TR-06 GOLDEN EAGLE HABITAT ANALYSIS DRAFT REPORT

SKAGIT RIVER HYDROELECTRIC PROJECT FERC NO. 553

Seattle City Light

Prepared by:
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March 2022
Initial Study Report

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List of Acronyms and Abbreviations

AAF............................area-adjusted frequencies
amsl............................above mean sea level
APLIC.........................Avian Power Line Interaction Committee
BBS............................Breeding Bird Surveys
BFD............................bird flight diverter
BMP...........................best management practice
City Light...................Seattle City Light
DEM...........................digital elevation model
DNR...........................Department of Natural Resources (Washington State)
DSM...........................digital surface model
FERC..........................Federal Energy Regulatory Commission
GAP............................Gap Analysis Project
GIS.............................Geographic Information System
GRA...........................geospatial risk assessment
HEP............................habitat evaluation procedure
HSI.............................habitat suitability index
HSM...........................habitat suitability model
IEUA..........................Important Eagle Use Area
ISR.............................Initial Study Report
LiDAR........................Light Detection and Ranging
NERC.........................North American Electric Reliability Corporation
NLCD.........................National Land Cover Dataset
NPS............................National Park Service
OPGW........................optical ground wire
PHS............................Priority Habitats and Species
Project........................Skagit River Hydroelectric Project
PRM...........................Project River Mile
ROW..........................right-of-way
RSP............................Revised Study Plan
SR...............................State Route
TRI.............................topographic roughness index

USFWS ......................U.S. Fish and Wildlife Service

USGS .........................U.S. Geological Survey

WDFW.......................Washington Department of Fish and Wildlife

WSDOT ....Washington State Department of Transportation

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1.0 INTRODUCTION

The TR-06 Golden Eagle Habitat Analysis 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 Golden Eagle Habitat Analysis as described in the RSP.

In its July 16, 2021 Study Plan Determination, FERC approved the Golden Eagle Habitat Analysis 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 Information

In Washington, golden eagles (*Aquila chrysaetos*) nest throughout much of the state but are most common east of the Cascade Range in the north-central highlands at the transition between montane and shrub-steppe landscapes. Golden eagles are considered uncommon to rare west of the Cascade crest (Larrison and Sonnenberg 1968). In 2017, only 46 territories had been identified by WDFW in western Washington (Hansen 2017). Much of the landscape in western Washington is dominated by closed-canopy coniferous forest, which is unsuitable habitat for this species (Singh et al. 2016).

1.1.1 Golden Eagle Observations in Project Vicinity

Few systematic avian monitoring studies have been conducted in the study area (defined in Section 3.0 of this study report). Six of the established once-annual survey routes that are part of the North American Breeding Bird Surveys (BBS; U.S. Geological Survey [USGS] 2018a) overlap with portions of the study area. The Newhalem BBS survey route is located almost entirely within the study area; though, golden eagles have never been recorded along this route in 52 years of surveys. The NPS has also conducted annual landbird monitoring within the North Cascades National Park Complex, which partially overlaps the study area, since 2007 (except 2017; NPS 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2017, 2019, 2020, 2021a). The surveys that occur in June and July of each year have not recorded golden eagles, though in some years golden eagles have been observed outside of the field season (i.e., during training or incidentally).

Incidental observations of golden eagles have been recorded by the NPS (2021b) and eBird (2021), and incidental observations of nest sites are available from WDFW (2021a, b). There have been

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

only 130 incidental observations of golden eagles within the North Cascades National Park Complex since 1970; three of these were within the study area. Only two nest sites have ever been confirmed within ten miles of the Project transmission line (one 4.5 miles southeast and the other about 10 miles northwest).

In western Washington, golden eagles nest in Douglas fir or relatively large trees in noncontiguous forest (Bruce et al. 1982), as well as on cliffs and rock outcrops. Nest trees are typically in small patches of forest at or near (i.e., within 1,500 feet) the edge of more open habitat; large contiguous forest tracts are not used. Clear-cuts and open forest stands offer prime habitat for mountain beaver and other small mammal prey. These areas are strongly associated with the golden eagle nest sites known in western Washington (Hansen 2017; Bruce et al. 1982).

The NPS incidental observation data suggests that most golden eagle sightings in the area occur during fall migration. Observations (n = 130) of golden eagles are highest in September (n = 94; Figure 1.1-1; NPS 2021b), more than three-times higher than any other month. This is consistent with other evidence that golden eagles are more commonly observed as they pass through the North Cascades National Park Complex in late summer/early fall during fall migration (Hawk Migration Association of North America 2021). Abundance appears to gradually increase throughout the summer until peaking in September and then declines steeply and remains low throughout the winter and spring. These data suggest the northern Cascades are primarily a fall migratory route for golden eagles as opposed to a breeding area (NPS 2021b).

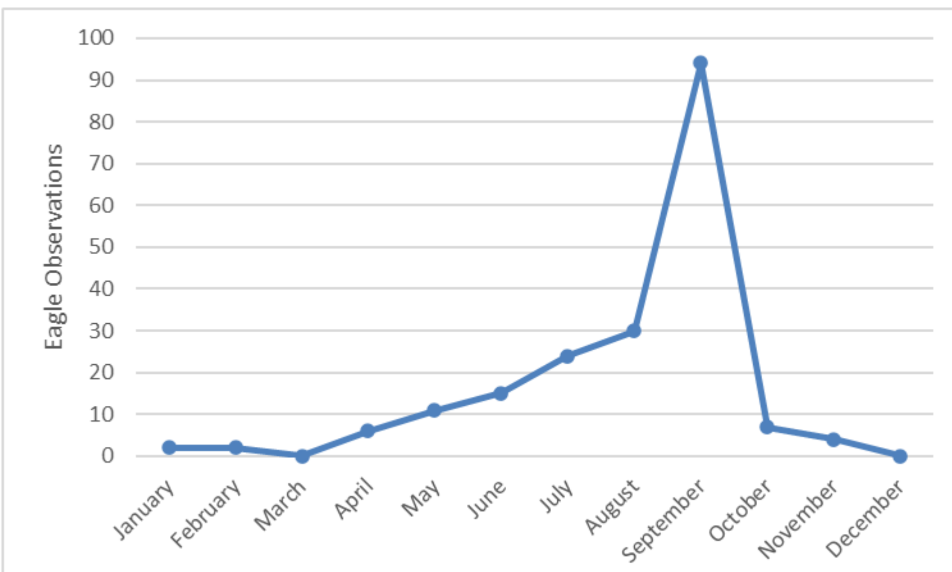

Figure 1.1-1. Golden eagle observations within the North Cascades National Park Complex by calendar month between 1970 and 2021 (NPS 2021b).

Timber harvesting in the northern Cascades began in the early 20th century, peaked between 1986 and 1992, then fell sharply after 1992. The passing of the Washington State Wilderness Act of 1984 and federal listing of the northern spotted owl (*Strix occidentalis caurina*) and marbled murrelet (*Brachyramphus marmoratus*) under the Endangered Species Act restricted logging activities in the late 20th century (Wilson 2012). Natural openings in the forest on federal lands are limited to higher elevations in the study area, so clear-cuts on non-federal lands can provide foraging areas for golden eagles.

The available data suggest that golden eagle abundance in the North Cascades was greatest during and immediately following the peak in timber harvest but has subsequently declined during the last two decades as clear-cuts have regrown. Figure 1.1-2 plots golden eagle observations (NPS 2021b) in the North Cascades National Park Complex against timber harvest, as measured by board feet, by year in Skagit and Whatcom counties combined (Cooke and Rogers 2015; UM 2021). Harvest data were unavailable at a smaller geographic scale than county-wide. Incidental observational data should be interpreted with caution, as they are not based on standardized searches (i.e., data were not collected using a systematic annual protocol) and cannot take the place of formal surveys. For this reason, eBird (2021) observations were omitted unless they were included in the NPS (2021b) dataset. Nonetheless, there appears to be a prominent increase in observations that coincides with and following a peak in timber harvest. Today, timber harvest predominately occurs on state and private lands (Washington Department of Natural Resources [Washington DNR] 2018), and evidence of recent clear-cuts is more common at lower elevations.

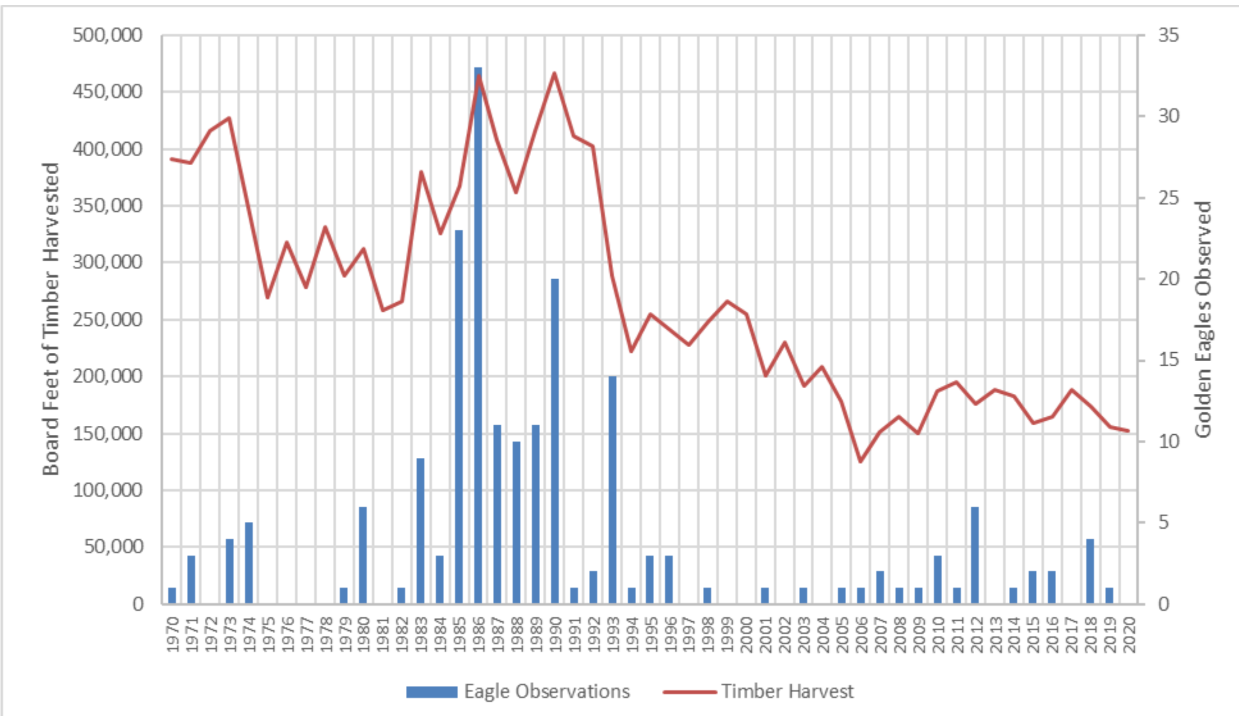

Figure 1.1-2. Golden eagle observations (NPS 2021b) and board feet of timber harvested in Skagit and Whatcom counties (1970-2020; Cook and Rogers 2015, UM 2021).

Avian collisions with power lines have been a growing concern as the number of power lines continues to increase (Bernardino et al. 2018). It is estimated that up to 23 million bird fatalities result from collisions with power lines each year in the U.S. (Loss et al. 2014). However, different types of birds have varying susceptibility to collisions. Factors that contribute to collision risk include maneuverability due to wing morphology and physiology, flight speed, and flight behavior, such as flying in flocks or nocturnal migrations (Rayner 1988; Bevanger 1998; Bernardino et al. 2018). Based on these factors, waterfowl, shorebirds, and cranes would be expected to have a much higher risk of collision with power lines, and this has been documented by several studies (Janss 2000; Rioux et al. 2013; Rubolini et al. 2005, Bevanger 1998). Almost all avian collisions reported along the Project transmission line have been waterfowl (City Light 2014).

Eagles and other raptor species have a much lower risk of collision with power lines, particularly transmission lines (Luzenski et al. 2016) that have larger diameter conductors than distribution lines, than other bird groups due to their strong eyesight and agility (Mojica et al. 2020; Slater et al. 2020, Janss 2000). Collisions with power lines by eagles is considered rare but may be more of a concern when power lines intersect travel corridors between nests, roosts, and foraging areas (Bevanger and Brøseth 2004; Stehn and Wassenich 2008; Avian Power Line Interaction Committee [APLIC] 2012; Watts et al. 2015; Eccleston and Harness 2018; Mojica et al. 2020). During migration, raptors tend to fly during clear weather (Ligouri 2005) and appear to have success avoiding transmission lines that cross even major migration corridors (Luzenski et al. 2016). Golden eagle collisions with power lines have been documented, but the number of incidents has been low. Electrocution of golden eagles on distribution lines is a much greater concern than collisions. For example, of 17 golden eagle fatalities along distribution lines in Colorado, only three were suspected collisions (Harness et al. 2003). Similarly, of 14 golden eagle fatalities in Mongolia, only one was determined to be caused by collision (Amartuvshin and Gombobaatar 2012).

One bald eagle collision with the Project transmission line has been recorded since 1973, but no golden eagle collisions have been noted (City Light 2014). In response to observed bald eagle avoidance maneuvers associated with the Project transmission line near the Corkindale crossing of the Skagit River and the Illabot Creek bald eagle wintering area, an intensive monitoring study was implemented between 1996 and 2000; no avian collisions were observed, and no golden eagles were recorded (Springwood 2001). There is no evidence that the Project transmission lines pose a collision hazard for golden eagles, and there has been no known golden eagle collision mortality.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study is to use existing information to map habitat for golden eagle nesting, foraging, and movement corridors in the study area (i.e., geospatial habitat assessment and golden eagle use assessment) and to conduct a geospatial risk assessment (GRA) to identify risk associated with potential collision with Project transmission lines. This information will be used to assess the potential effects of continued operation and maintenance of the Project with respect to collision risk of golden eagles with transmission lines and to inform best management practices (BMP) and elements of City Light's Avian Protection Plan.

Specific objectives are to:

- Use existing information to characterize areas of potentially suitable golden eagle habitat for nesting, foraging, and movement corridors within the study area.
- Identify historical golden eagle observations and habitats used for nesting, foraging, and movement corridors within the study area.
- Develop a GRA to identify and map areas of potential golden eagle risk of collision with Project transmission lines within the study area.

3.0 STUDY AREA

The Golden Eagle Habitat Analysis study area is limited to the transmission line right-of-way (ROW) and a 1-mile buffer on either side of the ROW (Figure 3.0-1).

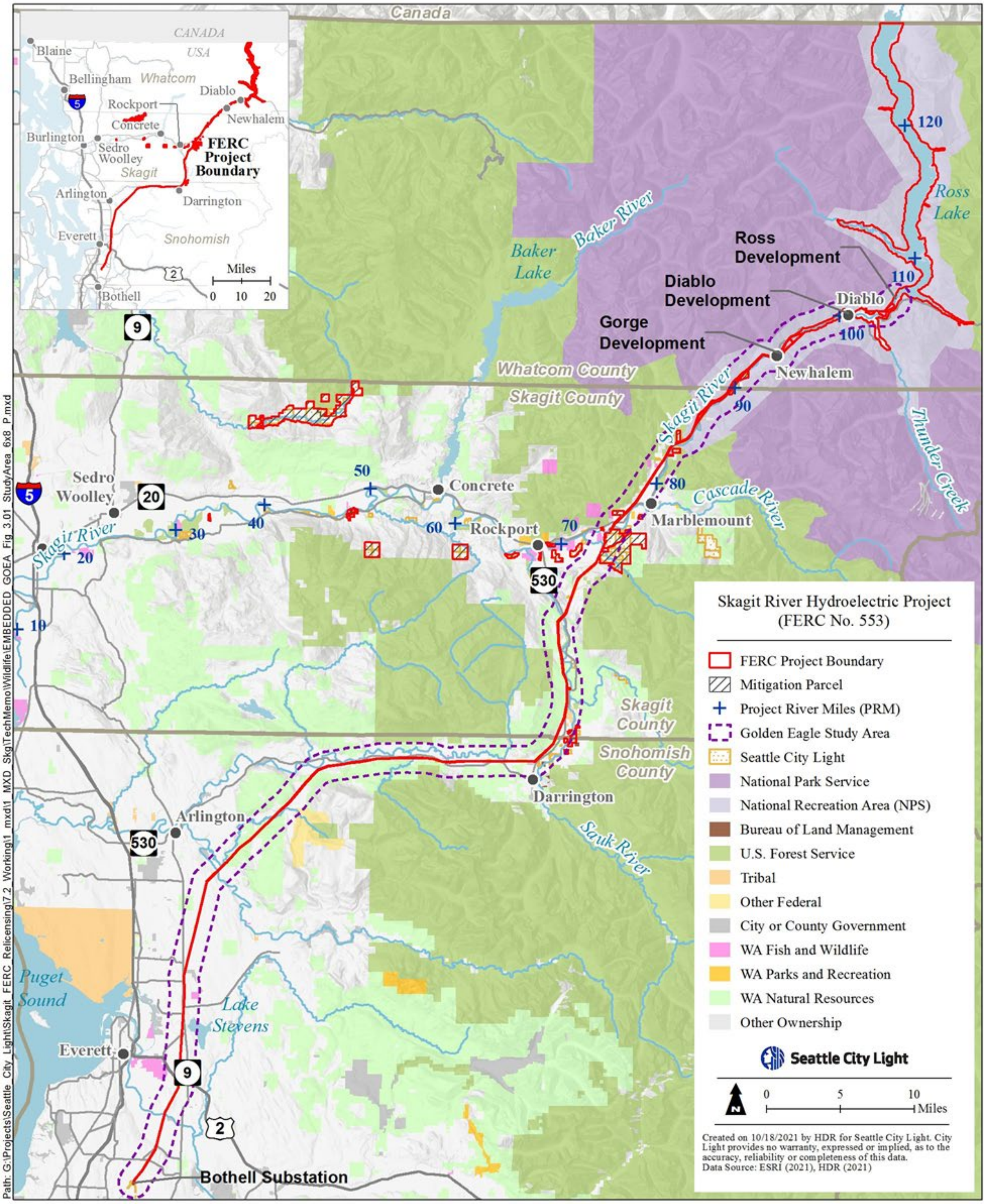

Figure 3.0-1. Golden Eagle Habitat Analysis study area.

4.0 METHODS

4.1 Compile and Review Existing Information

Existing information on golden eagle nesting and foraging habitats in the region and on golden eagle observations were compiled and reviewed as described in Section 2.6.1 of the RSP (City Light 2021). All datasets reviewed, including those that were ultimately used as model inputs for nesting and foraging habitat and the development of the GRA, are summarized below.

4.1.1 Observational Information

Incidental observational golden eagle data (non-systematic collection) were compiled from the NPS, WDFW, and the following citizen-science programs: WDFW Priority Habitats and Species (PHS) data, USGS BBS, the eBird database, and the Washington Breeding Bird Atlas. In addition, one incidental observation of a golden eagle was recorded by biologists conducting field work in support of the Project. In following established agency (WDFW) policies regarding the release of sensitive fish and wildlife information, golden eagle nest sites and observation locations are not displayed in this study report.

Both probable and confirmed incidental observations of golden eagles within the North Cascades National Park Complex were provided by the NPS (2021b) and included 130 records between 1970 and 2019. Section 1.1 of this report includes graphs of the temporal distribution of these incidental observations by month (Figure 1.1-1) and by year (Figure 1.1-2). Of these 130 observations, there was only one confirmed nest site and one possible nest site. The confirmed nest site, observed in 1986, was located near Baker Lake, approximately 13 miles northwest of the study area. The possible nest site, observed in 2019, was located north of Monogram Lake, approximately 6 miles east of Marblemount and 3.5 miles southeast of the study area. Only two golden eagle observations from the NPS data were noted within the study area—one in April 1995 soaring at Ross Dam, and the other, in November 1985, flying along the Skagit River 4 miles downstream of Newhalem, between Damnation and Thornton creeks (NPS 2021b). The majority of NPS (2021b) observations were in the Upper Skagit (60 observations) and Lake Chelan (39 observations) watersheds. Clusters of observations have been recorded near the headwaters of Fisher Creek and Cascade Pass. Eight observations were recorded in the Sumas River watershed (NPS 2021b).

The eBird (2021) database includes 21 incidental observations in the study area since 2007. Eleven of these were located between Newhalem and Diablo Lake. This includes one observation of a golden eagle perched on a transmission line structure just west of Newhalem in October 2021. Another nine observations occurred at Corkindale, while a single golden eagle was observed along the Arlington-Darrington Road (State Route [SR] 530) north of Wheeler Ridge near Rowan (about 3 miles east of Oso). The sighting near Rowan was the furthest south observation in the study area. Beyond the study area, golden eagles are commonly observed during the winter months in the estuaries and farmland near the mouths of the Skagit, Stillaguamish, and Snohomish rivers. The Project transmission line crosses the lower reaches of the Snohomish River, but observations of golden eagles in this area are sparse and widespread (eBird 2021).

The WDFW provided known nest locations within and near the study area. This dataset included only one nest site within a 10-mile radius of the study area. The nest was observed in 2013 in

Township 36N, Range 9E, which is approximately 13 miles northwest of the study area in the Baker River drainage (WDFW 2021a).

Portions of six BBS routes overlap the study area. The Newhalem route (004 – Newhalem) follows the Skagit River along SR 20 from Project River Mile (PRM) 71 between Rockport and Marblemount to PRM 97 (Gorge Dam). The North Cascades route (903 – No Cascades) follows the Project along SR 20 upstream from Gorge Dam along the south sides of Diablo Lake and Ross Lake to beyond Ruby Arm. The Cascade River route (902 – Cascade Riv) starts at the Cascade River confluence with the Skagit River and continues upstream to the east. The Suiattle River route (067 – Suiattle Riv) follows the Sauk River upstream along SR 530 for about 3 miles within the study area, turning east on Suiattle River Road across from the Sauk River Boat Launch. The Everett (034 – Everett) and Mukilteo (870 – Mukilteo) routes cross the study area north of Seattle. Golden eagles have never been observed on any of these six routes. Statewide, BBS routes have recorded only a maximum of five golden eagles each year since 1966 (USGS 2018a); in many years, there were no observations. The Washington Breeding Bird Atlas contains no records of golden eagles (BBAE 2021).

4.1.2 Existing Habitat Models

A search of the available literature identified two sources of geospatial data mapping golden eagle nesting and seasonal distribution in and near the study area.

4.1.2.1 Nest Density Model

Dunk et al. (2019) modeled golden eagle nest density within 12 ecoregions across the western U.S. The models were evaluated against known nest locations, and tests showed similar outputs to other small-scale studies in the western U.S. The study area is within the Forested Montane ecoregion, which includes most forested areas across the western U.S. Within this ecoregion, the most important variables in the best performing models were elevational difference, terrain slope, proportion of shrub landcover, and proportion of alfalfa landcover. These variables may not all apply to northwestern Washington, but they are the variables that were most influential across the entire ecoregion. The classified area-adjusted frequencies (AAF) map layer, which is a derivative of the raw nest site density model output surface, was used. The classified layer includes seven categories of predicted nest density relative to random densities expected across the ecoregion. The model predicts the highest probability of nest presence in the study area to be between Gorge Dam and Ross Dam, followed by Marblemount to Gorge Dam. This area consists of high topographic relief, steep slopes, and barren areas, such as cliffs and alpine habitat. Low nest density in the study area is generally predicted south and west of Marblemount (Figure 4.1-1), where the terrain is moderately level and alpine habitat is nonexistent (Dunk et al. 2019).

Given the extent of the nest density model, the output is available at a relatively coarse scale of 394 x 394 feet (120 x 120 meters), and there are limitations on accuracy, particularly in areas with low golden eagle densities and environmental conditions that differ considerably from the rest of the Forested Montane ecoregion (i.e., coastal rainforests). Finally, the model's extent does not include the southernmost portion of the study area from approximately the Sisco Heights neighborhood (about 5 miles south of Arlington) south to the Bothell Substation. For these reasons, the nest density model was not used to map nesting habitat in the study area but provided a comparison to this study's model output. It was also used to identify golden eagle source habitats beyond the study area boundaries in development of the GRA.

