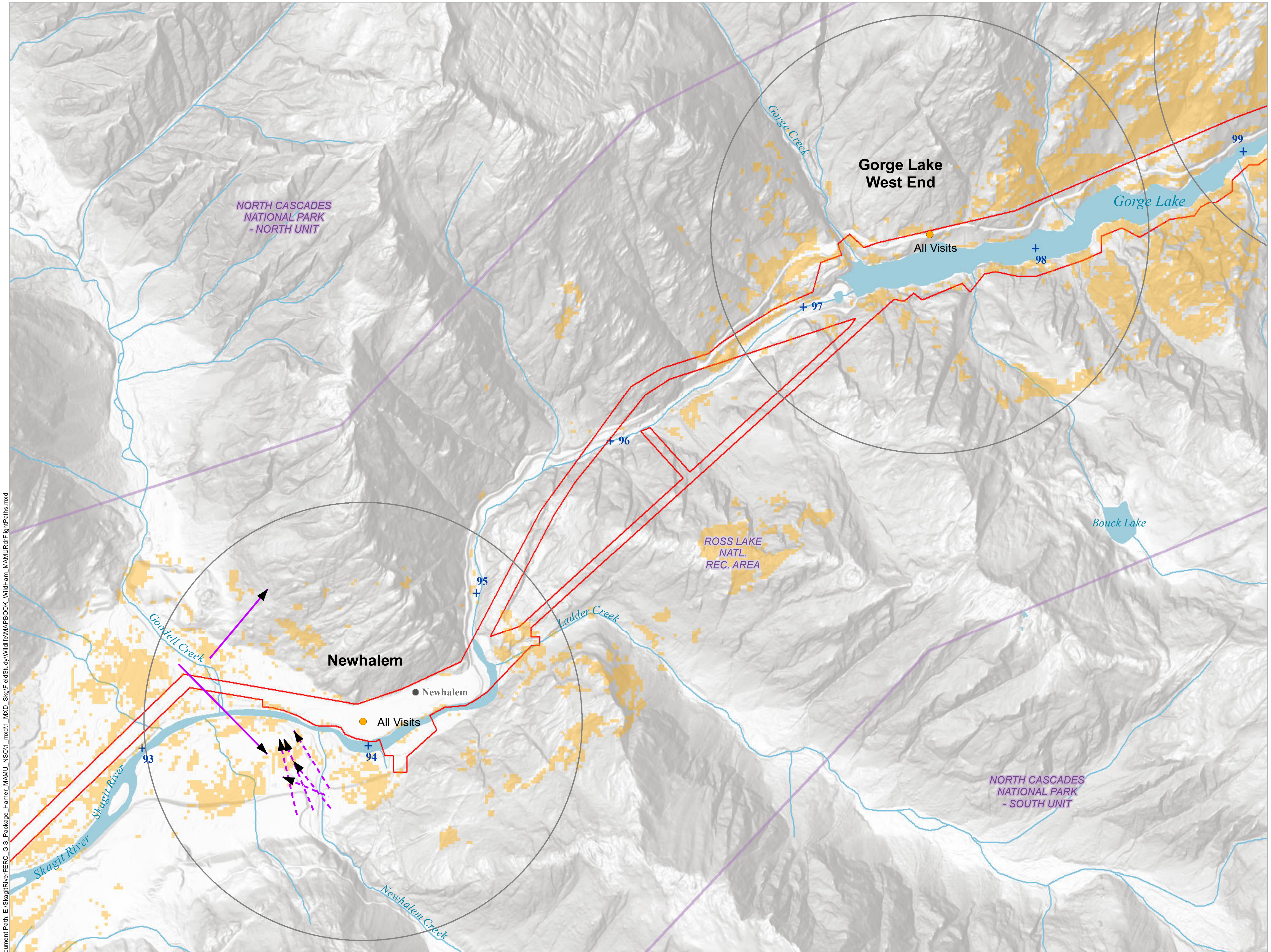
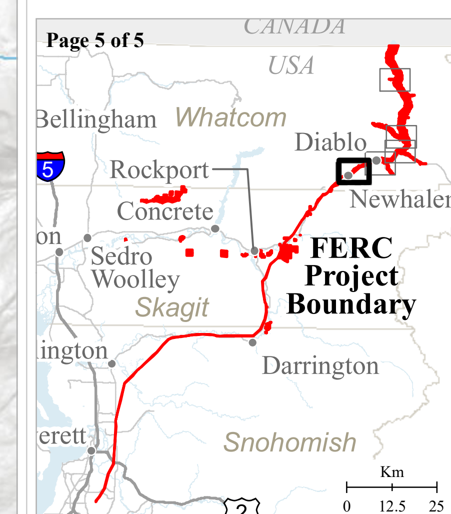
TR-05 MARBLED MURRELET STUDY FLIGHT PATHS DETECTED DURING RADAR SURVEYS MAPBOOK

FERC Project Boundary
+ Project River Miles (PRM)
National Park / National Recreation Area Boundary
Radar Survey Site
Radar Range (3 km diameter)
Potentially Suitable Marbled Murrelet Nesting Habitat
Murrelet-type Target Flight Path Pre-Sunrise:
Newhalem
Murrelet-type Target Flight Path Post-Sunrise:
Newhalem





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