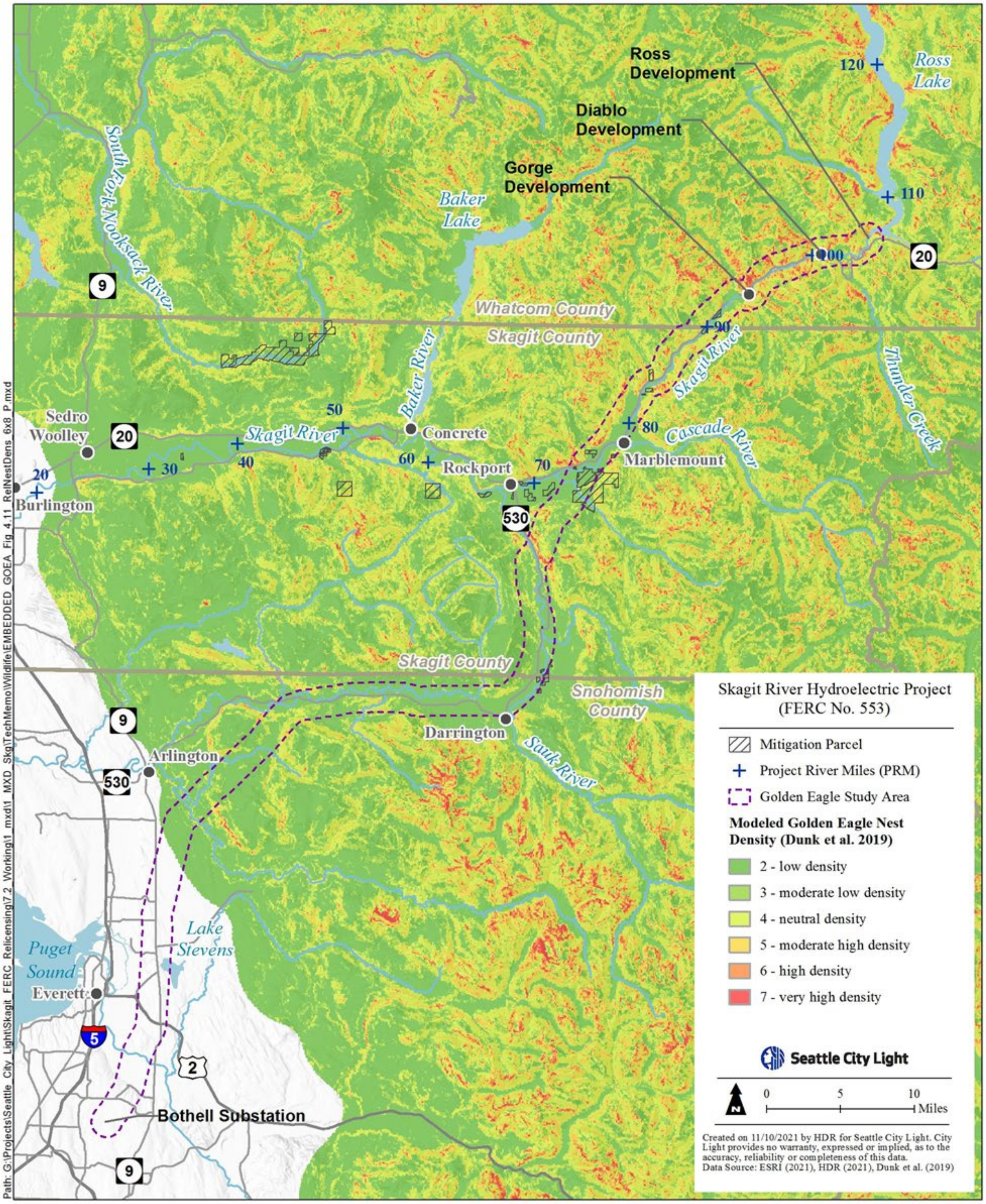

Figure 4.1-1. Modeled golden eagle nest density in and near the study area (Dunk et al. 2019).

4.1.2.2 USGS GAP Golden Eagle Model

The USGS has modeled the range and seasonal habitat distribution of golden eagles throughout the continental U.S. as part of its Gap Analysis Project (GAP) (USGS 2017). The USGS delineated habitat based on public literature and vegetation types mapped in the National GAP Land Cover Ver. 1.0 (USGS 2016). The map generated from the GAP model shows summer habitat for golden eagles, primarily concentrated near Ross Dam and Diablo Lake. Year-round habitat is primarily located east of the Cascade crest, outside of the study area (Figure 4.1-2). Reliability of this model is low due to its broad geographic extent and reliance on a suite of habitat variables common in one region but less suitable for golden eagles in western Washington. In addition, observations in and near the study area suggest that golden eagle abundance is higher in early fall than during summer (Figure 1.1-1), and numerous observations were recorded outside of mapped suitable habitat. For these reasons, the GAP model was not used to map nesting or foraging habitat for golden eagles in the study area.

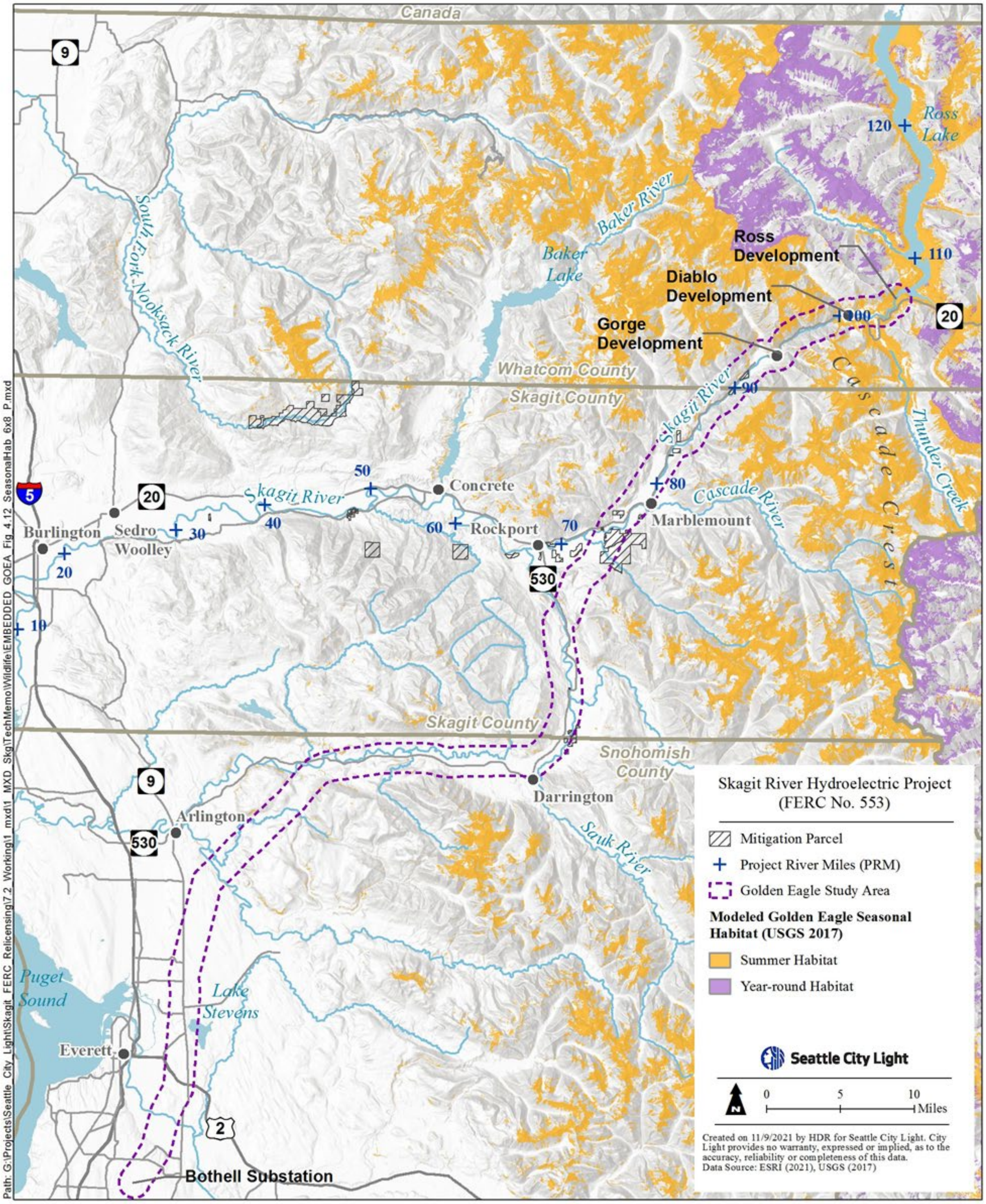

Figure 4.1-2. Modeled golden eagle seasonal habitats in and near the study area (USGS 2017).

4.1.3 Physical and Ecological Datasets

4.1.3.1 USGS GAP Mountain Beaver Models

As described in the RSP (City Light 2021), mountain beaver or sewellel (*Aplodontia rufa*) is an important prey source for golden eagles in the Pacific Northwest. To model foraging habitat for golden eagles, the GAP species models for both *A. rufa* and *A.r. olympica* (Olympic mountain beaver) were acquired. These datasets are very similar: both include riparian areas and wetlands. Mapped habitat for *A. rufa* extends further upstream along higher-gradient tributary streams than *A.r. olympica* (Figure 4.1-3; USGS 2018b, c). Because mountain beaver is a primary prey source for golden eagles in the study area (Thomas 1977; Servheen 1978, as cited in Hansen 2017; Bruce et al. 1982), the mountain beaver habitat models were used as inputs to map and model foraging habitat for golden eagles (see Section 4.2.2 of this study report).

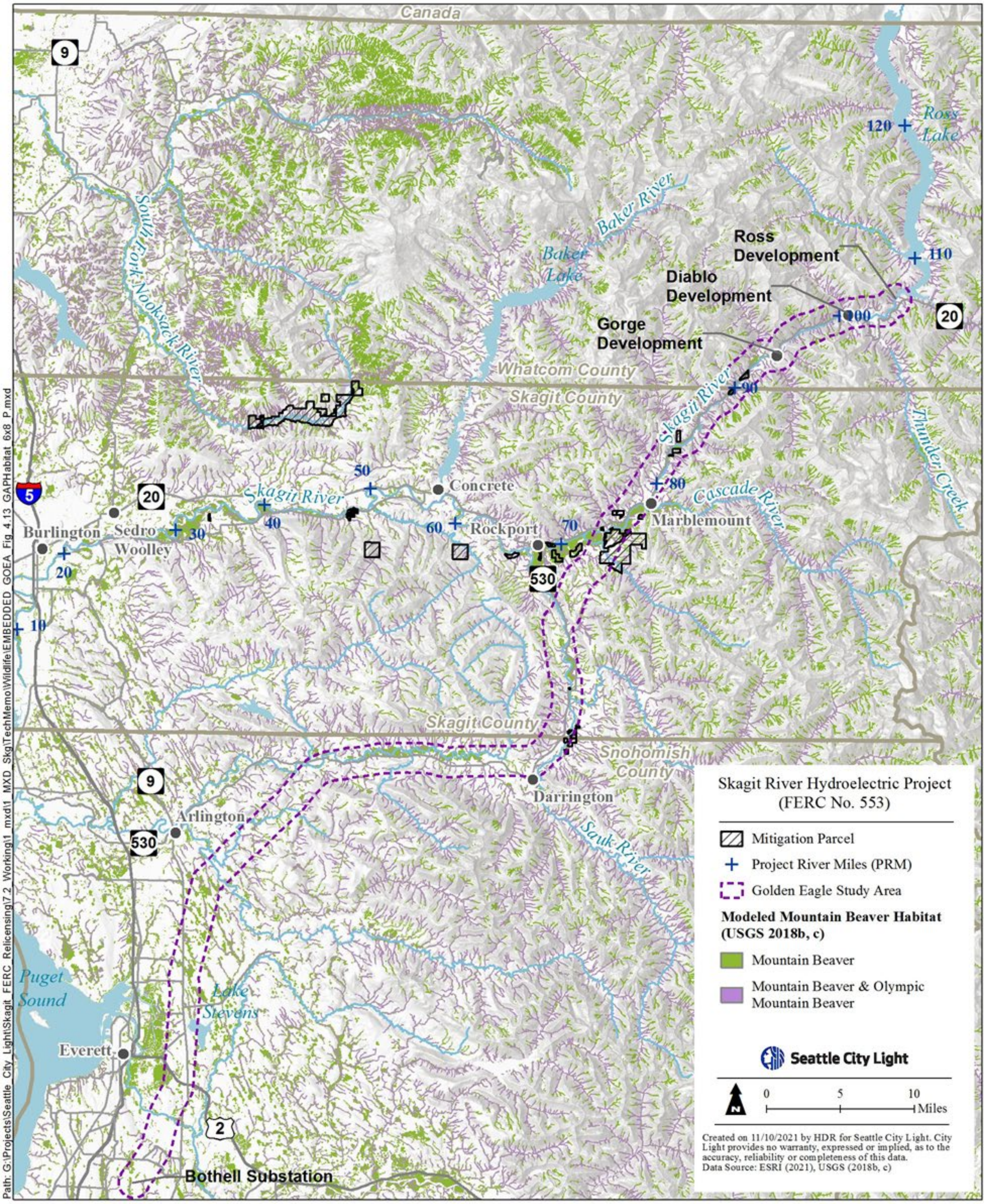

Figure 4.1-3. Modeled mountain beaver (*A. rufa* and *A.r. olympica*) habitat in and near the study area (USGS 2018b, c).

4.1.3.2 LiDAR Derivatives

Light Detection and Ranging (LiDAR) coverage is available for 99.8 percent of the golden eagle study area (City Light 2020). For the purposes of mapping golden eagle nesting and foraging habitat, LiDAR was reprocessed to produce four derivative surfaces: (1) canopy height model; (2) slope; (3) aspect; and (4) topographic roughness index (TRI).

Canopy Height Model

A canopy height model was created by subtracting the bare earth digital elevation model (DEM) from the digital surface model (DSM). The DSM represents the first return values from the raw LiDAR datasets, while the DEM was derived from the classified ground returns. In vegetated areas, this provides an estimate of canopy heights and percentage of canopy cover. A 243-acre portion at the north end of the study area near Ross Dam did not include both a DEM and DSM, so a canopy height surface could not be derived. This area was digitized as either open or forested from aerial imagery and merged with the converted polygons for the remainder of the study area. Canopy height is shown in Figure 4.1-4. Canopy height can be used to identify clear-cuts, meadows, shrubland, grassland, and other non-forested areas that represent potential foraging habitat. It can also be used to identify mature forests adjacent to openings and cliffs or rock outcrops where potential nesting habitat may exist.

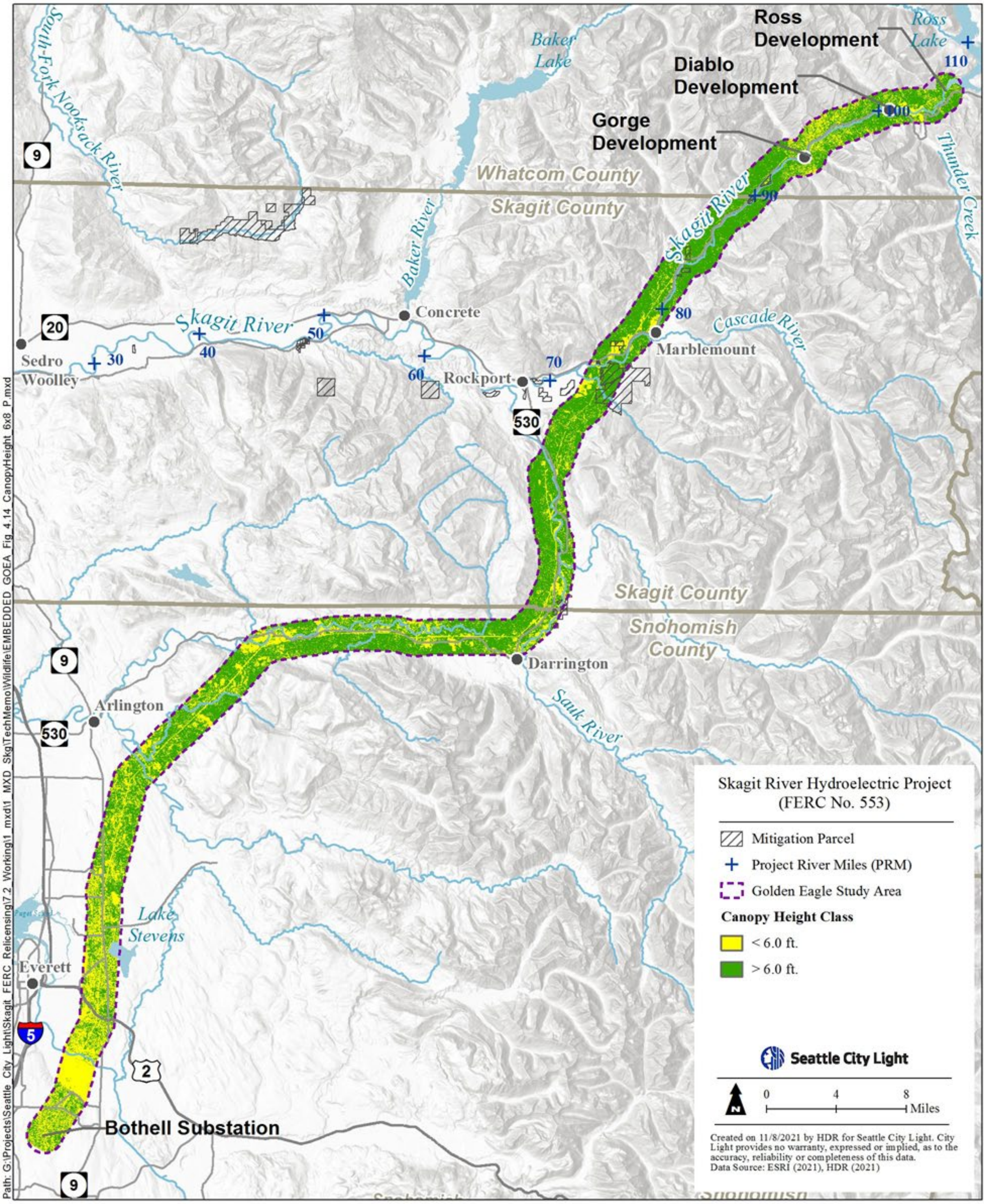

Figure 4.1-4. Modeled canopy height within the study area.

Topographic Roughness Index

A TRI surface was derived from the LiDAR-derived DEM using the terrain roughness index raster function template in ArcGIS Pro. It expresses the elevation difference between adjacent cells of a DEM to give a relatively accurate measure of the vertical change from cell to cell. Golden eagles across their range primarily nest on cliffs and other areas with steep terrain (Katzner et al. 2020). Topographic relief provides orographic lift used by eagles for soaring during foraging and migration (Duerr et al. 2019). "Slope" is another dataset that is commonly used to identify cliff sites. Visual comparisons of TRI and slope in the study area have a high level of agreement. Standardized TRI values range from 1 to 7 to express the amount of elevation difference between adjacent cells, with 1 representing 'level' (i.e., relatively flat) areas and 7 corresponding with 'extremely rugged' (i.e., steep) areas (ESRI 2020). The TRI surface was created specifically for this study and is shown in Figure 4.1-5.

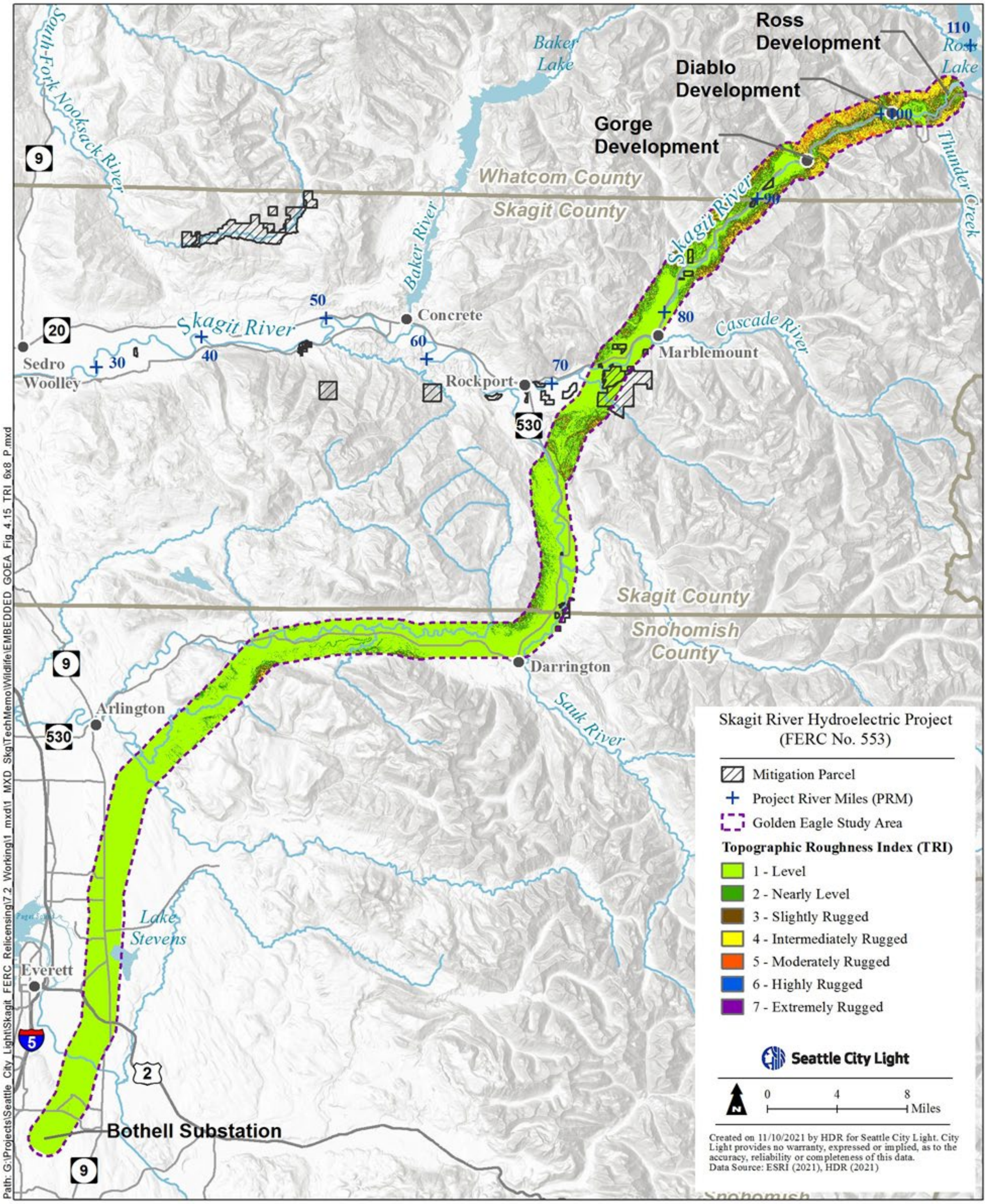

Figure 4.1-5. Topographic Roughness Index within the study area.

4.1.3.3 Landscape Characteristics

Land Cover

The TR-01 Vegetation Mapping Study geographic information system (GIS) database describes the existing vegetative conditions within and near the Project Boundary and was conducted in 2020-2021. This study mapped vegetation within an area roughly defined by a 0.5-mile buffer of the Project transmission line ROW (refer to the Vegetation Mapping Study Draft Report for maps; City Light 2022). The Vegetation Mapping Study did not include most of the outer 0.5-mile portion of the golden eagle study area. To address this difference in coverage, publicly available land cover data from the National Land Cover Dataset (NLCD; USGS 2021) obtained from the Multi-Resolution Land Characteristics Consortium (Figure 4.1-6) were used outside of the Vegetation Mapping study area. A crosswalk table was used to relate the 38 unique cover types identified in the Vegetation Mapping Study to the 16 cover types represented by NLCD. Not all cover types from the Vegetation Mapping Study could be directly related to an NLCD cover type, in which case that unique vegetation mapping cover type was used, but only within the study area of the Vegetation Mapping Study. Both datasets were merged in GIS to develop a single land cover layer for the study area using NLCD cover type definitions (Attachment A). Land cover data were used to model foraging and nesting habitat. National Hydrography Datasets (USGS 2020) and National Wetlands Inventory data (USFWS 2021) were reviewed for relevance to land cover types and suitable habitat characteristics. However, it was determined that NLCD and vegetation mapping data were equal or better at addressing the factors that most affect golden eagle habitat.

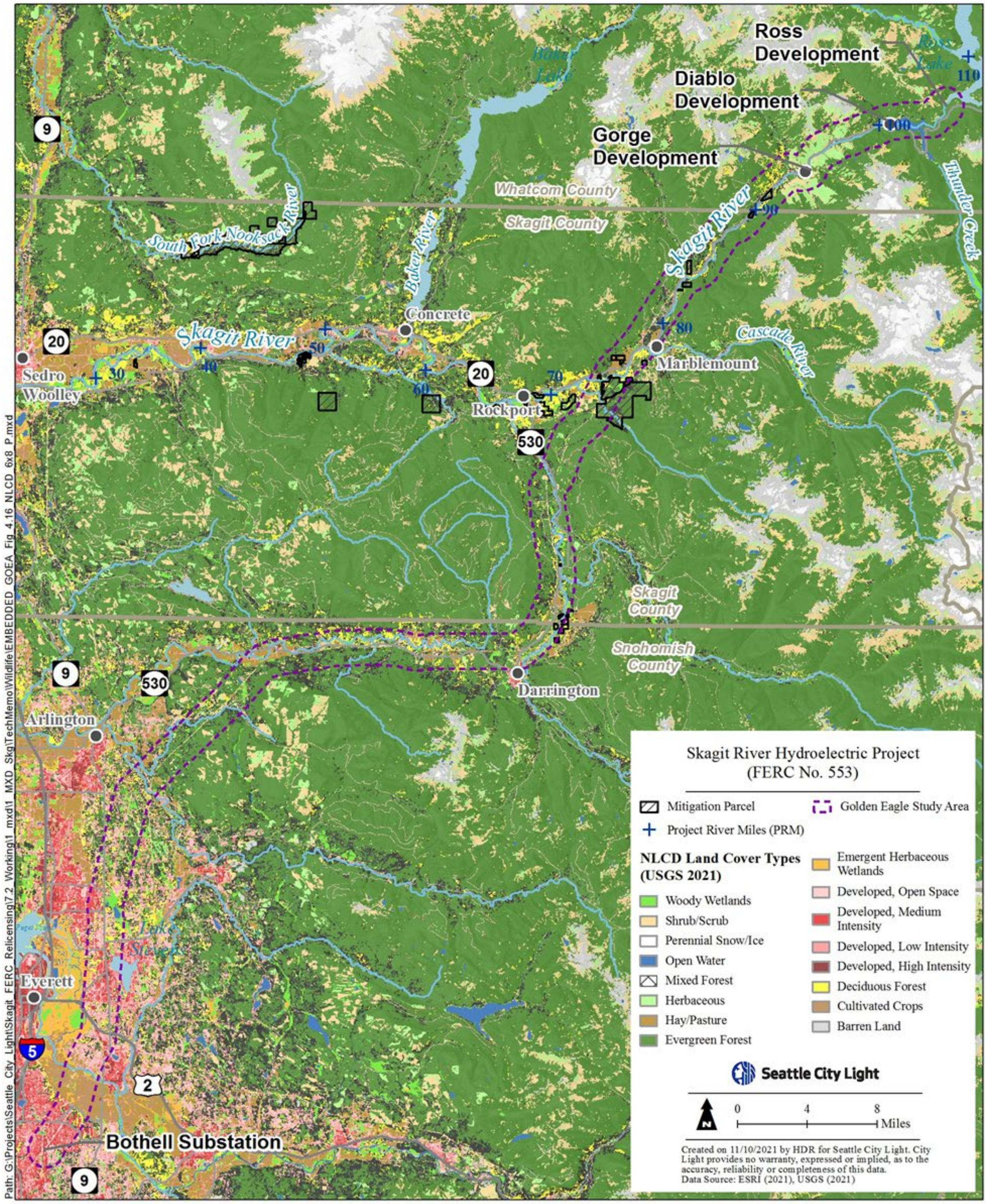

Figure 4.1-6. Land cover from the National Land Cover Dataset within and near the study area (USGS 2021).

Roads

Roadways (including highways, county roads, and other routes) create noise and light and introduce other human activity, which can deter eagle nesting and foraging. However, carrion (or roadkill) on roadways is an important food source for golden eagles (Bedrosian et al. 2017). The presence of carrion on roadways is positively associated with traffic volume, speed, and various environmental factors (e.g., vegetation proximity to roadway, habitat quality, terrain, etc.). Geospatial data on state and non-state roadway locations and functional classes (e.g., types of roads) were downloaded from the Washington State Department of Transportation (WSDOT 2021). All state roads were determined to meet thresholds for traffic volume and travel speed necessary to produce carrion. Non-state routes within the study area with a functional class of "rural minor collector" or "rural minor arterial" were also determined to have potential to produce carrion. These functional classes included all roads within the mountains and foothills of the study area but excluded urban and suburban residential streets in the southern portion of the study area. The selected linear roadway features were buffered by 25 feet on each side to approximate a normal roadway width of 50 feet, including both surface and shoulders. The roads included in the analysis are shown in Figure 4.1-7.

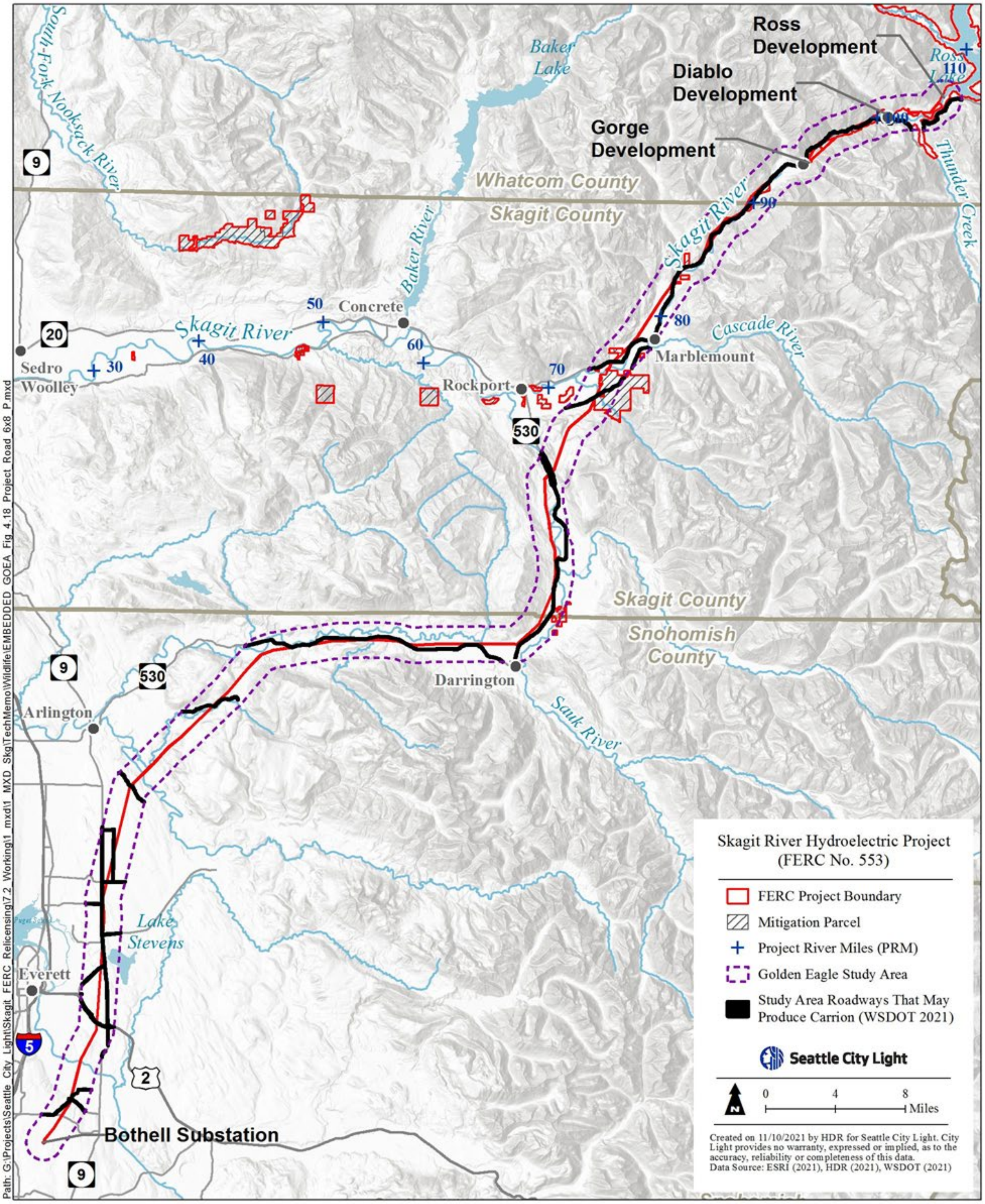

Figure 4.1-7. Roadways that have potential to produce carrion in the study area (WSDOT 2021).

4.2 Map Observations and Potential Nesting and Foraging Habitat

The above datasets can be used individually to approximate the distribution of potential golden eagle nesting and foraging habitat in the study area as described in Section 2.6.2 of the RSP (City Light 2021). However, the combined influence of key landscape characteristics more effectively describes the distribution of potential habitat in the study area. As such, a habitat suitability model (HSM) was developed to map nesting and foraging habitat in the study area. The process was, roughly based on a multi-criterion habitat evaluation procedure (HEP) which was developed by the USFWS in 1976 to document the quality and quantity of available habitat for a wildlife species. It is commonly used in the evaluation of resource development projects. The objective is to use detailed ecological information about a species to evaluate habitat based on key characteristics (Kushwaha and Roy 2002). Publicly available literature describing nesting and foraging habitat in western Washington was used to identify the key characteristics (or criteria) of each habitat type to inform the golden eagle HSM. Each of these criteria was then identified within a geospatial dataset that was developed based on one or more spatial datasets described in Section 4.1 of this study report. A habitat suitability index (HSI) value was assigned to specific attributes of each criterion on a scale from 0 to 3, where:

- 3 = high-quality habitat;
- 2 = moderate-quality habitat;
- 1 = low-quality habitat; and
- 0 = unsuitable habitat.

The criteria were further weighted based on relative importance using Saaty's multi-criterion evaluation technique (Saaty 1977). Each criterion was evaluated against each other criterion on a scale of importance; increasing importance values indicate increasing favorability of one criterion over the other. The measurement scale is as follows:

- 1 = equal importance;
- 3 = weak importance;
- 5 = essential or strong importance;
- 7 = demonstrated importance;
- 9 = absolute importance; and
- 2, 4, 6, 8 = intermediate values between two adjacent judgments.

For example, if criterion *i* has one of the above values assigned to it (e.g., 7) when compared with criterion *j*, then *j* has the reciprocal importance value (e.g., 1/7) when compared with *i*. The absolute weights from these relative pairwise importance weights were roughly obtained by finding the geometric mean of each criterion and then scoring it as a fraction of 1 (Kushwaha and Roy 2002). Finally, the geospatial layers representing each criterion were summed based on their relative weights using the "Weighted Sum" tool in the Spatial Analyst/Overlay toolbox in ArcGIS, which produced a single raster output representing habitat quality. This process was completed for both nesting and foraging habitat separately and is described in detail in the following sections.

4.2.1 Nesting Habitat

A review of the literature (as summarized in Section 2.3.1 of the RSP [City Light 2021] and Section 1.1.1 of this study report) identified the following key characteristics of suitable golden eagle nesting habitat in the Pacific Northwest:

- Cliffs, rugged terrain, and steep slopes (Katzner et al. 2020; Bruce et al. 1982; Hansen 2017);
- Large trees, such as mature Douglas fir, at or near the edge of clear-cuts and open fields (Bruce et al. 1982);
- Distance from human activity (Steenhof et al. 1983; Scott 1985);
- Barren land and cliffs on south facing slopes (Mosher and White 1976; Kochert et al. 2002); and
- Proximity to empirical evidence of previous nesting.

Five raster layers were developed to represent each of the key characteristics (or criteria) described above and specific attributes were assigned an HSI as summarized in Table 4.2-1.

Table 4.2-1. Attributes and corresponding habitat suitability index (HSI) for each of the nesting habitat mapping criteria in the study area.

HSI[1]	Presence of Cliffs/ Topographic Roughness (TRI[2])	Proximity to Clear-cuts and Forest Openings	Distance from Human Use and Developed Areas	Steep Slopes on South Facing Aspects	Proximity to Empirical Observations
3	6-7	Barren[3] and forested cover types < 500 ft from clear-cuts and openings	> 1,500 ft	≥65-degree slope on S, SW, or SE facing aspects	Within 1 mi of a known nest
2	4-5	Barren and forested cover types 500-1,000 ft from clear-cuts and openings	1,000-1,500 ft	≥65-degree slope on E, NE, W, or NW facing aspects	Within 1 to 5 mi of a known nest
1	2-3	Barren and forested cover types 1,000-1,500 ft from clear-cuts and openings	500-1,000 ft	≥65-degree slope on N facing aspects	Within 5-10 mi of a known nest
0	1	Areas > 1,500 ft from clear-cuts and openings	< 500 ft	< 65-degree slope on any aspect	> 10 mi of a known nest

1 HSI = habitat suitability index
2 TRI = terrain roughness index
3 Barren cover type primarily consists of rock outcrops and cliffs.

Potential cliff sites, rugged terrain, and steep slopes were identified using TRI. An attribute field was added to the ESRI Grid format geodatabase file in which HSI values on a scale of 0 to 3 corresponded to the TRI values as described in Table 4.2-1.

Bruce et al. (1982) found that all golden eagle nests evaluated in his study in western Washington were located within 1,500 feet of clear-cuts or open fields. Therefore, 1,500 feet was adopted as the maximum distance that nesting could occur from clear-cuts, meadows, and other forest openings with a minimum size of 0.5 acre. This criterion was developed from the canopy height raster and the land cover dataset. Prior to identifying open areas, a series of generalization tools was used to remove height anomalies in the LiDAR-derived canopy height raster. Tools including "majority filter," "nibble," "eliminate polygon part," and "boundary clean" were used to create polygons with clean edges and internal consistency. Next, portions of the canopy height raster with values less than 6 feet were isolated and converted to vector polygons to represent open areas. Six feet was selected as the threshold for canopy height because it represents a value that conservatively accounts for inherent variability in DEM and DSM returns in the LiDAR and patchiness of vegetation height across the landscape. The resulting polygons were sequentially buffered by 500; 1,000; and 1,500 feet and were merged into a single vector layer. Portions of the land cover dataset corresponding to barren ground and forested areas were then clipped to each of the distance bands. This allowed shrublands, herbaceous, developed, and other areas that lack suitable nesting substrate to be excluded from the potential nesting distance bands. Finally, the various polygons were attributed an HSI ranking from 0 to 3 as detailed in Table 4.2-1, and the open area vector layer was converted to a raster.

Developed areas in the land cover dataset were isolated, sequentially buffered by 500; 1,000; and 1,500 feet, and then merged into a single developed areas vector layer. The various polygons were attributed an HSI ranking from 0 to 2, and all areas beyond 1,500 feet were assigned an HSI of 3 as detailed in Table 4.2-1. Lastly, the vector layer was converted to a raster.

Cliff nests at northern latitudes are often located on south facing aspects where snow accumulation is reduced. Both a slope and aspect raster were developed for the study area from the source DEM derived from LiDAR. Steep slopes (i.e., ≥ 65 degrees) with south facing aspects were ascribed the highest HSI, and other aspects and other slope angles were assigned lower HSI values as listed in Table 4.2-1.

Observational data obtained from NPS and WDFW were used to identify known nest sites recorded incidentally. Although the presence of nest sites alone does not suggest additional nests (golden eagles occupy large territories and do not nest communally), the presence of previous nesting indicates the presence of environmental or biological factors suitable for nesting. Nest sites were buffered sequentially by 1, 5, and 10 miles and the resulting polygons were merged and clipped to the study area. The various polygons were attributed an HSI ranking from 0 to 3 as detailed in Table 4.2-1, and the vector layer was converted to a raster.

Each of the five criteria described above was weighted relative to one another based on relative importance, and the absolute weight for each criterion was calculated using Saaty's multi-criterion evaluation (Table 4.2-2). Although the criteria were not all equally important to each other, most were similarly important (i.e., importance scores of 2s and 3s indicating a relatively low favorability of one criterion over the other), and no relative importance weights exceeded a value of 5:1. The absolute weights indicate that cliffs/rugged terrain and proximity to open areas were the most important criteria, whereas empirical observations were ranked as least important. Empirical observations were ranked low because the data was incidental and not systematically collected.

Table 4.2-2. Relative and absolute weights of each criterion used to describe nesting habitat in the study area.

	Presence of Cliffs/ Topographic Roughness (TRI)	Proximity to Clear-cuts and Forest Openings	Distance from Human Use and Developed Areas	Steep Slopes on South Facing Aspects	Proximity to Empirical Observations	Absolute Weights[1]
Presence of Cliffs/ Topographic Roughness (TRI)	1	2	2	4	5	**0.39**
Proximity to Clear-cuts and Forest Openings	1/2	1	2	3	3	**0.26**
Distance from Human Use and Developed Areas	1/2	1/2	1	2	3	**0.18**
Steep Slopes on South Facing Aspects	1/4	1/3	1/2	1	3	**0.11**
Proximity to Empirical Observations	1/5	1/3	1/3	1/3	1	**0.06**

1 Absolute weights are calculated by finding the geometric mean of the other five values in that row, then scoring as a fraction of 1.

The Weighted Sum tool was used to find the cumulative combination of all five criteria. This was accomplished by multiplying the HSI value by each criterion's absolute weight within each pixel of the model inputs. Then the sum of the five weighted HSI values for each pixel was expressed as a positive value in the model output. The product was a raster representing relative nesting habitat quality for golden eagles in the study area.

4.2.2 Foraging Habitat

A review of the literature (as discussed in Section 2.3.2 of the RSP [City Light 2021] and Section 1.1.1 of this study report) identified the following key characteristics of suitable golden eagle foraging habitat in the Pacific Northwest:

- Clear-cuts and other open areas (Bruce et al. 1982);
- Shrublands, herbaceous meadows, barren ground, young forests, open woodlands (Bruce et al. 1982; Katzner et al. 2020);
- Presence of mountain beaver and other small mammals (Hansen 2017);
- High-use roadways for scavenging carrion (Phillips 1986); and

- Proximity to empirical evidence of previous observations.

Following the same methodology as described for nesting habitat in Section 4.2.1 of this study report, five raster layers were developed to represent each of the criteria of foraging habitat, and each attribute was assigned an HSI as summarized in Table 4.2-3.

Table 4.2-3. Attributes and corresponding habitat suitability index for each of the criterion used to map foraging habitat in the study area.

HSI	Presence of Canopy Openings	Presence of Open Land Cover Types[1]	Presence of Roads	Presence of Mountain Beaver Habitat	Proximity to Empirical Observations
3	Canopy height < 6 ft and > 2 acres in size	Barren Land, Shrub/ Scrub, Grassland/ Herbaceous, Pasture/ Hay	NA	Within modeled mountain beaver habitat	Within 0.25 mi of previous observation
2	Canopy height < 6 ft and 1-2 acres in size	Cultivated Crops	Road surface and shoulder	NA	Within 0.25-0.5 mi of previous observation
1	Canopy height < 6 ft and 0.5-1 acre in size	Emergent Herbaceous Wetlands	NA	NA	Within 0.5-1 mi of previous observation
0	Canopy height < 6 ft and 0.5 acre in size OR canopy height > 6 ft	All other land cover types	Non-roadway	Outside modeled mountain beaver habitat	> 1 mile from previous observation

1 Land cover types from Vegetation Mapping Study (City Light 2022) and NLCD (USGS 2021).

Openings in the canopy were identified from the canopy height layer. Returns with a canopy height equal to or less than 6 feet were isolated and converted to a vector format. This process returned linear areas of low or no canopy cover, such as roadways and rivers. To exclude these areas the *developed* and *open water* cover types from the land cover layer were used to erase those land cover types from the areas of low or no canopy height. The quality of foraging habitat in forest openings (i.e., clear-cuts and meadows) was based on the size of the opening (Table 4.2-3).

The HSI values corresponding to the land cover types listed in Table 4.2-3 were added to the land cover layer. Golden eagles also avoid areas of human activity while foraging (Steenhof et al. 1983; Scott 1985). Developed areas within the land cover layer were all ascribed an HSI of 0, which functionally excludes areas of human activity from suitable foraging habitat.

Selected roads, as described in Section 4.1.3.3 of this study report, were converted to a raster and represented by a binary surface with HSI of 0 (non-roadway) and 2 (roadway and shoulders). Roads do not represent a high-quality habitat type, so roadways were denoted with an HSI of 2 (as opposed to 3) to represent moderate-quality habitat (Table 4.2-3).

The two mountain beaver habitat models described in Section 4.1.3.1 of this study report were merged and converted to a binary raster surface with HSI of 0 (outside mountain beaver habitat) and 3 (within mountain beaver habitat; Table 4.2-3).

Incidental observational data obtained from NPS and WDFW were used to identify the locations of past golden eagle sightings. Although the past presence of eagles does not correspond to future presence, it does indicate the potential presence of environmental or biological factors suitable for foraging and movement. Observation locations were buffered sequentially by 0.25, 0.5, and 1.0 miles, and the resulting polygons were merged and clipped to the study area. The various polygons were attributed an HSI ranking from 0 to 3 as detailed in Table 4.2-1, and the vector layer was converted to a raster.

As was completed for nesting habitat, each of the five criteria described above was weighted relative to one another, and the absolute weight for each criterion was calculated using Saaty's multi-criterion evaluation (Table 4.2-4). The absolute weights indicate that both the structural and vegetative composition of clear-cuts and other open areas were highly indicative of foraging probability, whereas roadways and empirical observations were ranked as least important. Roadways represent both moderate- and low-quality habitat that varies based on numerous factors, such as: the presence of humans, amount of carrion/roadkill, availability of adjacent food sources, and seasonal variation in these and other factors. Empirical observations were ranked low because sightings were highly limited in number and based on old observations.

Table 4.2-4. Relative and absolute weights of each criterion used to describe foraging habitat in the study area.

	Presence of Canopy Openings	Presence of Open Land Cover Types	Presence of Roads	Presence of Mountain Beaver Habitat	Proximity to Empirical Observations	Absolute Weights[1]
Presence of Canopy Openings	1	1/2	5	4	3	**0.31**
Presence of Open Land Cover Types	2	1	5	4	3	**0.41**
Presence of Roads	1/5	1/5	1	1/2	2	**0.08**
Presence of Mountain Beaver Habitat	1/4	1/4	1/2	1	2	**0.12**
Proximity to Empirical Observations	1/3	1/3	1/2	1/2	1	**0.08**

1 Absolute weights are calculated by finding the geometric mean of the other five values in that row, then scoring as a fraction of 1.

The Weighted Sum tool was used to find the cumulative combination of all five criteria. This was accomplished by multiplying the HSI value by each criterion's absolute weight within each pixel of the model inputs. Then the sum of the five weighted HSI values for each pixel was expressed as a positive value in the model output. The product was a raster representing relative foraging habitat quality for golden eagles in the study area.

4.3 Develop Golden Eagle Geospatial Risk Assessment

The GRA is intended to identify areas of relatively high risk of golden eagle collision with the transmission line as described in Section 2.6.3 of the RSP (City Light 2021). The GRA follows standards outlined in APLIC's Eagle Risk Framework a Practical Approach to Power Lines (2018). The GRA uses GIS to consider how golden eagle Important Eagle Use Areas (IEUA) are positioned relative to the transmission line. IEUAs are defined as: nest sites and nesting habitat; foraging habitat; roost sites (not applicable, there are no known roost sites in the study area); and important movement corridors (USFWS 2016a). The IEUAs identified for use in the GRA are described in Table 4.3-1.

Table 4.3-1. Golden eagle Important Eagle Use Areas (IEUA) used to develop the Geospatial Risk Assessment, their extent, and brief description.

IEUA	Extent[1]	Description
Modeled Nesting Habitat	Study Area	Nesting habitat developed as described in Section 4.2.1 of this study report. IUEAs were defined by high-quality nesting habitat.
Nest Sites	Regional[1]	Incidental observational data from WDFW and NPS. Known nest sites were buffered by 1,500 feet to create a vector polygon source/target habitat.
Modeled Foraging Habitat	Study Area	Foraging habitat developed as described in Section 4.2.2 of this study report. IUEAs were defined by high-quality foraging habitat.
Observations	Regional	Incidental observational data from WDFW and NPS. Observations were buffered by 500 feet to create a vector polygon source/target habitat.
Nest Density Model	Regional	Regional model of relative nest site density developed by Dunk et al. (2019). IUEA defined by AAF category $\geq$5 (moderate-high density).
Clear-cuts and Forest Openings	Regional	Open areas (i.e., barren land, cultivated crops, hay/pasture, herbaceous, shrub/scrub) based on NLCD land cover mapping that are $\geq$ 0.5 acre in size.
Ridgelines	Regional	Prominent ridges identified through aerial imagery and hill shade derived from DEM.

1 Data available at a regional extent was clipped to a 5-mile buffer of the transmission line which, with the exception of ridgelines, excluded the study area.

The nesting and foraging habitat models (i.e., geospatial habitat assessment [RSP 2.6.3.1] and golden eagle use assessment [RSP 2.6.3.2] from Sections 4.2.1 and 4.2.2 of this study report) are the primary golden eagle IEUAs within the study area extent. These datasets represent potential golden eagle habitat use within the study area and are based on fine-scale data with limited extent. IEUAs that overlap or are immediately adjacent to the transmission lines represent a relatively high-risk location. However, the movement between IEUAs (i.e., source habitats) within the study area and across the broader landscape also represent areas of potentially elevated risk, though not to the same degree as nesting and foraging habitat that overlaps or is immediately adjacent to the transmission line.

Golden eagles are large, mobile, avian predators with the ability to traverse large geographic areas in short time periods. Therefore, it is important to consider risk to golden eagles that nest and/or forage outside the study area but may travel across the transmission line ROW to reach these locations. IEUAs available at a regional extent (equal to or greater than 5 miles from transmission line) include observational data (Section 4.1.1 of this study report), NLCD land cover (Section 4.1.3.3; USGS 2021), and a nest density model (Section 4.1.2; Dunk et al. 2019). These datasets were clipped to a 5-mile buffer of the transmission line. Five miles sufficiently covers year-round high-intensity golden eagle flight and perch use around a nest (Watson et al. 2014) and captures any theoretical influence the surrounding landscape may have on movement at the transmission line. The nest density model and NLCD land cover represent nesting and foraging habitat, respectively, in areas outside of the study area where fine scale geospatial data is limited or unavailable. These are included in the GRA as described below, for areas between 1 and 5 miles from the transmission lines.

The golden eagle IEUAs were combined into a single dataset to simplify them into source habitats. All high-quality nesting and foraging habitat (see Sections 4.2.1 and 4.2.2 of this study report) was included. Known nest sites and historical observations were buffered by 1,500 and 500 feet, respectively, and defined as source habitats. Portions of the nest density model classified as moderately high, high, or very high density (i.e., 5, 6, or 7) were selected as source habitats between 1 and 5 miles from the transmission line. The following land cover types from the NLCD land cover layer located between 1 and 5 miles from the transmission line were selected as potential foraging habitat if they occurred in patches greater than 0.5 acre in size: barren land, cultivated crops, hay/pasture, herbaceous, and shrub/scrub.

The resulting binary vector layer represents source habitats for golden eagle movement. To approximate golden eagle movement between habitats and to assess movement relative to the transmission line, a cost distance raster surface (ESRI 2021) was developed. This analysis was conducted within a 5-mile buffer of the transmission line. The source habitat vector layer was converted to a raster. A cost surface layer was created from elevation data (i.e., DEM). Because golden eagles can travel long distances with minimal effort, features of the landscape represent only minor impediments. Therefore, elevations greater than 2,000 meters (about 6,562 feet) above mean sea level (amsl) were classified as a moderate impediment (value of 0.5 in cost raster). Areas greater than 2,000 meters amsl largely consist of perennial ice/snow and are the highest elevations within and near the study area. Elevations less than 2,000 meters were classified as a minimal barrier to movement (value of 0.1 in cost raster). The "cost distance" tool calculates the least accumulative cost distance for each cell in the output raster from or to the least-cost source habitat. The output is a raster surface where shorter distances between source habitats represent greater likelihood for golden eagle use. The output surface provides a relative probability of golden eagles crossing the transmission line ROW during movement between nesting and foraging habitats. Where eagles cross the transmission line ROW, there is a risk for collision with the transmission line itself.

In mountainous terrain, golden eagles use orographic lift and thermal updrafts produced by air flow over topography during migration and local movements (Kerlinger 1989). Aerial imagery and hill shade derived from DEM were used to manually digitize prominent ridges within 5 miles of the transmission line. Ridges within source habitats and ridges within or near areas with short cost distances represent elevated risk for collision.

The final step in the GRA was a qualitative review of the available spatial data to rank relative risk across the Project transmission line. This involved consideration of modeled nesting and foraging habitat, cost distance raster, ridges, other topography, and the positioning of the transmission line relative to those factors. A relative collision risk ranking (“high”, “moderate”, “low”) was ascribed to all parts of the transmission line based on all available information.

5.0 RESULTS

5.1 Nesting and Foraging Habitat

Modeled nesting and foraging habitat each included five input variables (Tables 4.2-1 and 4.2-3) weighted according to relative importance (Tables 4.2-2 and 4.2-4). The weighted sums of the nesting habitat model had a possible range between 0 and 3, whereas the foraging habitat model had a possible range between 0 and 2.92. For each model output, relative habitat quality was determined by the following weighted sums:

- High-quality habitat = weighted sums ≥ 2.5;
- Moderate-quality habitat = weighted sums 1.5 - 2.5;
- Low-quality habitat = weighted sums 0.5 - 1.5; and
- Unsuitable = weighted sums ≤ 0.5.

5.1.1 Modeled Nesting Habitat

The nesting habitat model output resulted in weighted sums ranging from 0 to 2.94. Most of the study area is modeled as low-quality nesting habitat (Table 5.1-1). High-quality nesting habitat is primarily located in very small patches near Diablo and Gorge lakes and on Sourdough Mountain. Moderate-quality nesting habitat is also found in this same area and also occurs in larger patches as far south as Wheeler Ridge, located just east of Arlington (Attachment B).

Table 5.1-1. Area of high-, moderate-, low-quality, and unsuitable nesting habitat modeled in the study area.

Modeled Nesting Habitat Quality	Study Area (acres)	Percent of Study Area	Project Boundary (acres)	Percent of Project Boundary	Length of Transmission Line (miles)
High	10	< 0.1	0.0	0.0	0.0
Moderate	9,680	8.0	204	2.8	1.0
Low	74,786	62.0	3,912	53.0	28.2
Unsuitable	35,961	30.0	3,260	44.2	62.2

5.1.2 Modeled Foraging Habitat

The foraging habitat model output resulted in weighted sums ranging from 0 to 2.76. Most of the study area is modeled as unsuitable for foraging (Table 5.1-2). Relatively large patches of high-quality foraging habitat are located within the boundaries of the Goodell Creek Fire near Newhalem, within clear-cuts near Rockport and Marblemount, and sporadically throughout the study area (Attachment C). Moderate- and high-quality foraging habitat was mapped within the transmission line ROW, where vegetation management results in a linear swath of open and non-forested land cover. A large and contiguous area of moderate- and high-quality foraging habitat was mapped within agricultural fields near the City of Snohomish, along the Snohomish River. Because most of the study area consists of forested land cover, less than 20 percent is modelled as suitable for foraging by golden eagles (Attachment C).

Table 5.1-2. Area of high-, moderate-, and low-quality and unsuitable foraging habitat modeled in the study area.

Modeled Foraging Habitat Quality	Study Area (acres)	Percent of Study Area	Project Boundary (acres)	Percent of Project Boundary	Length of Transmission Line (miles)
High	1,841	1.5	339	4.5	10.6
Moderate	12,734	10.6	1,398	19.0	37.0
Low	14,132	11.7	1,143	15.5	27.6
Unsuitable	91,692	76.2	4,496	61.0	16.3
Total	**120,399**	**100**	**7,376**	**100**	**91.5**

5.2 Geospatial Risk Assessment

The most important predictor of risk is the presence of modeled nesting and foraging habitat within or very close to the transmission line ROW. The total length of transmission line traversing nesting and foraging habitat is shown in Tables 5.1-1 and 5.1-2, respectively. Although the transmission line does not traverse high-quality nesting habitat, it does cross areas of moderate-quality nesting habitat between Diablo Lake and Ross Dam. Moderate-quality nesting habitat is also present near the transmission line between Newhalem and Diablo Lake (Attachment B) but is less common elsewhere along the transmission line ROW. Because high-quality foraging habitat is mapped within the ROW, the transmission line crosses this habitat type regularly. Notable locations with higher concentrations of high-quality foraging habitat are in the vicinity of Newhalem, Bacon Creek, Marblemount, and along the Sauk River near North Mountain.

The golden eagle IEUAs (or source habitats) mapped within 5 miles of the transmission line were most common towards the northern end of the study area, but also present at a lower density throughout a regional extent. The nature of the cost distance output is that areas in closer proximity to the source habitats have a lower cost distance and higher expected risk, but a lower risk than areas within mapped high-quality habitats. As such, many of the same areas along the transmission line would be identified as higher risk in the cost distance layer.

The transmission line primarily traverses flat valley bottoms and rarely crosses prominent ridgelines. However, in areas where the transmission line does cross ridgelines and variable terrain, collision risk is elevated because golden eagles use topography for lift during foraging or migratory flight.

The transmission line crosses or comes close to mapped ridgelines in the following notable locations (Attachment D):

- Diablo Dam;
- Newhalem;
- Near the Sauk River south of Rockport; and
- Near Ebey Hill, northeast of Arlington.

The qualitative and relative assessment of all the above variables categorized approximately 24 percent of the transmission line as “high” risk, 46 percent as “moderate” risk, and 30 percent as “low” risk. The mapbook in Attachment D shows the portions of the transmission line categorized as low, moderate, and high risk for golden eagle collision. Note that the use of “high,” “moderate,” and “low” terminology is relative and Project-specific, describing comparative risk only within the extent of the study area (see Section 6.1.3 of this study report for detailed discussion). Furthermore, as described in Section 1.1.1 of this study report, golden eagle abundance is considered very low in the study area.

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. The objectives included: (1) characterize golden eagle nesting, foraging, and movement corridors in the study area; (2) map historical observations and nesting, foraging and movement corridors in the study area; and (3) develop a GRA to identify and map the relative risk of golden eagle collision with Project transmission lines within the study area.

Based on the review of existing golden eagle observational data, systematic monitoring, and available literature as described in Section 1.1.1 of this study report, golden eagle abundance in and near the study area is extremely low. Golden eagles are uncommon during fall migration and rare during spring, winter, and summer in the study area. There are several eBird (2021) observations of golden eagles in the study area during winter and spring, likely moving along major drainages towards estuaries where they occur in relatively large numbers during winter. Our habitat models and GRA should be carefully interpreted in consideration of this fact. Habitat quality and collision risk are all described in relative terms within the extent of the study area and should not be considered relative to the golden eagle's broader range. Overall, observational data and habitat modeling suggest golden eagles, if they were to occur in the study area, would most likely be observed between Newhalem and Ross Dam. In this area, the rugged, mountainous topography is most like that preferred by golden eagles. Nesting habitat, although limited, is present on cliffs and barren alpine slopes as well as trees that border forest openings. Recent burns provide temporarily suitable foraging habitat in addition to the alpine slopes outside of the study area. Although nesting and foraging habitat is present in patches throughout the study area, its abundance wanes as one heads south, largely due to moderating topographic relief. Based on the model, the transmission line ROW provides moderate- and high-quality foraging habitat. However, it is unlikely that golden eagles would venture further south than Marblemount to access this foraging habitat due to a lack of other important habitat parameters both in and adjacent to the study area. As a result of the above, relative collision risk would be greatest between Newhalem and Ross Dam as well as other points at which topography, habitat, and the position of the transmission line combine to be considered relatively elevated risk.

Golden eagle risk of collision with Project transmission lines can be confidently described as very low because: (1) golden eagle abundance is very low; (2) high-quality nesting habitat is limited in and near the study area; (3) foraging habitat is limited relative to other portions of golden eagle range; (4) collisions are rare during migration (greatest during foraging and territorial defense), which is when golden eagles are most commonly in the study area; and (5) golden eagles, like all raptors, rarely collide with transmission lines due to their visual acuity and maneuverability.

6.1 Model Outputs

As discussed in Section 1.1 of this study report, very few systematic avian monitoring studies have been conducted within or near the study area, and none have been conducted specific to golden eagles, likely due to very low abundance in the general area. There are no available data to inform a confident estimate of golden eagle abundance, distribution, or to identify territories. Spatial models often rely on empirical data to test model outputs, but no empirical data (e.g., standardized golden eagle survey results) exist to assess the nesting or foraging models or GRA in the study area. The HSM (pseudo-HEP) approach performed well in this scenario, combining several complex variables to produce fine-scale spatial models of relative habitat quality based on habitat requirements in the literature.

As described in Section 4.1.3.3 of this study report, two different land cover (i.e., vegetation) datasets were used to fully cover the study area with the best available land cover information. Because these datasets include different vegetation types and are available at different spatial scales, there is some incongruity between these datasets. In some small and isolated areas, the intersection of these different land cover datasets is visible via a straight edge where the datasets meet. However, because these contrasting land cover types are both forested, they were represented equally in the models, and there are likely no significant inaccuracies in either the nesting or foraging habitat models.

6.1.1 Nesting Habitat

The nesting habitat model was based on five input variables, which describe optimal golden eagle nesting habitat as steep slopes on southerly aspects adjacent to clear-cuts and other non-forested areas that are distant from human activity. Based on absolute weights (Table 4.2-2), terrain roughness and land cover were the most important variables in describing golden eagle nesting habitat. As such, moderate- and high-quality nesting habitat is most common in the higher elevation portions of the study area, where the terrain is steeper and barren. Undeveloped landcover is more plentiful within areas of topographic ruggedness. Most of the forests in the study area are mapped as low-quality nesting habitat because they exhibit densely closed canopies with few edges. Rivers, lakes, developed areas (roads, buildings), and the transmission line ROW are unsuitable for nesting. A large portion of the transmission line ROW is within low relief river valleys, which typically do not represent moderate- or high-quality nesting habitat. High-quality nesting habitat is rare in the study area (Table 5.1-1) and, likewise, is rare throughout the western slope of the Northern Cascades (as discussed in Section 1.1 of this study report). Known nest sites are also rare, which is consistent with the very low amount of high-quality nesting habitat in the model output, and likely relates to relative scarcity of suitable foraging habitat in the region.

The nesting habitat model output is qualitatively corroborated by other spatial models of golden eagle habitat and distribution. The USGS (2017) GAP golden eagle model only mapped suitable summer habitat in the Diablo Lake and Ross Lake area, which is the same area where much of the high- and moderate-quality habitat was modeled. The output of the nesting habitat model showed broad agreement with Dunk et al. (2019), whereas higher density nesting probability is located within the northern portion of the study area, particularly near Diablo and Gorge lakes. Detailed comparisons between any two models are not practical due to differences in model inputs, scale, and inherent modeling limitations.

6.1.2 Foraging Habitat

The foraging habitat model was based on five input variables, which describe optimal golden eagle foraging habitat as non-forested areas with open but undeveloped land-cover. Roadways and mountain beaver habitat can also function as important habitat for prey. Based on absolute weights (Table 4.2-4), land cover and canopy height were the most important variables in describing golden eagle foraging habitat. As such, most of the study area is mapped as unsuitable for foraging golden eagles because most of the study area is forested. Burned areas, the transmission line ROW, and agricultural fields contain most of the moderate- and high-quality foraging habitats. Some of the agricultural fields, such as blueberry farms near the Snohomish River, may not be suitable foraging habitat, but, based on the model inputs, the model output suggests they are of moderate quality. Moderate- to high-quality foraging habitat is much more widespread across the study area than moderate- and high-quality nesting habitat.

Beyond the study area, but within five miles of the transmission line, foraging habitat may occur where indicated by NLCD cover types (i.e., shrubland, barren land, herbaceous, and cultivated crops). Barren land is common in alpine areas near the northern portion of the study area and some clear-cuts and agricultural fields are found near Arlington. The above-mentioned blueberry farms extend beyond the study area near the Snohomish River. In addition, eBird observations beyond the study area may imply foraging use in these areas. While observations are sporadic at best, there appears to be concentrations in the mountains west of Ross Dam and along the Skagit and Cascade rivers near Marblemount (eBird 2021).

Areas mapped as shrub/scrub in the land cover dataset could exhibit a range of shrub height and structural characteristics. Height of vegetation was not a readily available attribute in the land cover dataset. As such, shrubs in these areas could exhibit a patchy mosaic of tall, short, and dwarf shrub types with different degrees of canopy closure, which all correspond to a different quality of foraging habitat. That is, dwarf shrubs in a patchy or open canopy distribution reflect higher quality foraging habitat than tall shrubs with closed canopies. As a result, there may be variability in modeled foraging quality in shrub/scrub habitats not captured by the model output. Consideration was given to changing the HSI score for shrub/scrub, but it was determined that a more conservative approach was warranted to account for inherent variability and to ensure the model captured high-quality foraging areas within shrub/scrub land cover types.

6.1.3 Geospatial Risk Assessment

It is important to reemphasize that the terms “high,” “moderate,” and “low” risk are used to describe different portions of the transmission line *relative* to one another rather than beyond the extent of the study area. Golden eagles are extremely rare in the study area and on the western slope of the Northern Cascades. Overall, even areas categorized as high-risk within the study area would likely be considered very low risk for golden eagle collision relative to risk at transmission lines elsewhere across the species’ range where golden eagles are more common (i.e., open grasslands, deserts, sagebrush-steppe, etc. of the intermountain west).

The areas of highest collision risk in the study area are located where the transmission line crosses moderate- and high-quality nesting or foraging habitat. Beyond these areas, the cost distance surface approximates relative risk during golden eagle movement between the modeled nesting and foraging habitats and other source habitats in the area. The topography can create pinch points along movement corridors where golden eagles are more likely to occur while traveling between habitats. This is particularly important when eagles use uplift created by ridgelines and variable terrain during foraging and migration. The qualitative assessment of relative risk considered these variables and ascribed generalized risk levels to each portion of the transmission line. In addition, specific portions of the transmission line that meet the characteristics of relatively high risk (Section 5.2 of this study report) have been identified.

6.2 Effects of Perturbations on the Landscape

The quality of golden eagle nesting and foraging habitat is temporally dynamic in this region and highly dependent on perturbations across the landscape. In 2015, the Goodell Creek Fire burned approximately 7,118 acres in the vicinity of Newhalem, including a portion of the study area between Newhalem and Gorge Lake (Washington DNR 2016). Current post-fire conditions range from open herbaceous ground cover to dead-standing forests among a mosaic of live trees. The land cover and vegetation mapping datasets used in the analysis capture the impact of this landscape change. Similarly, the canopy height data in this burn area indicate a highly fragmented forest with large open patches. As such, this area is reflected in the model output as moderate- and high-quality foraging habitat (Attachment C). As the forest in this area regrows, the foraging quality for golden eagles will decline. Future wildfires may result in moderate- to high-quality foraging areas for a relatively short duration. In Idaho, golden eagles avoided burned areas during breeding (Marzluff et al. 1997), but a fire edge (transition zone caused by fire resulting in a difference in structural characteristics, Parkins et al. 2018) may provide suitable nesting habitat for a period of time, as shown in the nesting habitat model (Attachment B).

Incidental observational data appears to be positively correlated with timber harvest in this region, as discussed in Section 1.1 of this study report. Looking forward, an increase in timber harvest using clear-cuts within or near the study area may result in an increase in suitable golden eagle foraging habitat.

While changes to the landscape can result in localized increases in suitability of golden eagle foraging habitat, golden eagles are expected to remain rare in and near the study area regardless of timber harvesting practices or wildfire occurrence. Even during years with the highest recorded incidental observations, overall abundance was relatively low (maximum of 33 incidental observations in 1986; Figure 1.1-2). Most available data suggests golden eagles are very rare in northwestern Washington, with peak abundance during fall migration. For example, since 1993, no more than six golden eagle observations have been reported in any year within the North Cascades National Park Complex (NPS 2021b; Figure 1.1-2). There are only two confirmed and one probable nest known within 10 miles of the study area (NPS 2021b; WDFW 2021a), and none of the BBS routes located in the study area has ever recorded golden eagles (USGS 2018a).

The transmission line ROW may provide moderate- to high-quality foraging habitat for golden eagles that sporadically use the Project vicinity because the vegetation is maintained at a low height to comply with North American Electric Reliability Corporation (NERC) standards, and much of the ROW has a forested edge. Forest edges are preferred habitat for many golden eagle prey species. The ROW was characterized in model inputs by low canopy height, forests adjacent to open areas, and often distance from developed areas. As such, much of the ROW was mapped as suitable foraging habitat. Moderate- and high-quality foraging habitat covered approximately 28 and 9 percent of the ROW (defined as the operational ROW of the transmission line as opposed to the Project Boundary, which is calculated in Table 5.1.2), respectively, and almost 17 percent of all mapped high-quality foraging habitat in the study area is located within the ROW. Vegetation within the transmission line ROW largely consists of shrubs. As discussed in Section 6.1.2 of this study report, shrubs in these areas could exhibit a patchy mosaic of tall, short, and dwarf shrub types with different degrees of canopy closure, which all correspond to different quality of foraging habitat. It bears repeating that there has not been a recorded incident of golden eagle collision with the transmission line, golden eagles are inherently at low risk of collision, and they are relatively rare in the study area and surrounding region (Section 1.1 of this study report). However, the moderate- and high-quality foraging habitat in the transmission line ROW may represent a relatively higher-use area in comparison to other portions of the study area (APLIC 2018).

6.3 Collision Risk Factors

A few factors that affect collision risk could not be modeled or assessed from the available information. Weather conditions, such as wind speed, direction and presence of clouds, fog, and precipitation, are all factors in collision risk (Eccleston and Harness 2018). Areas along the transmission line with consistently high velocity or volatile winds could result in elevated relative risk, but identification of these areas was not within the scope of this study. Golden eagle behavior can also influence collision risk, such as when birds are distracted by courtship or territorial defense (Eccleston and Harness 2018). These factors are highly variable, but somewhat captured by modeling potential habitat and inclusion of proximity to existing territories in the models.

Migratory flights often follow leading lines, such as ridgelines and rivers, and are concentrated in areas with high topographic relief that provide updrafts (Eisaguirre et al. 2018). This study did not investigate migratory movements beyond incorporation of observational data and theoretical extrapolation of the influence of topography during movement. In the study area, golden eagles would be expected to follow river valleys, and, in the surrounding mountains, foraging as habitat is available. While no golden eagle observations have been recorded directly on the transmission line ROW, the transmission line ROW is a prominent source of moderate- and high-quality foraging habitat in the upper Skagit and lower Sauk river valleys and may be used by the few golden eagles that migrate through this area.

Areas where the highest wires on the transmission line (typically the optical ground wire [OPGW] wire on top of the D line [B line does not have an OPGW]) and its towers are taller than the surrounding forest may have higher relative collision risk. Eagles flying just above the canopy may cross over the transmission line avoiding collision if the surrounding forest is higher than the transmission line but may be at risk for collision where the transmission line is higher than the surrounding forest canopy. However, the available data were insufficient to map or model this risk factor. Golden eagles also tend to soar at higher elevations, rather than just above treetops, and, as mentioned previously, have very good vision, making collisions of this type rare. In addition, this factor may be negated by the relatively wide (approximately 250-300 feet) ROW, where trees have been removed or pruned to meet NERC standards.

6.4 Avoidance Measures

Marking transmission lines has been shown to significantly reduce avian collisions (Manville 2005, Jenkins et al. 2010, Barrientos et al. 2011, Bernardino et al. 2021). Marking may include PVC spirals; polypropylene or reflective flappers that swing or are fixed; near-ultraviolet light; aerial marker spheres; or aviation balls (Sporer et al. 2013, Dwyer et al. 2019, Ferrer et al. 2020). APLIC (2012) provides recommendations for spacing and other design specifications. Marking of transmission lines is most often done to prevent collisions by waterfowl and other avian species at greater risk of collision than raptors. In fact, raptors typically do not benefit as much from marking transmission lines (see Section 1.1.2 of this study report). City Light has installed markers on the

Project transmission line in several locations that are near areas identified as relatively high risk for golden eagle collision (see Attachment D). These include three areas:

(1) Bird flight diverters (BFD) on the OPGW wire from the Corkindale crossing of the Skagit River (PRM 74.2) to near Illabot Creek where wintering bald eagles forage and communally roost (installed in 2001) as well as Skagit River crossing near Bacon Creek (PRM 83.3) and at “Pinkies” (PRM 86.3);

(2) Aviation markers over the Sauk River; and

(3) BFDs over the Snohomish River and adjacent agricultural areas where trumpeter swans sometimes occur during winter and collisions have been recorded (installed in 2021).

Several other areas were evaluated for marking in 2001, but a study documented many safe bald eagle flights across the lines, and City Light consulted state and federal biologists and eagle researchers, who agreed additional line markers would do little to provide protection (Springwood 2001). City Light shared this information with FERC, and FERC issued an order concluding City Light was not required to install BFD to prevent bald eagle collisions (FERC 2001).

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

There was one minor variance to the study plan as it was approved by FERC. One of the objectives in the RSP was to map historical golden eagle observations and habitats used for nesting, foraging, and movement corridors within the study area. While golden eagle observations (individuals and nests) were incorporated into the model as indicated in Section 4.2 of this study report, a map of those observations is not included as a study product due to sensitive information and confidentiality concerns. The eBird data is a public data set and can be viewed by LPs if interested[2]. City Light met the intent of the study plan by including these data in the model, while maintaining the confidentiality of the sensitive data, and the goals and objectives of this study were accomplished.

[2] eBird data can be found at the following link: http://www.ebird.org

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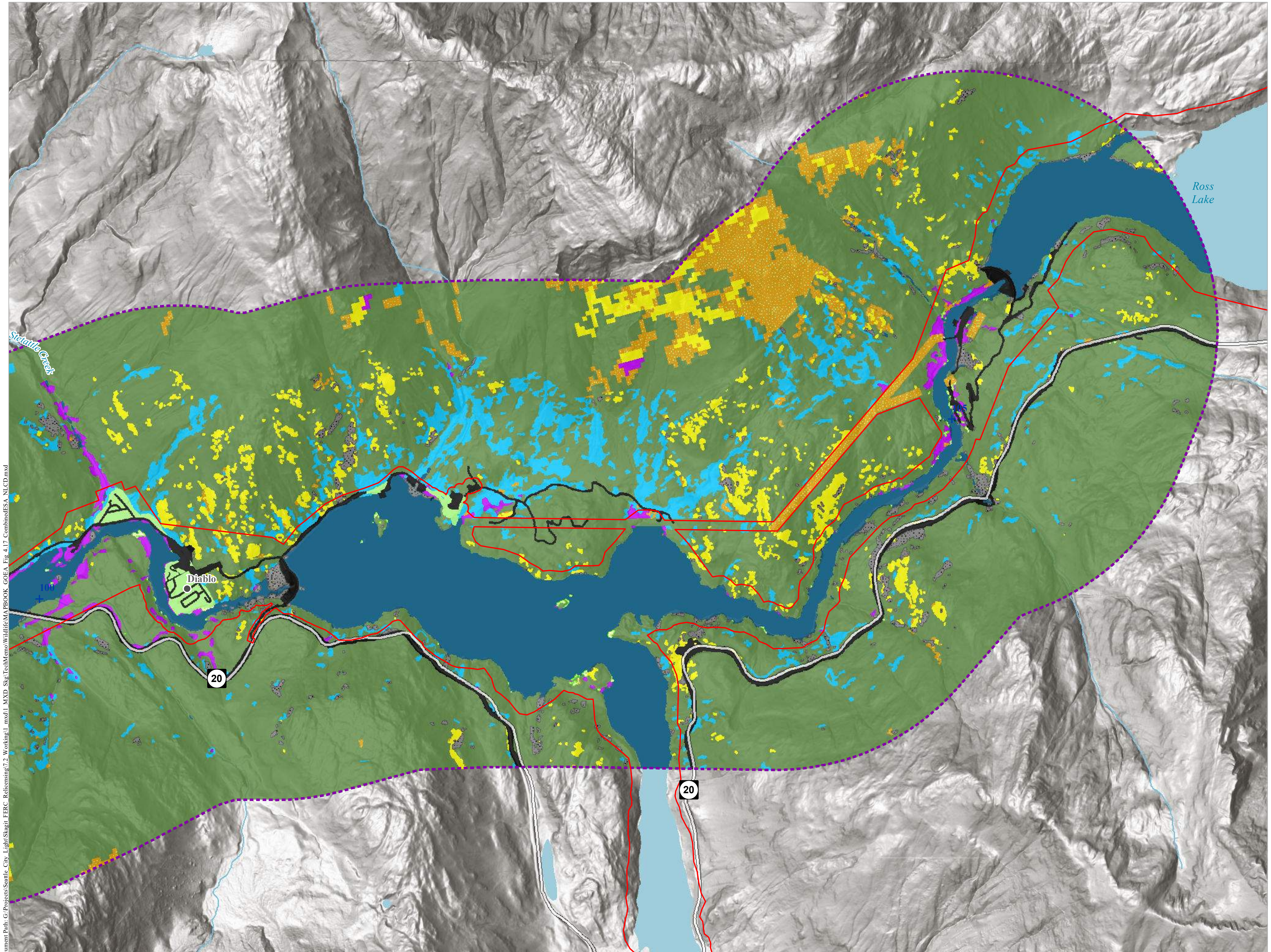
GOLDEN EAGLE HABITAT ANALYSIS DRAFT REPORT

ATTACHMENT A

COMBINED VEGETATION (TR-01 VEGETATION MAPPING STUDY) AND LAND COVER (NLCD) WITHIN THE STUDY AREA MAPBOOK



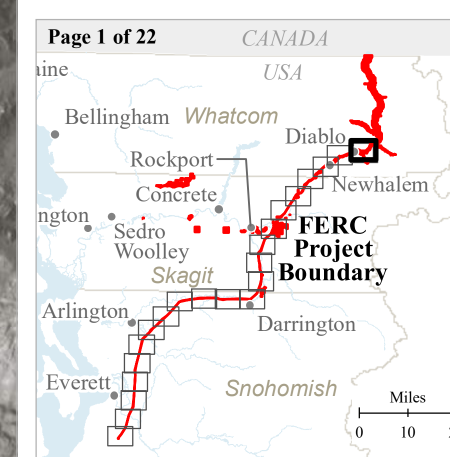
TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

FERC Project Boundary
Project River Miles (PRM)
Streams
Secondary Highway
Golden Eagle Study Area

ESA & NLCD Combined Cover Types (City Light 2022, USGS 2021)

Grassland/Herbaceous
Pasture/Hay
Shrub/Scrub
Deciduous Forest
Evergreen Forest
Mixed Forest
Emergent Herbaceous Wetlands
Open Water
Developed
Barren Land (Rock/Sand/Clay)

0 0.25 0.5 Miles



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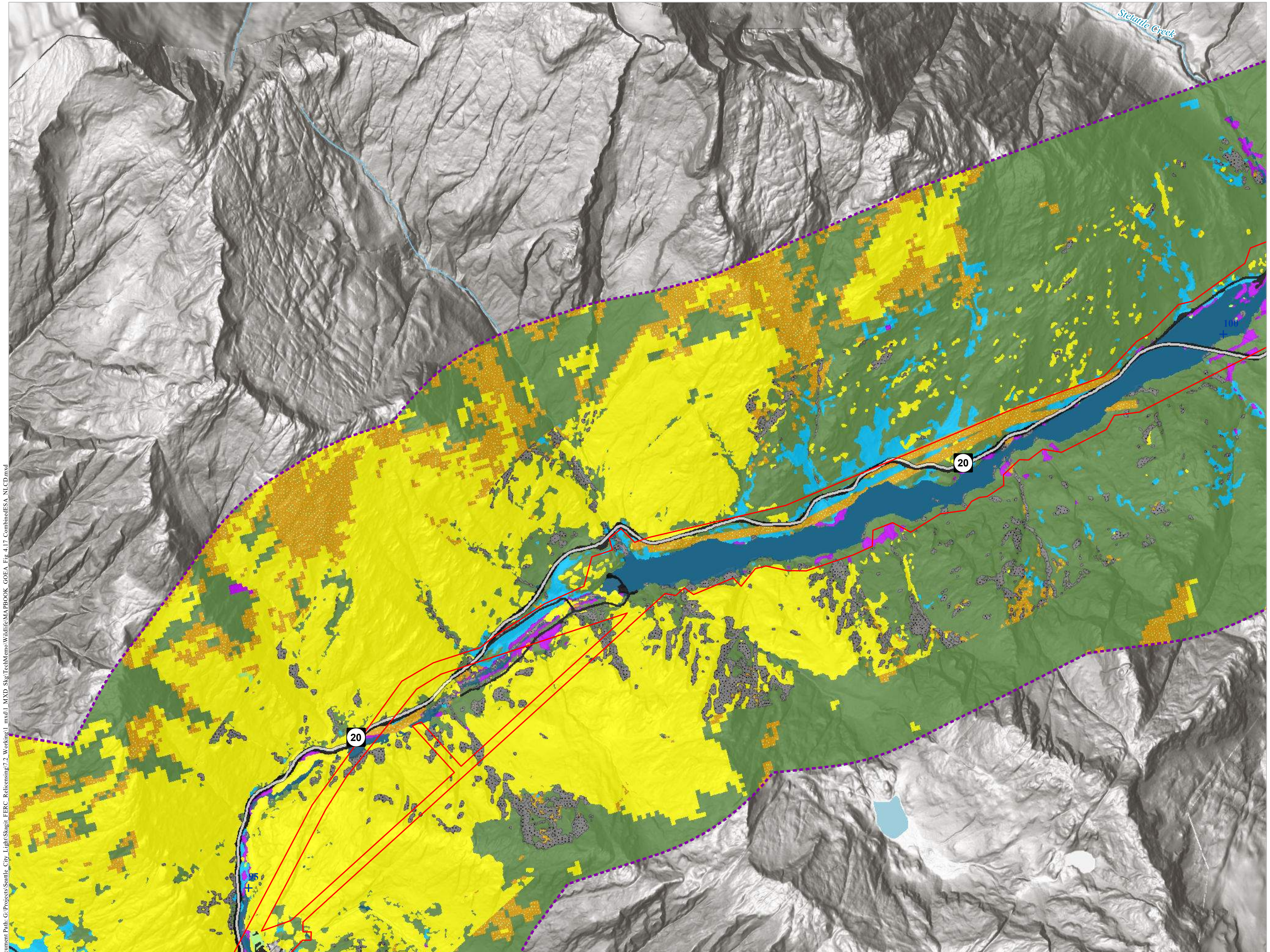

TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

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Secondary Highway
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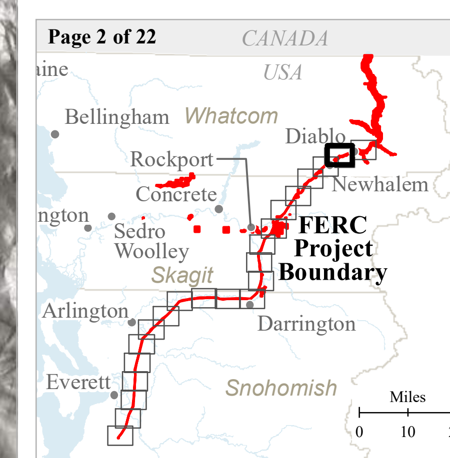
Evergreen Forest
Mixed Forest
Emergent Herbaceous Wetlands
Open Water
Developed
Developed/Open Space
Barren Land (Rock/Sand/Clay)

N

0 0.25 0.5 Miles



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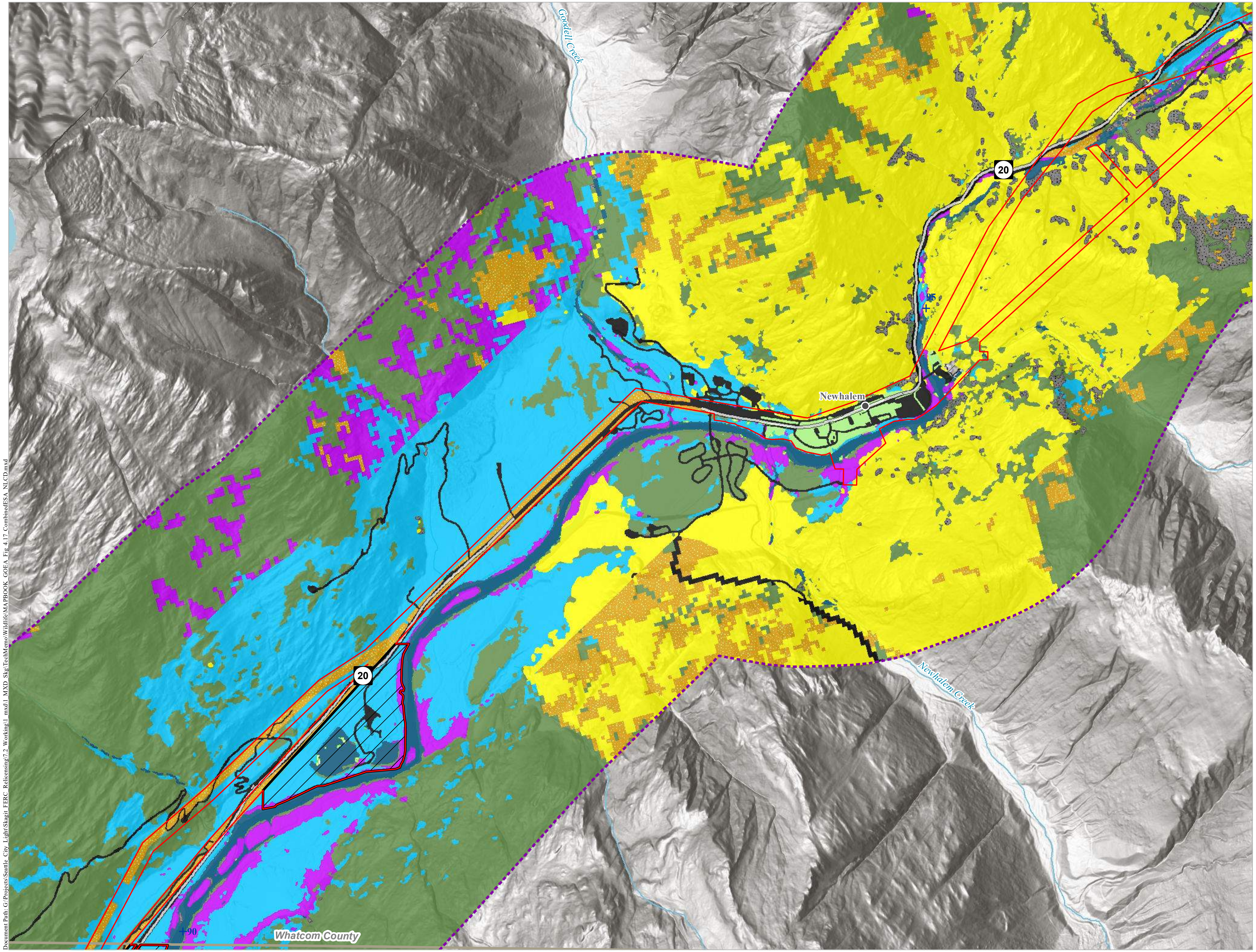

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TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

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- Mitigation Parcel
- Project River Miles (PRM)
- Streams
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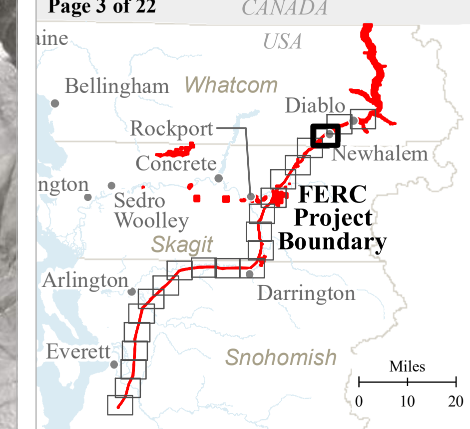
- Open Water
- Developed
- Developed/Open Space
- Barren Land (Rock/Sand/Clay)

N

0 0.25 0.5 Miles



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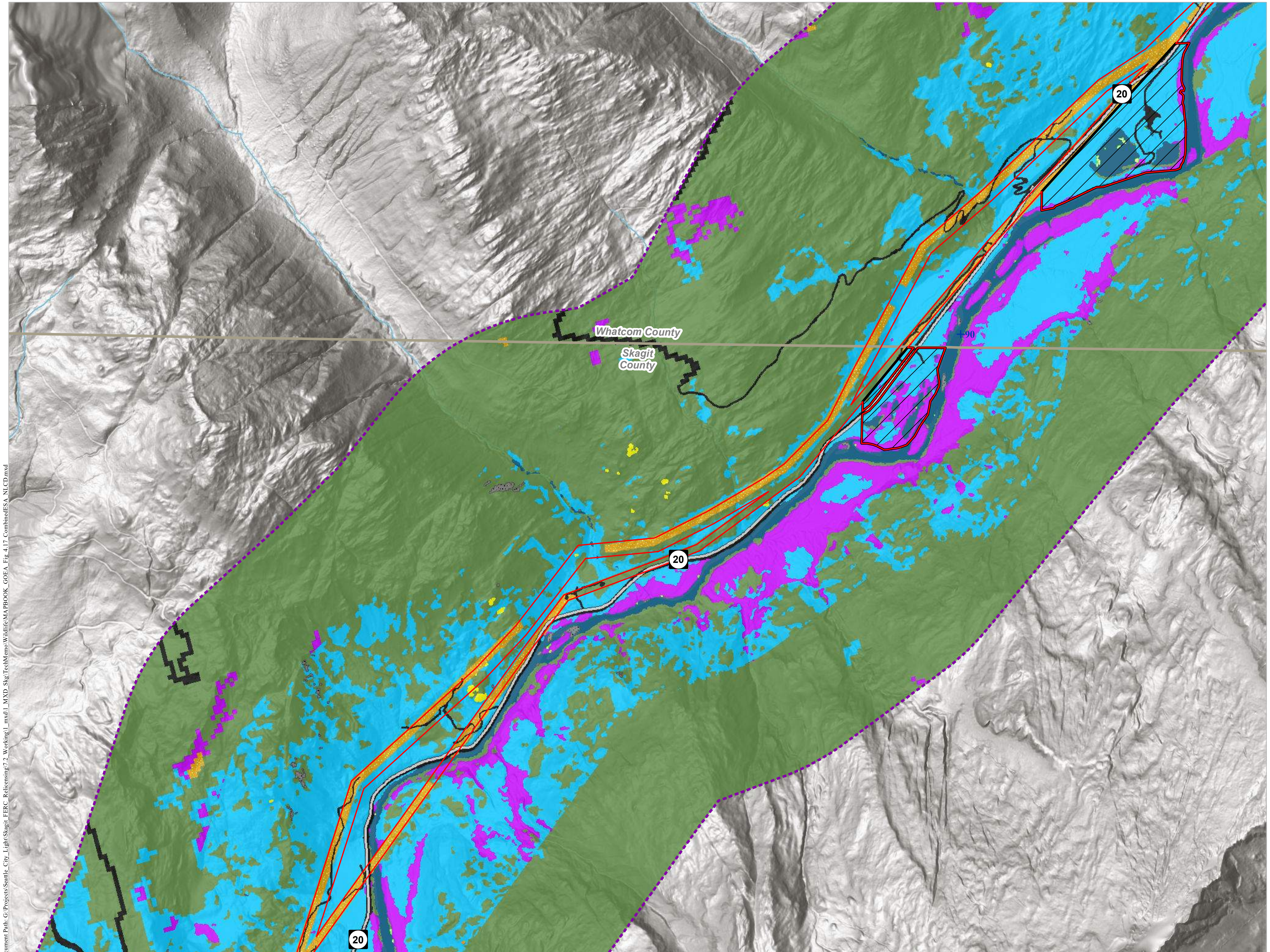

FERC Project Boundary
Mitigation Parcel
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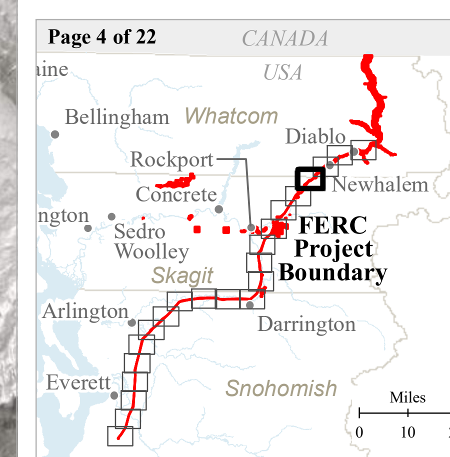
0 0.25 0.5 Miles



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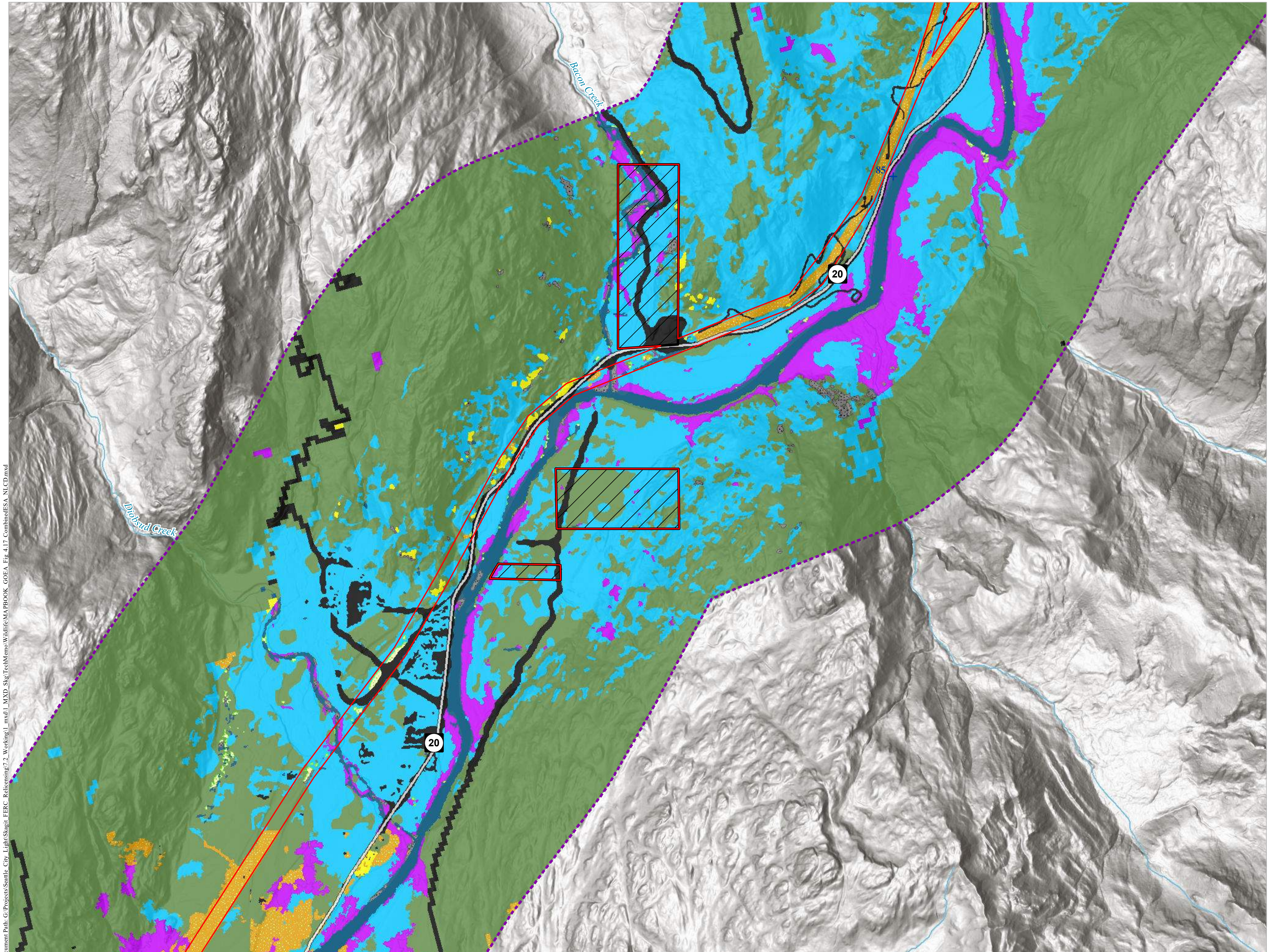

TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

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Mitigation Parcel
Project River Miles (PRM)
Streams
Secondary Highway
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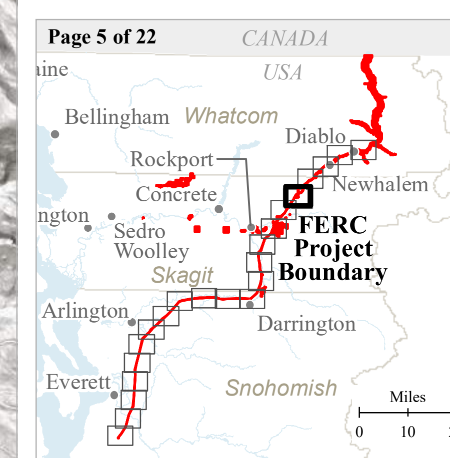
0 0.25 0.5 Miles



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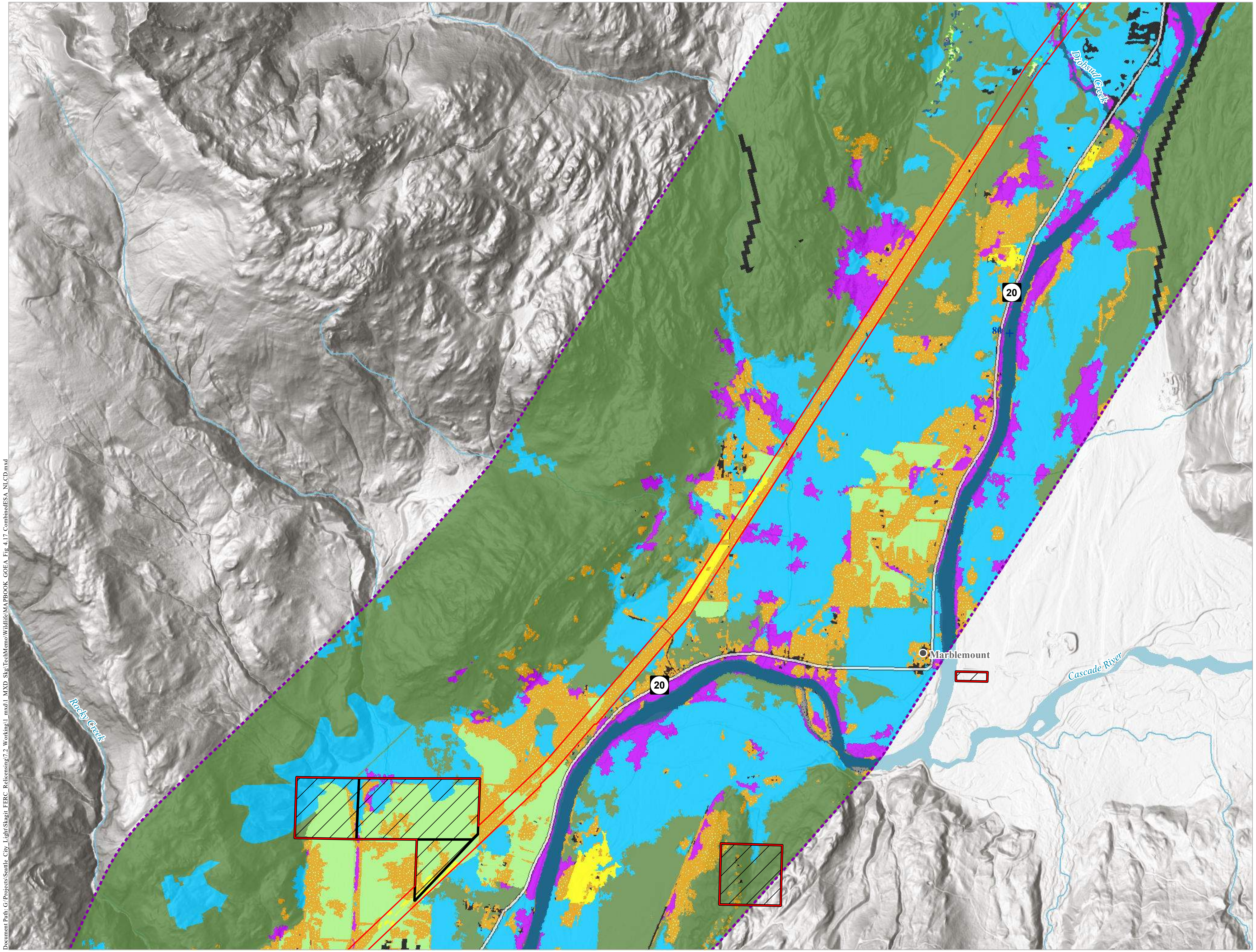

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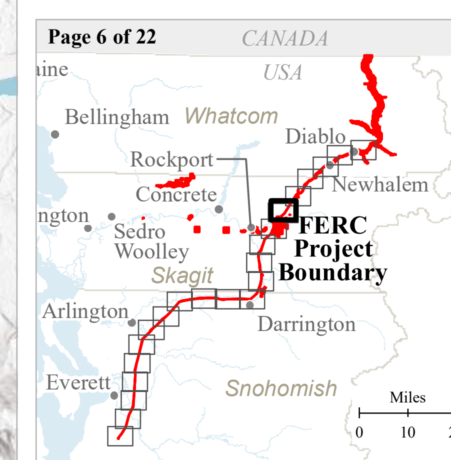
N

0 0.25 0.5 Miles



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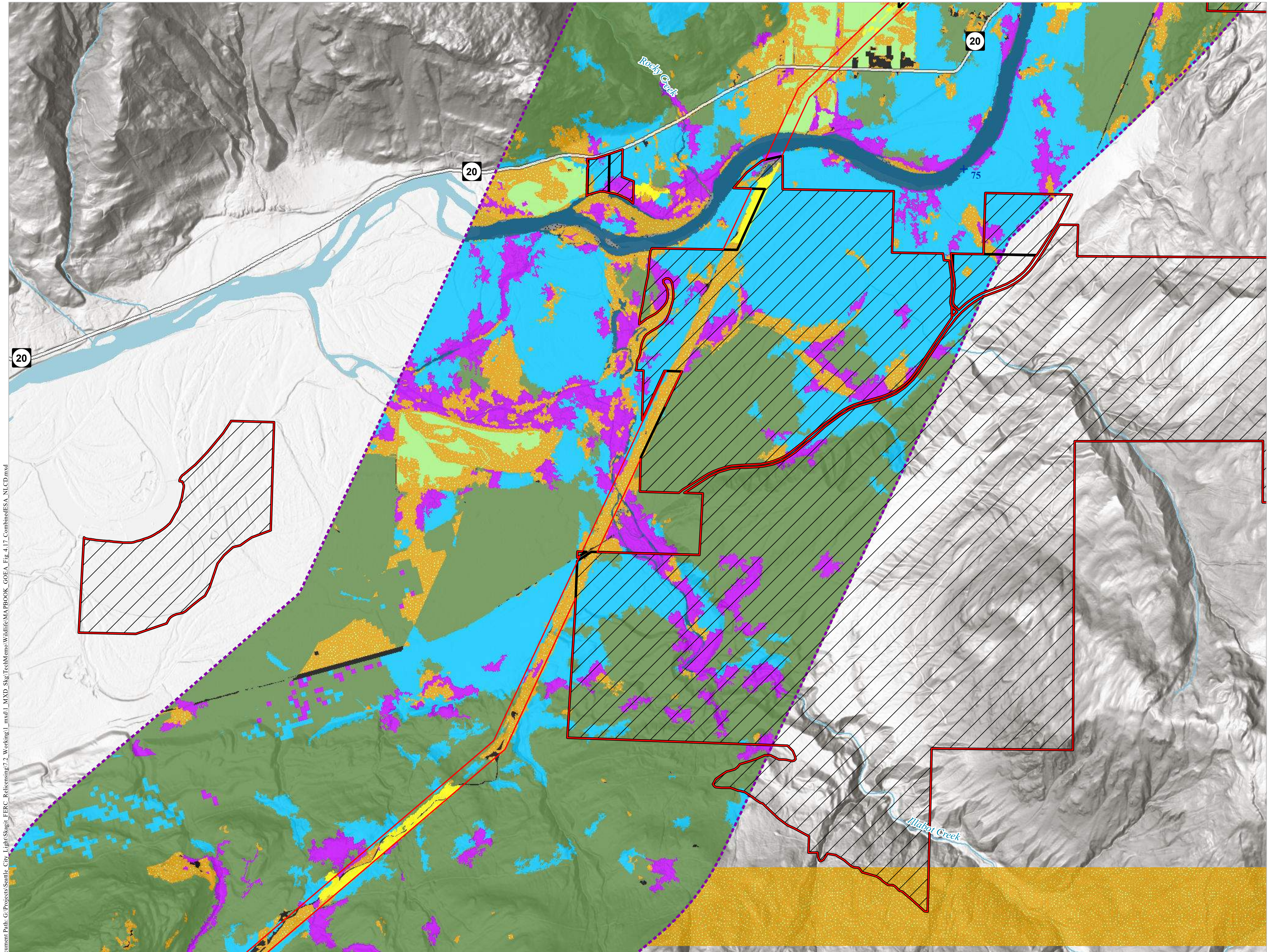

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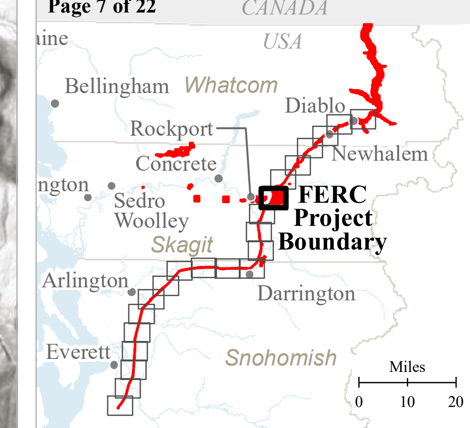

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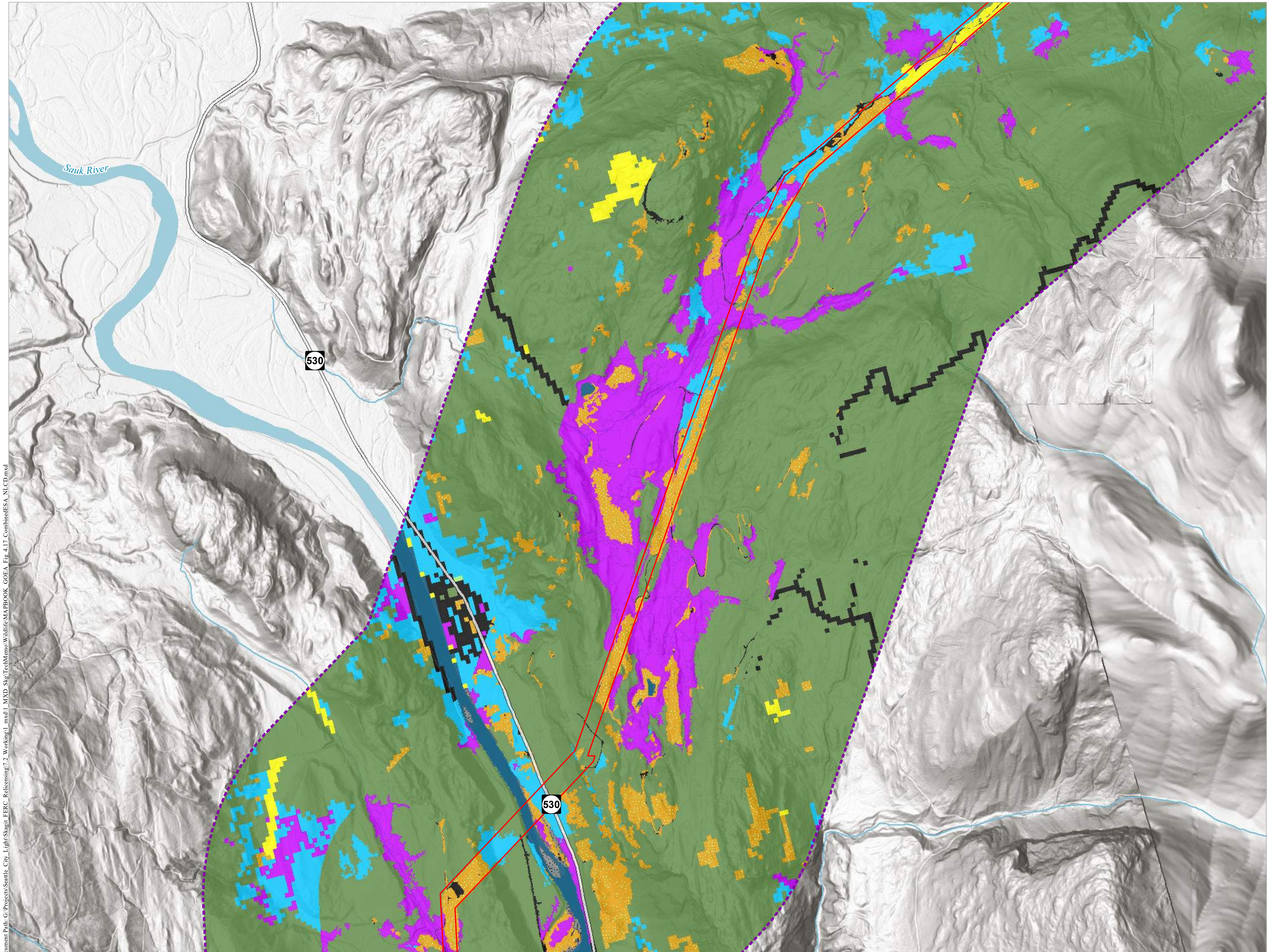

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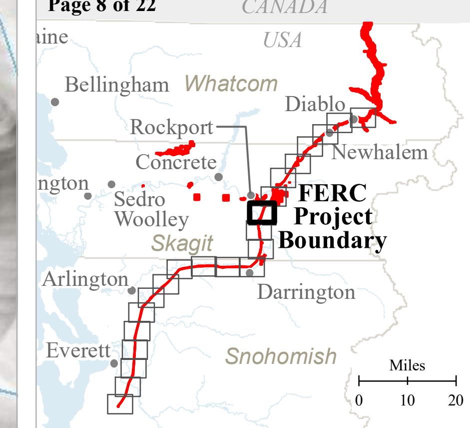

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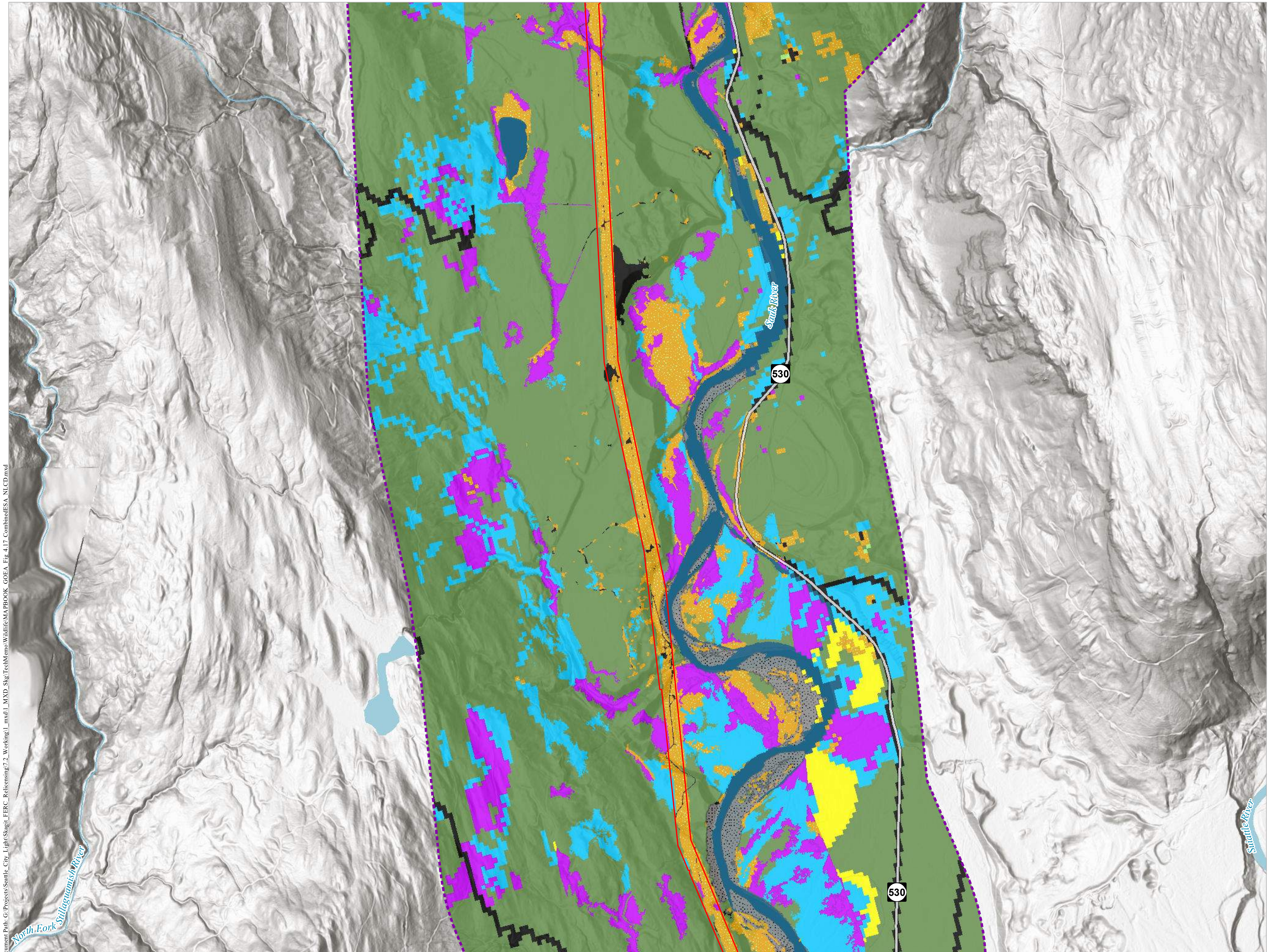

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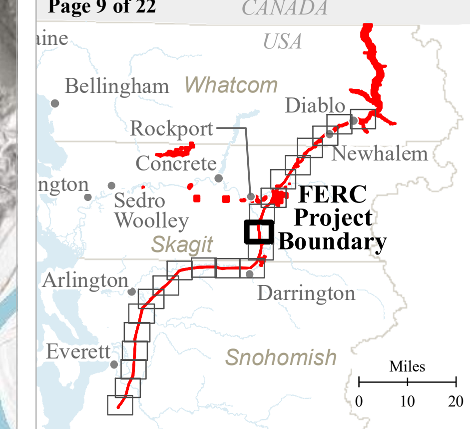

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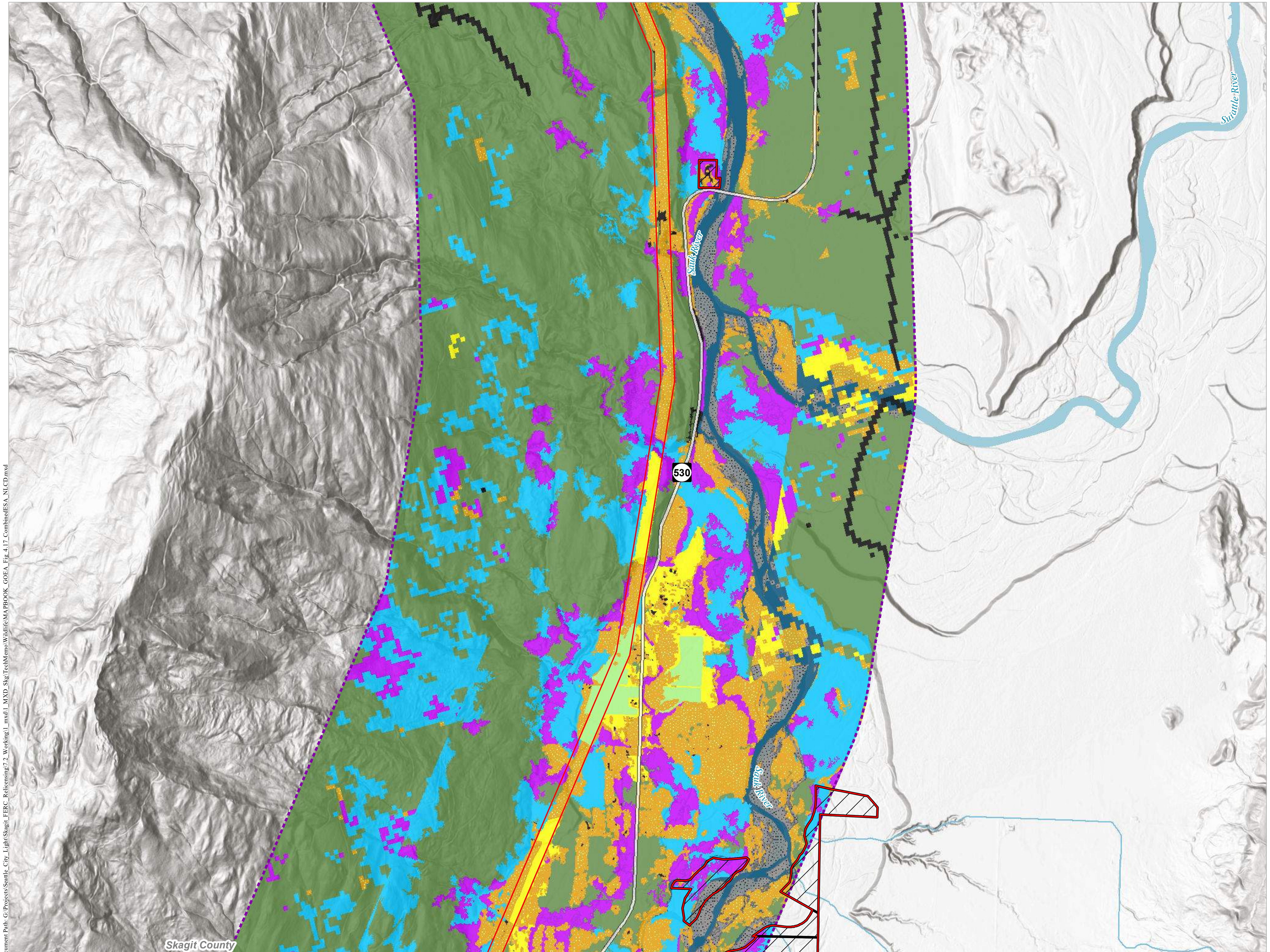

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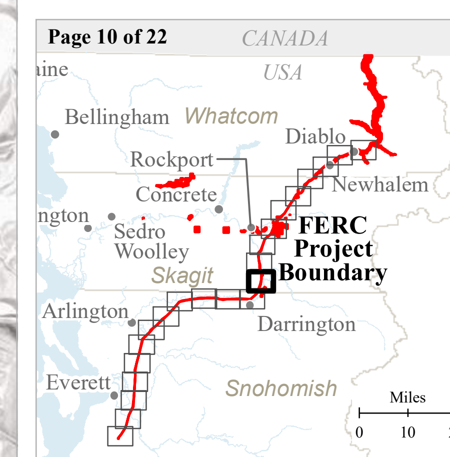
N

0 0.25 0.5 Miles



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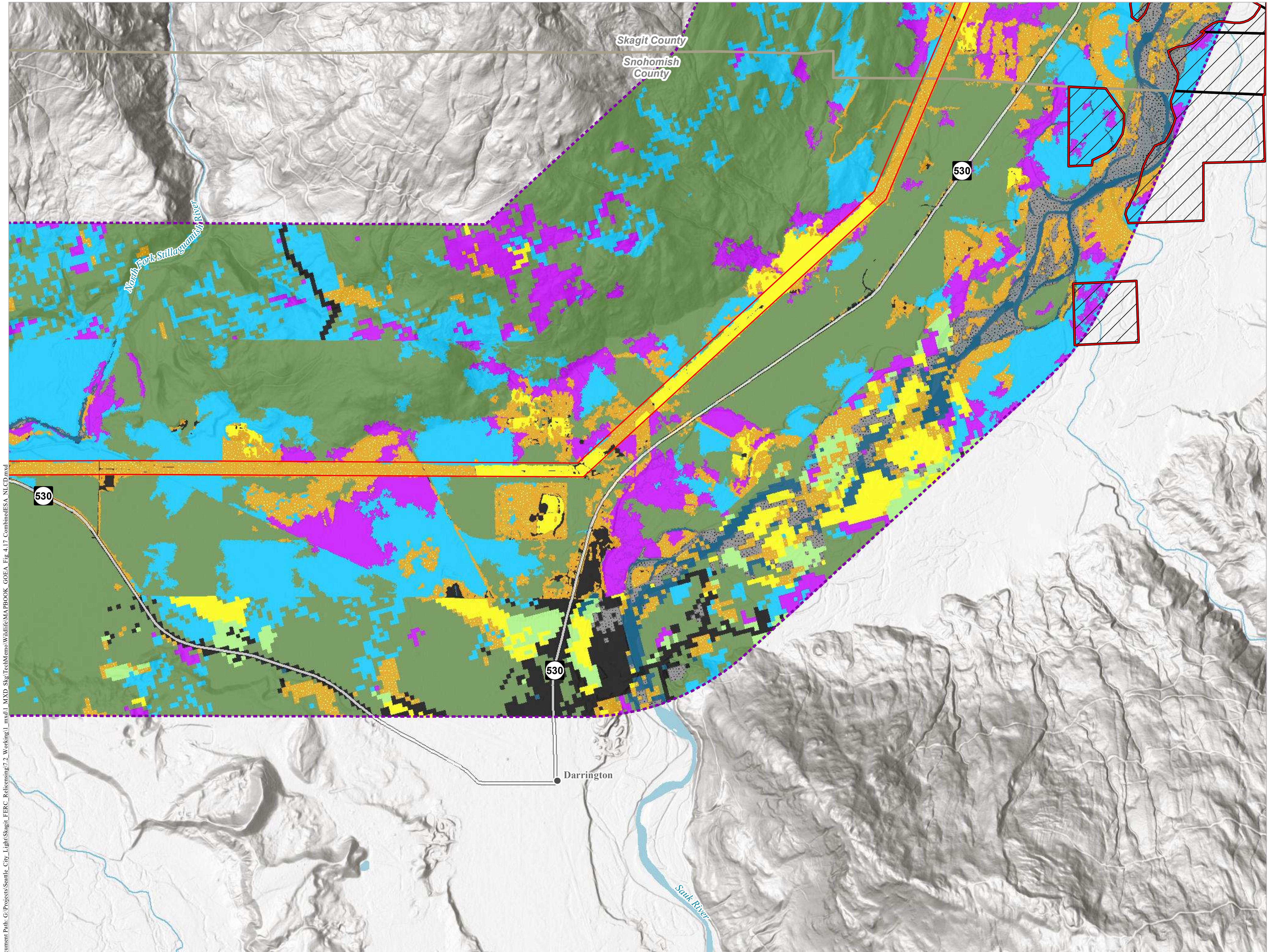

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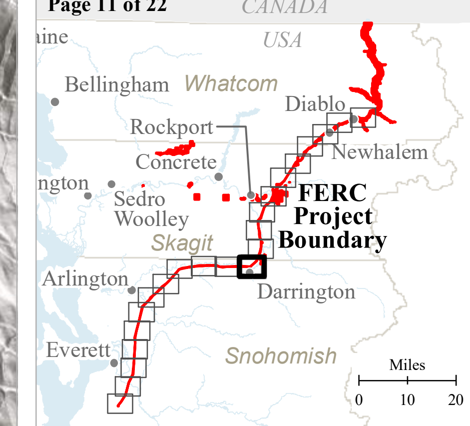

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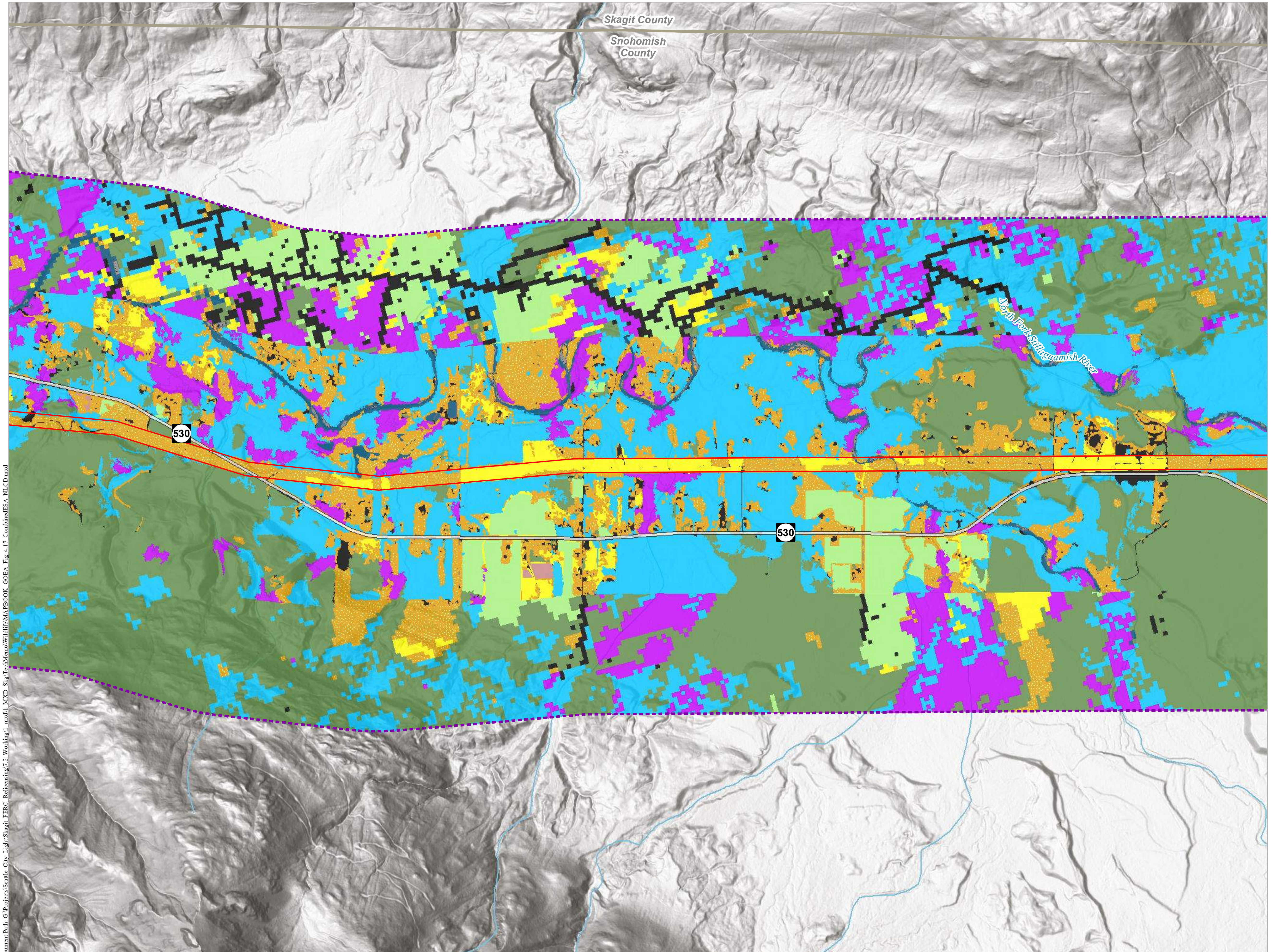

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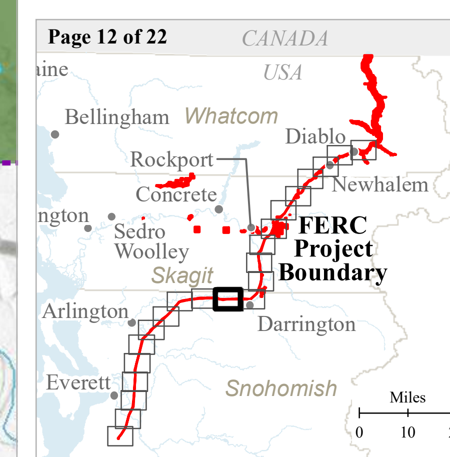

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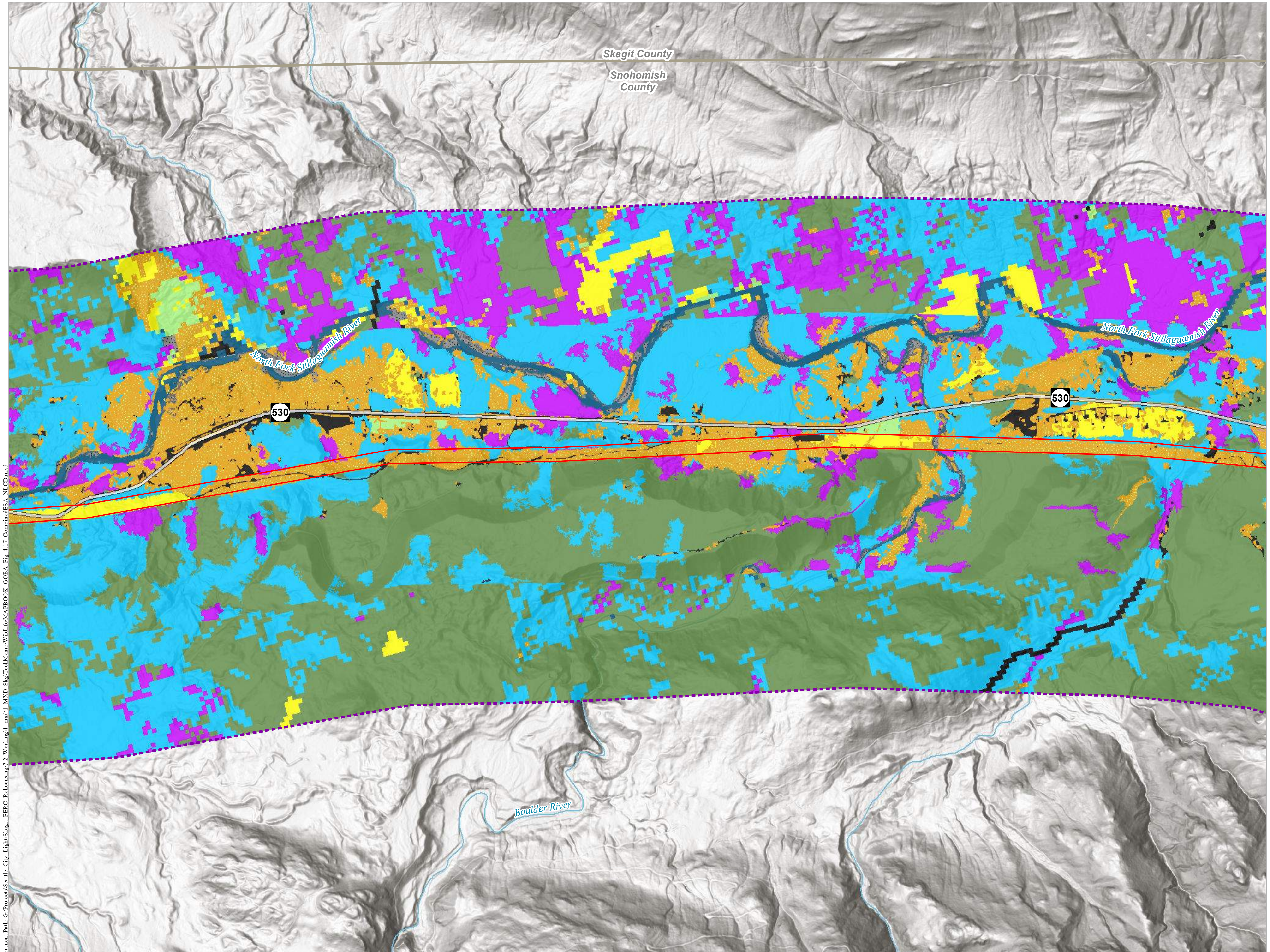

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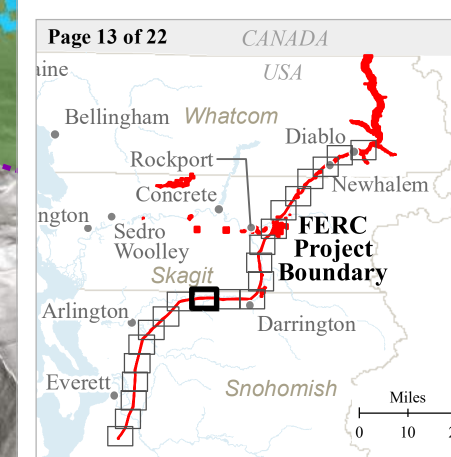
Evergreen Forest
Mixed Forest
Open Water
Developed
Barren Land (Rock/Sand/Clay)

N

0 0.25 0.5 Miles



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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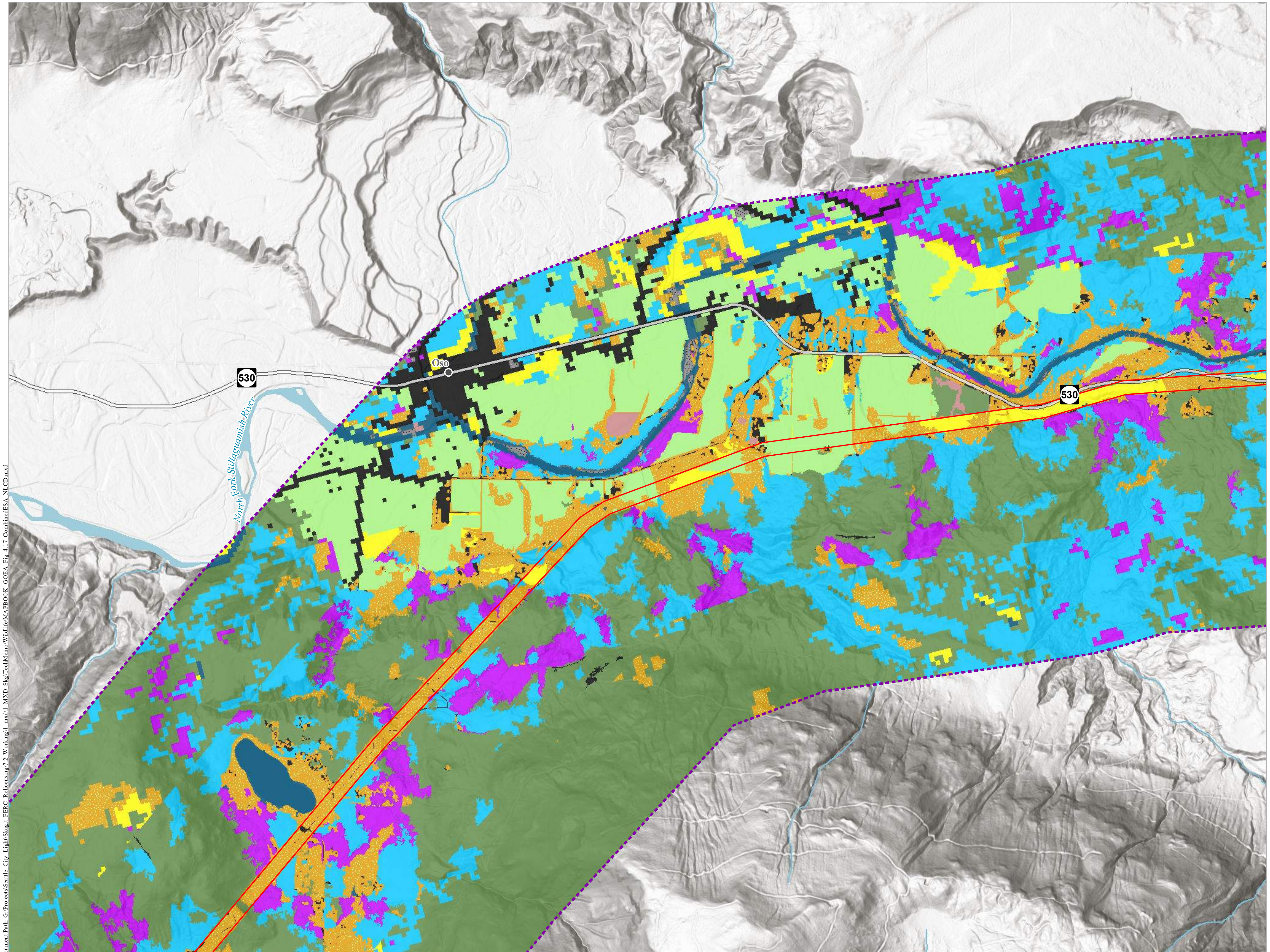


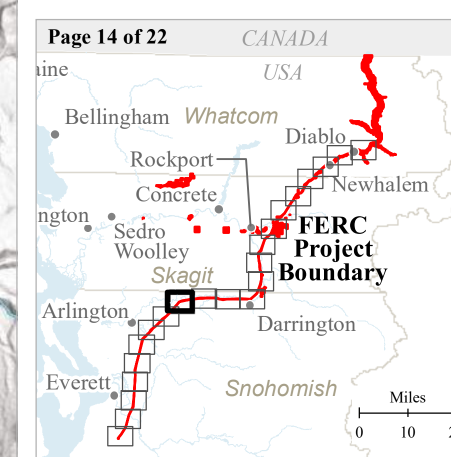
TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

ESA & NLCD Combined Cover Types (City Light 2022, USGS 2021)

Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Shrub/Scrub
Deciduous Forest
Evergreen Forest
Mixed Forest
Open Water
Developed
Barren Land (Rock/Sand/Clay)

N
0 0.25 0.5 Miles



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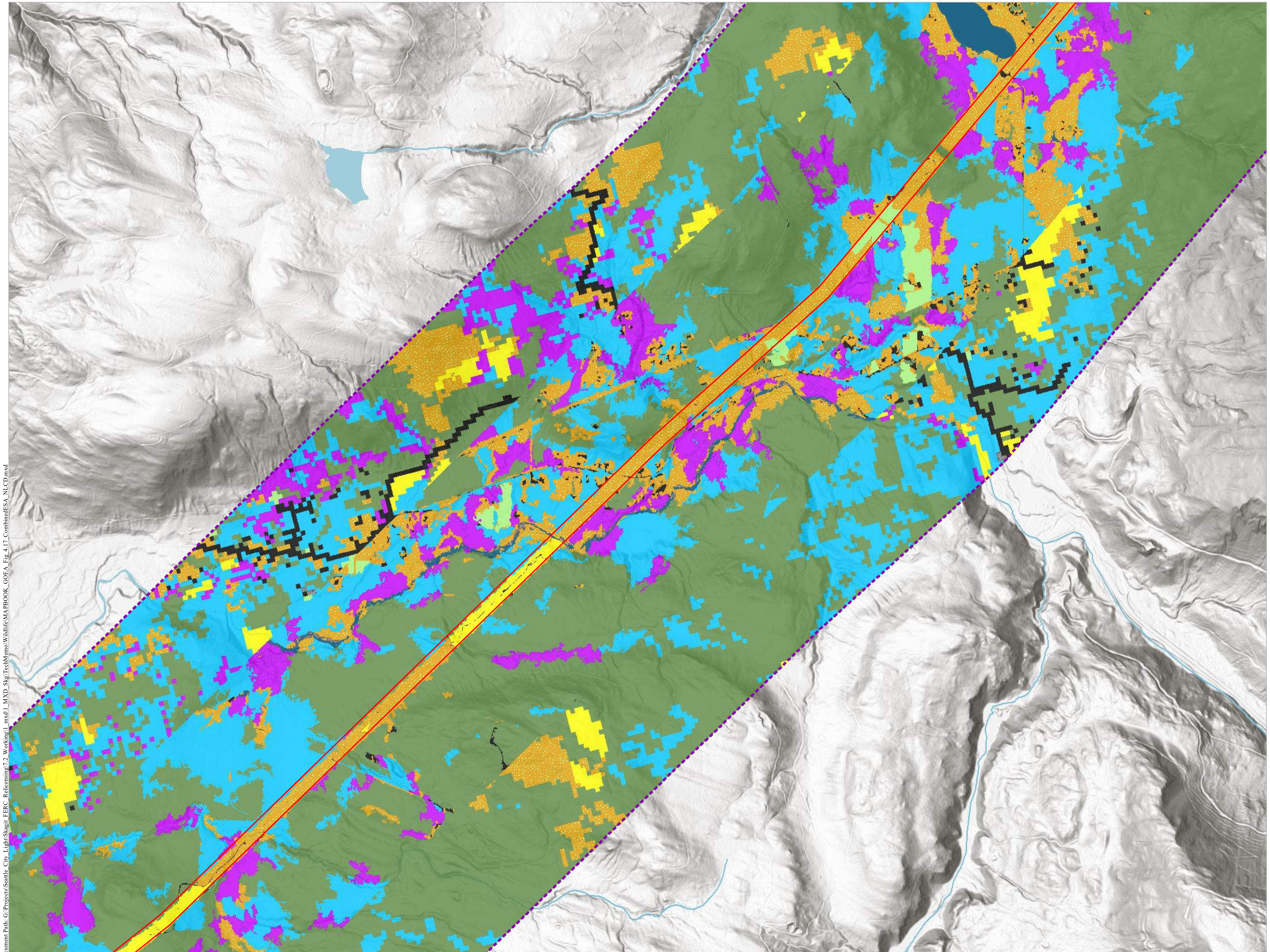

TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

FERC Project Boundary
Streams
Golden Eagle Study Area

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Barren Land (Rock/Sand/Clay)

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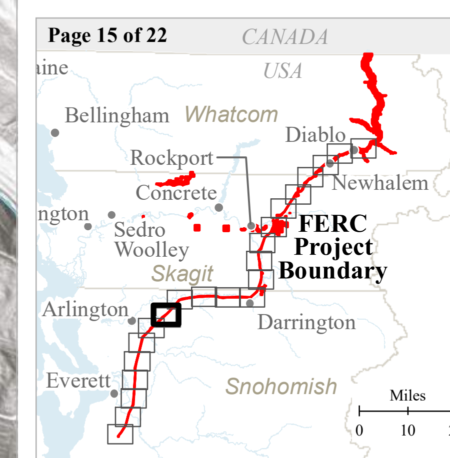

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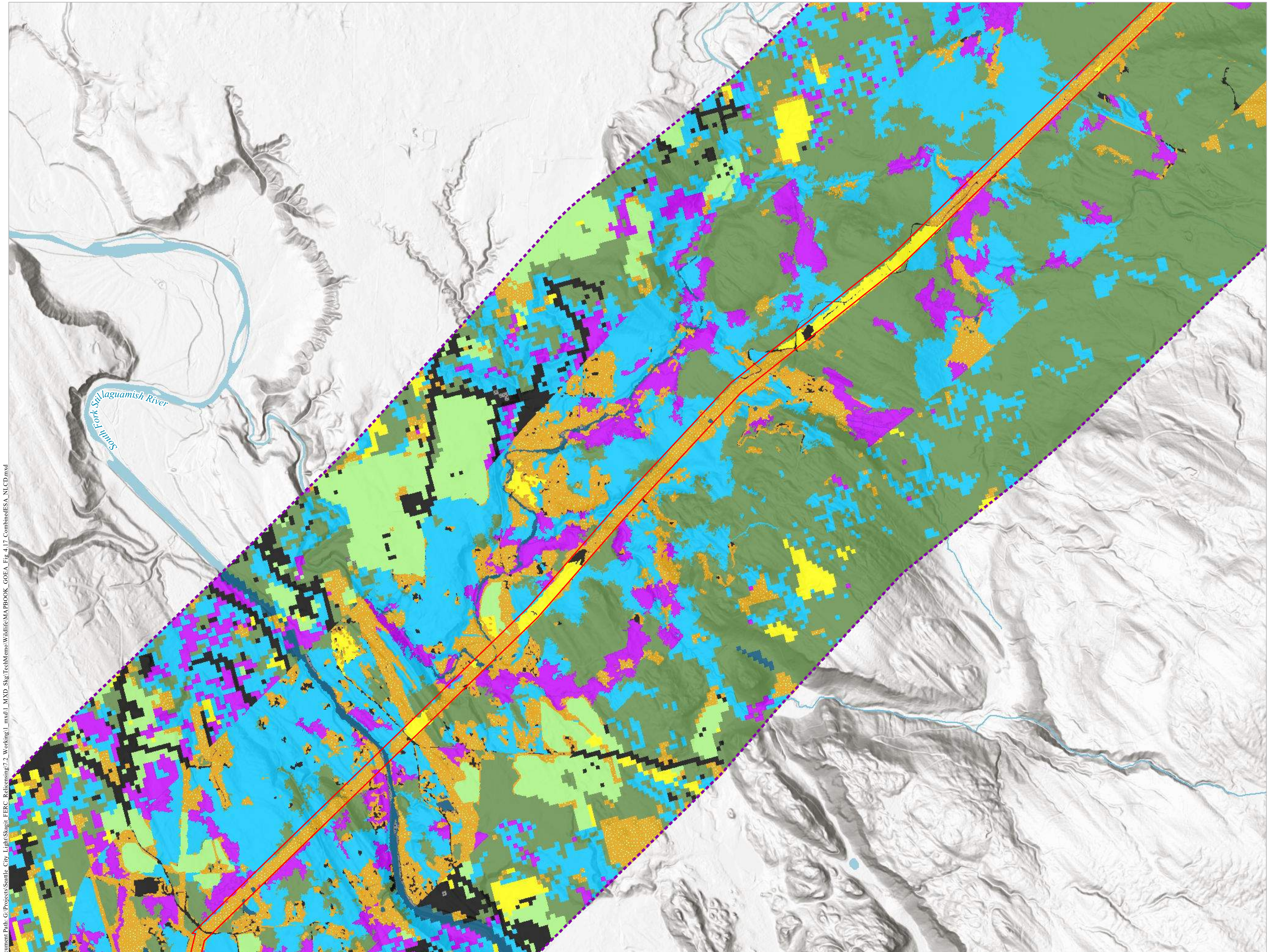

TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

FERC Project Boundary
Streams
Golden Eagle Study Area

ESA & NLCD Combined Cover Types (City Light 2022, USGS 2021)

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Pasture/Hay
Shrub/Scrub
Deciduous Forest
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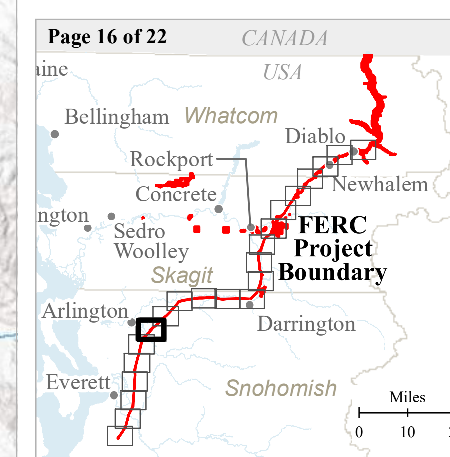

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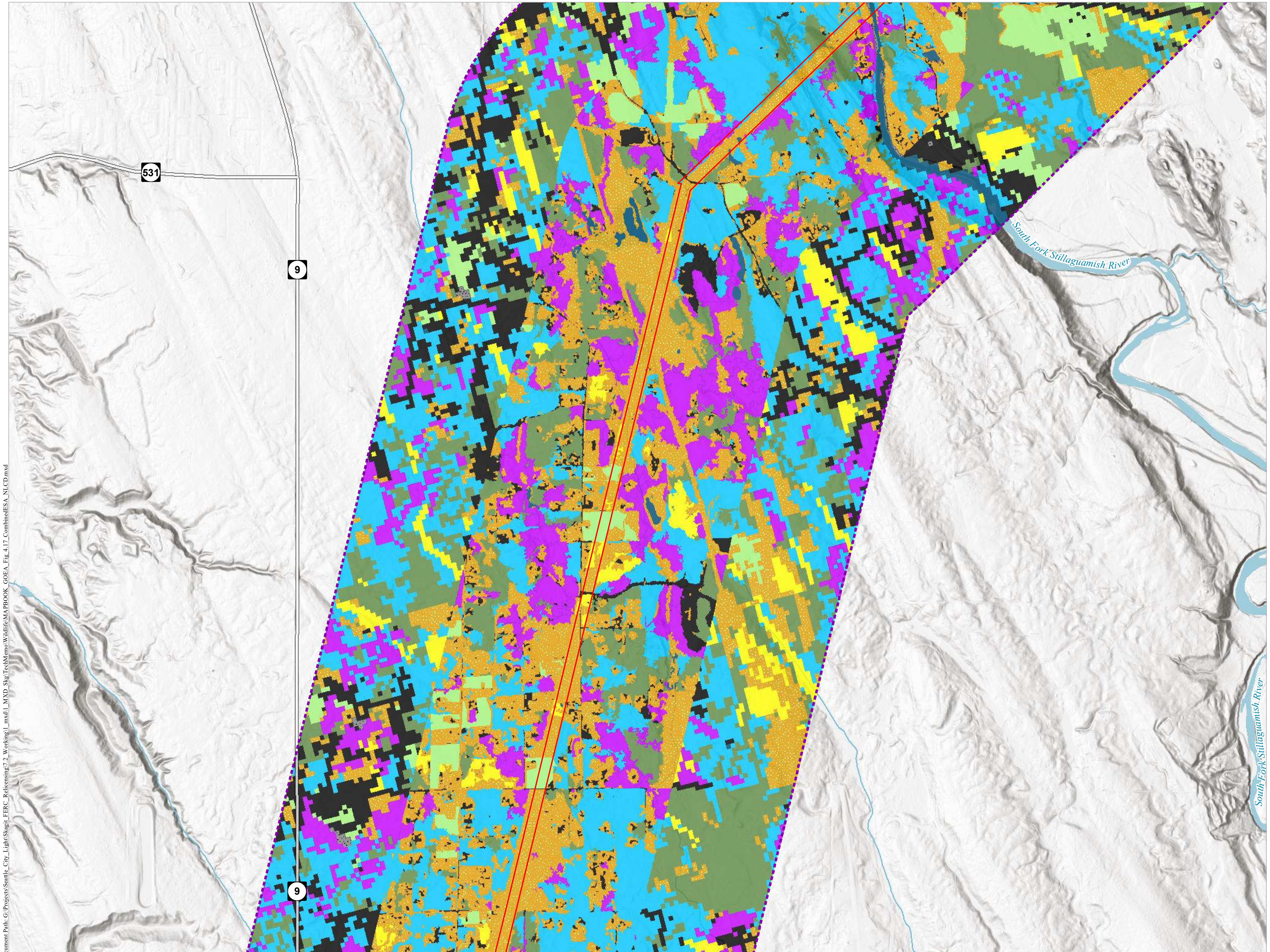

FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

ESA & NLCD Combined Cover Types (City Light 2022, USGS 2021)

Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Shrub/Scrub
Deciduous Forest
Evergreen Forest
Mixed Forest
Open Water
Developed
Barren Land (Rock/Sand/Clay)

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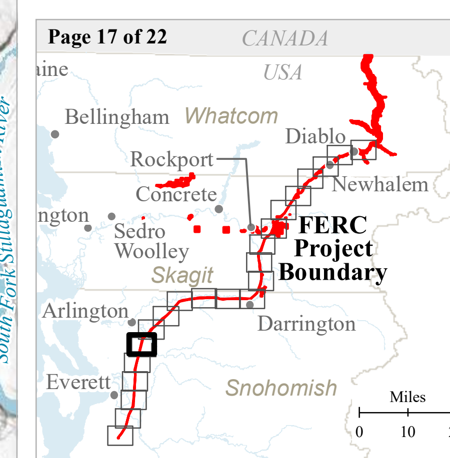

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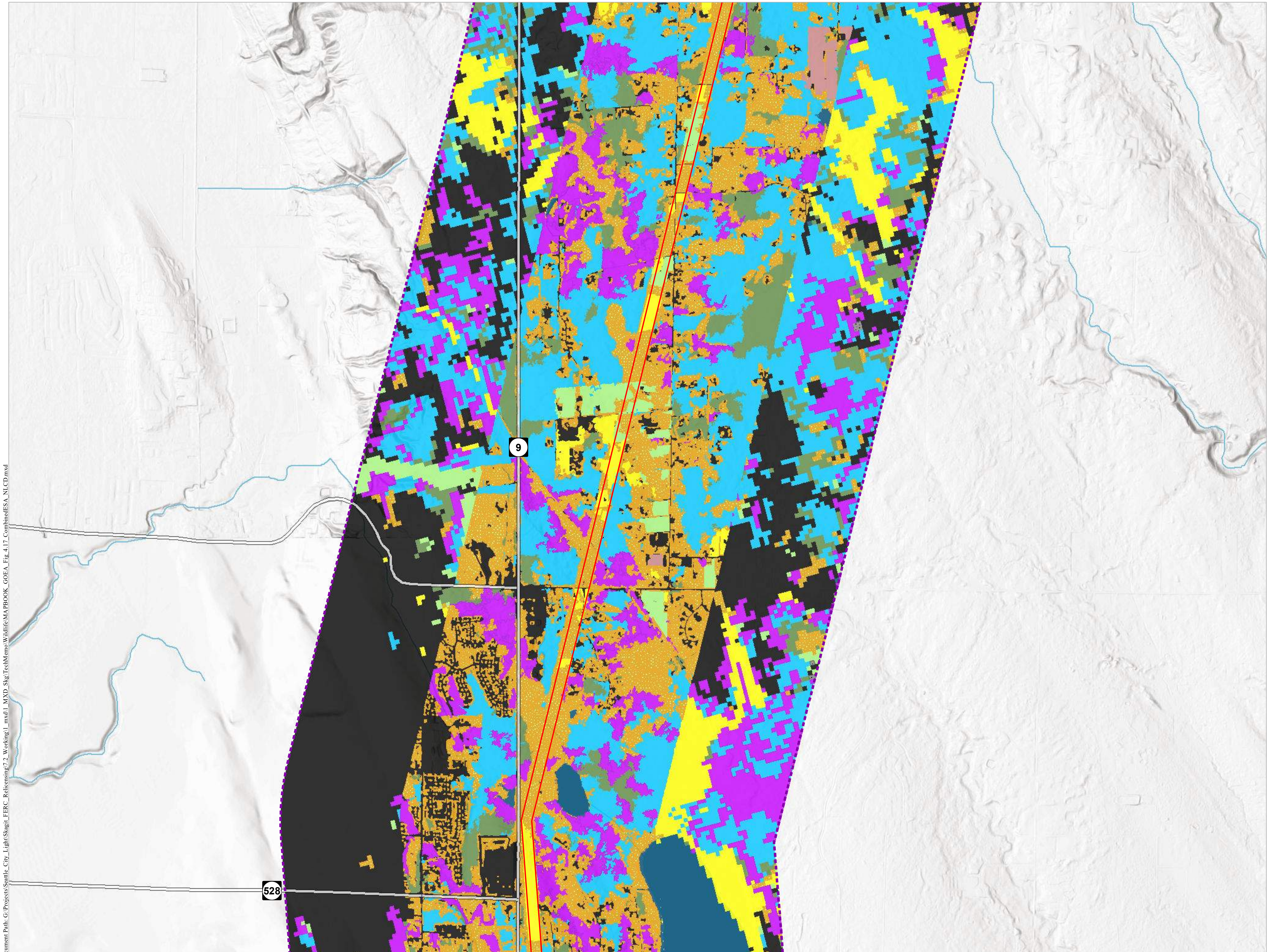

- FERC Project Boundary
- Streams
- Secondary Highway
- Golden Eagle Study Area

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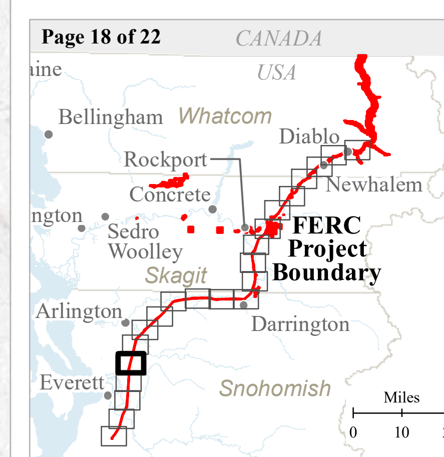

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FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

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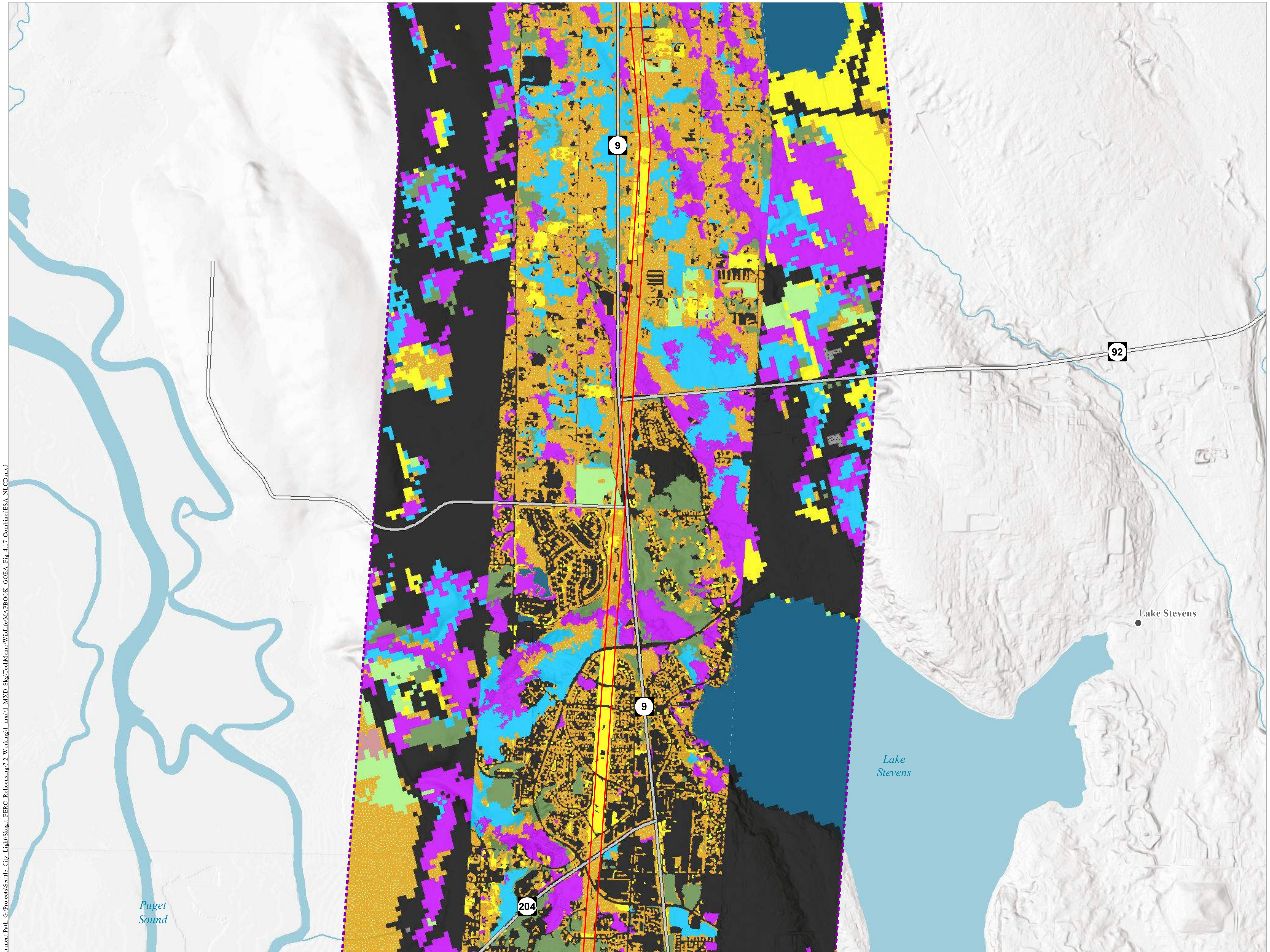

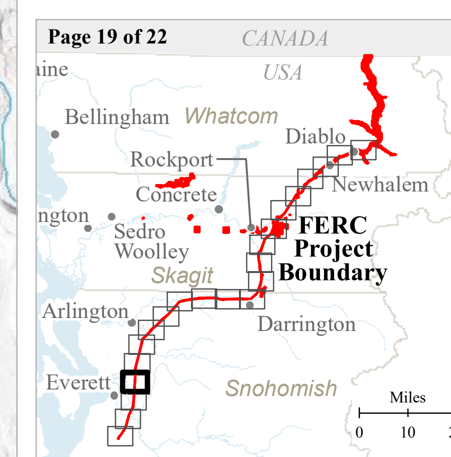

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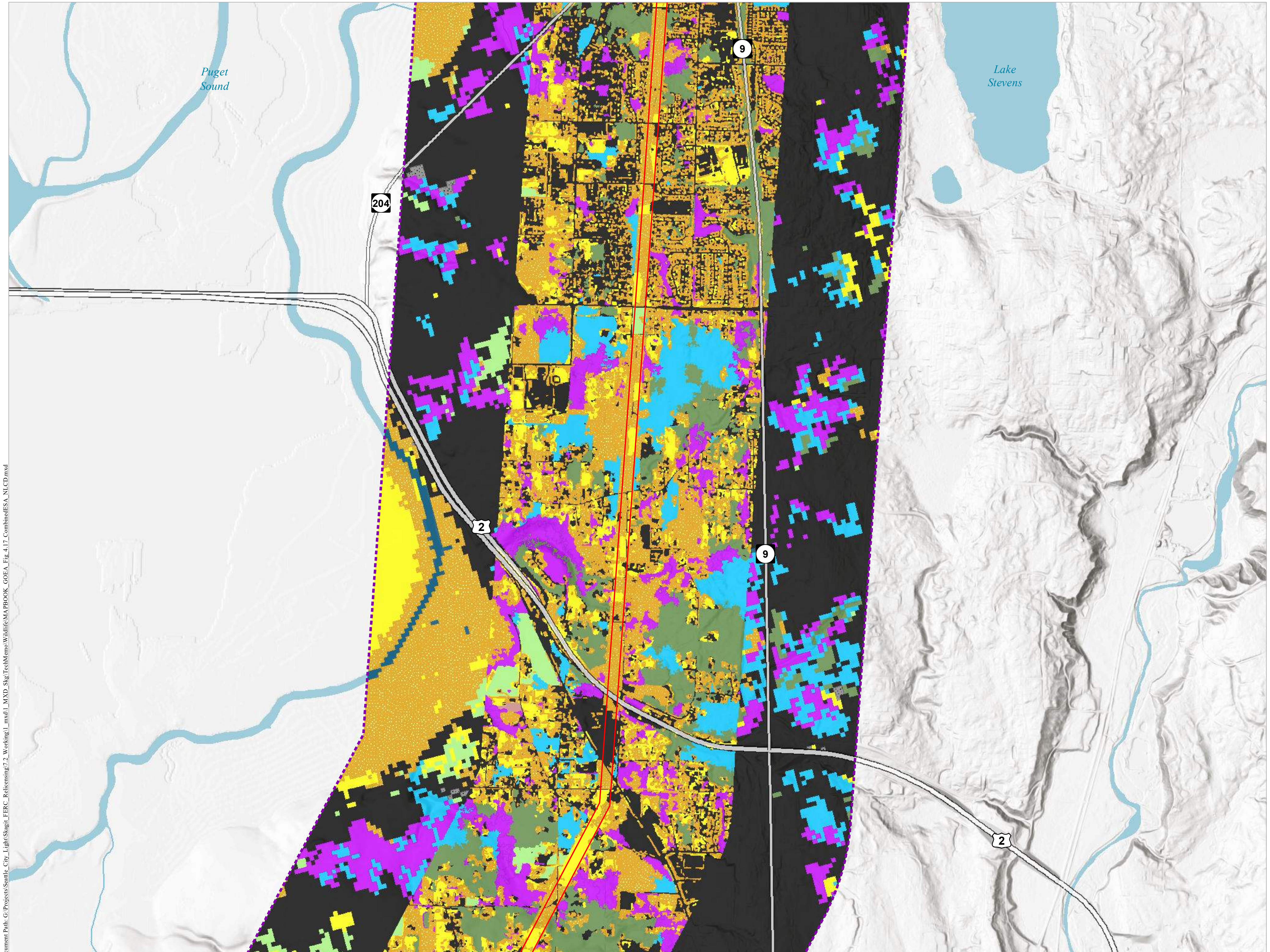
TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)



- FERC Project Boundary
- Streams
- Primary Highway
- Secondary Highway
- Golden Eagle Study Area

ESA & NLCD Combined Cover Types (City Light 2022, USGS 2021)

- Grassland/Herbaceous
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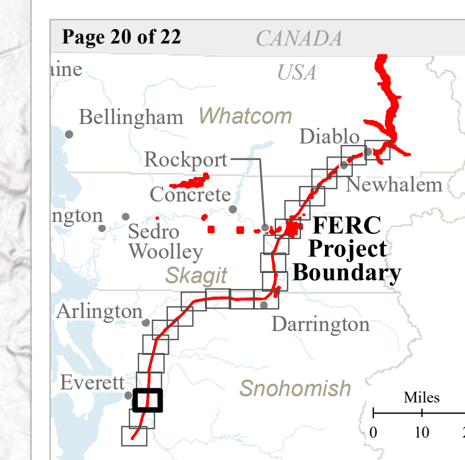
- Open Water
- Developed
- Barren Land (Rock/Sand/Clay)

0 0.25 0.5 Miles



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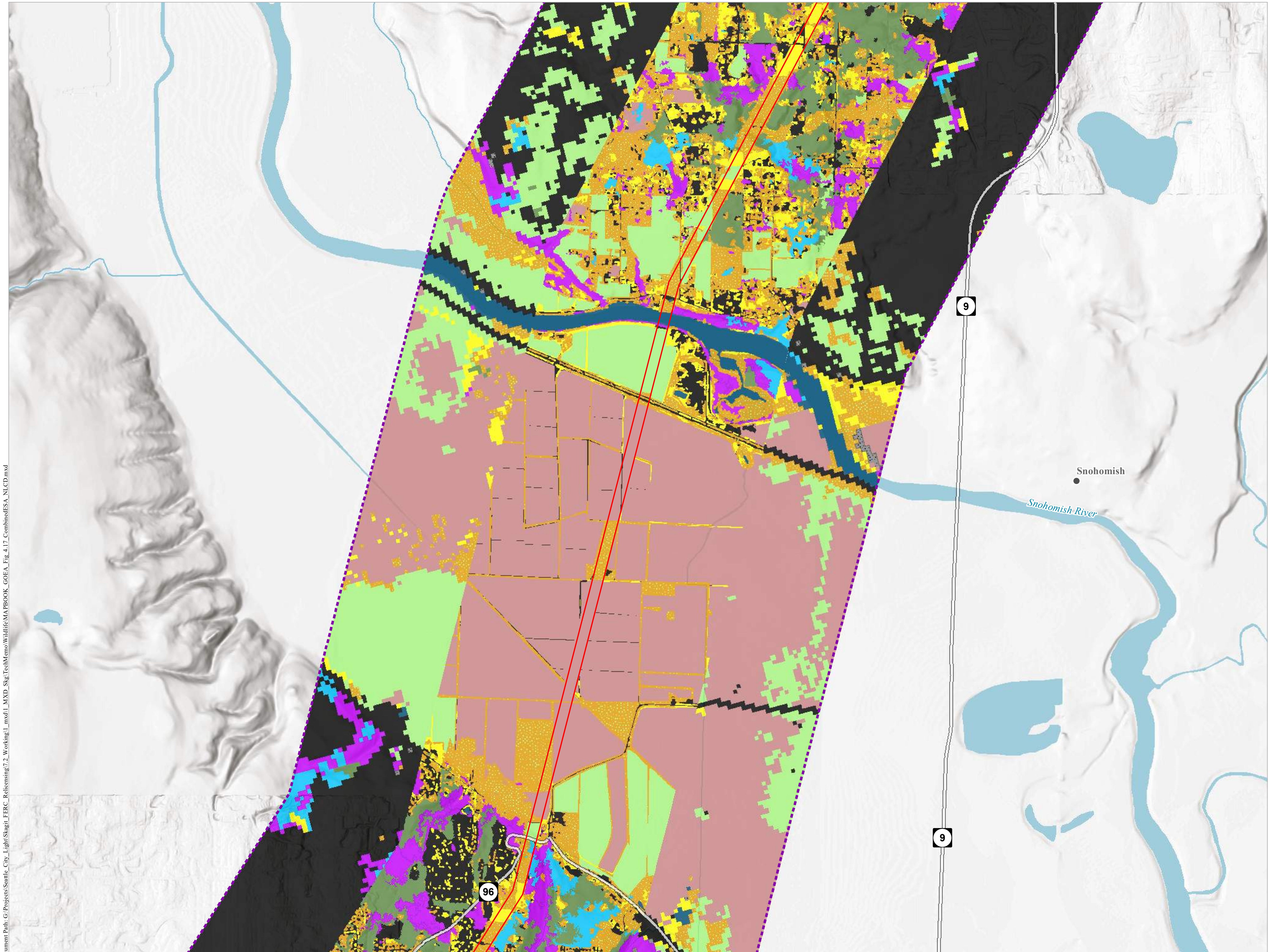

TR-06 COMBINED VEGETATION AND LAND COVER MAPPING IN THE STUDY AREA (1:24,000 SCALE)

FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

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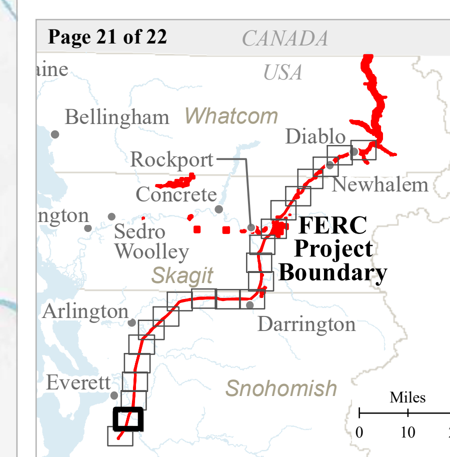
0 0.25 0.5 Miles



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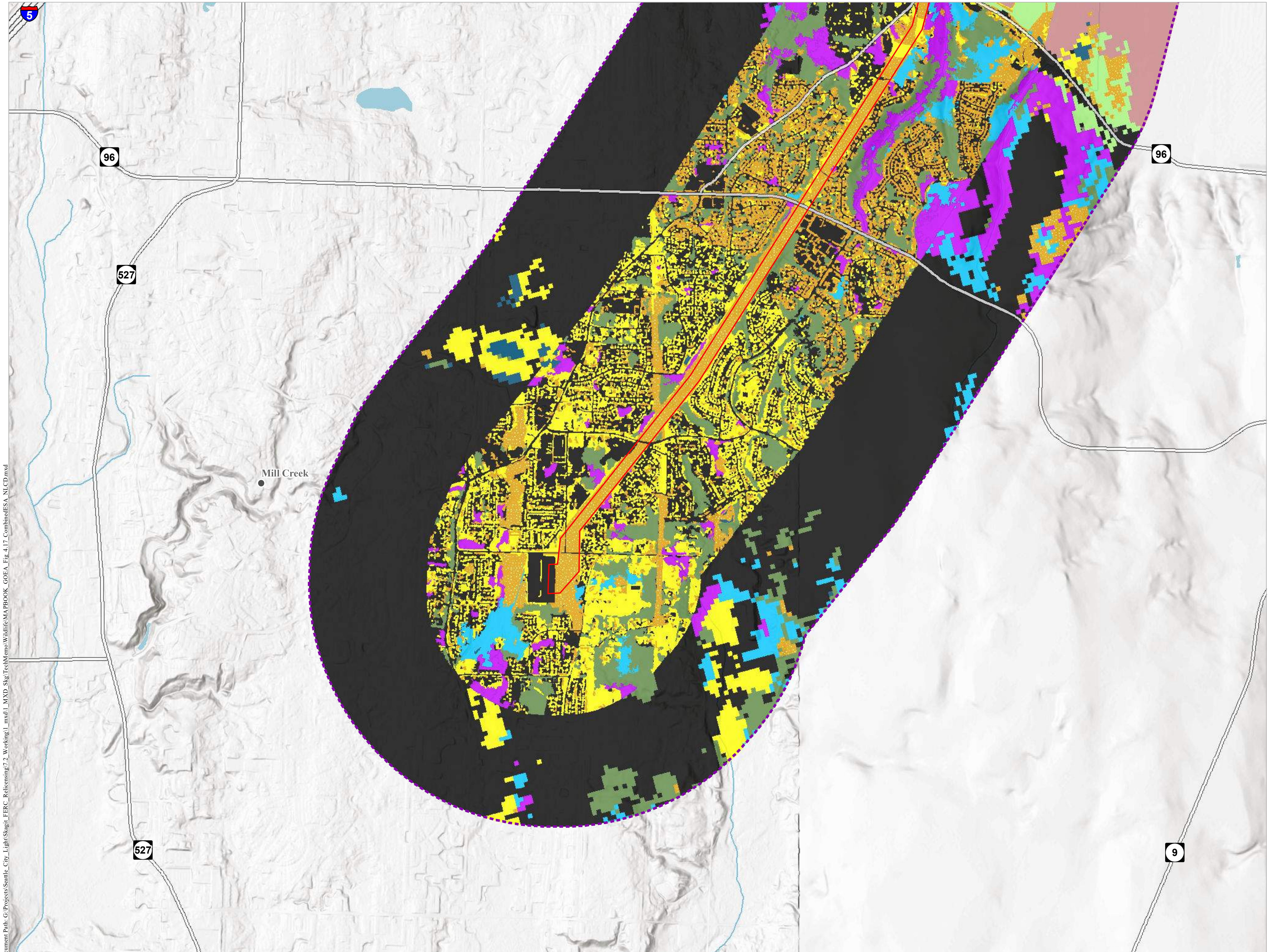

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FERC Project Boundary
Streams
Primary Highway
Secondary Highway
Golden Eagle Study Area

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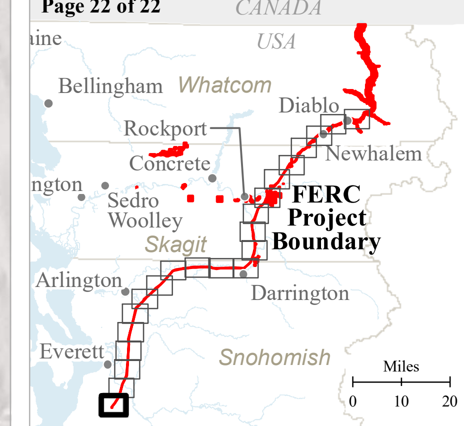
Shrub/Scrub
Deciduous Forest
Evergreen Forest
Mixed Forest
Open Water
Developed
Barren Land (Rock/Sand/Clay)

N

0 0.25 0.5 Miles



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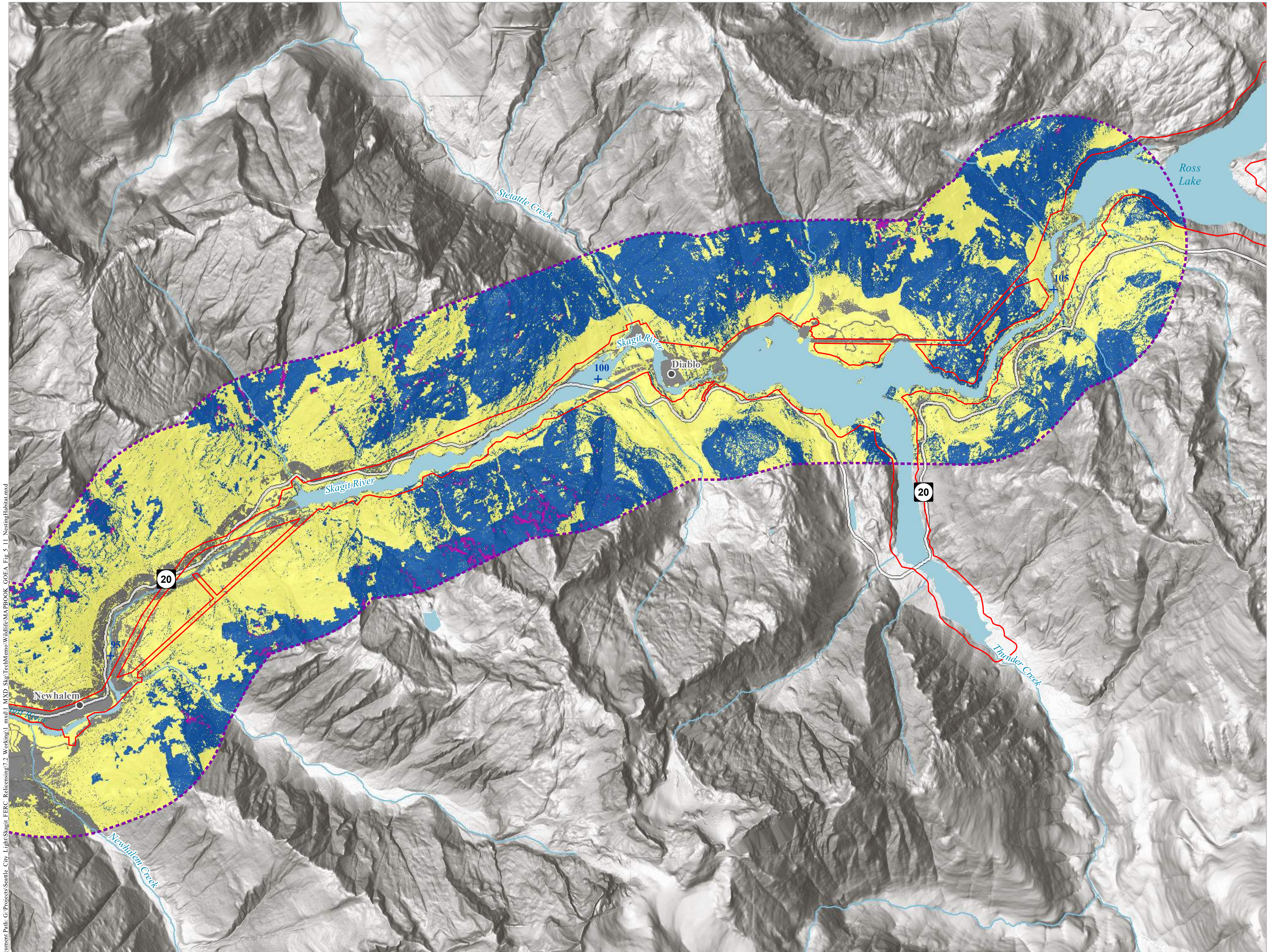
GOLDEN EAGLE HABITAT ANALYSIS DRAFT REPORT

ATTACHMENT B

GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA MAPBOOK



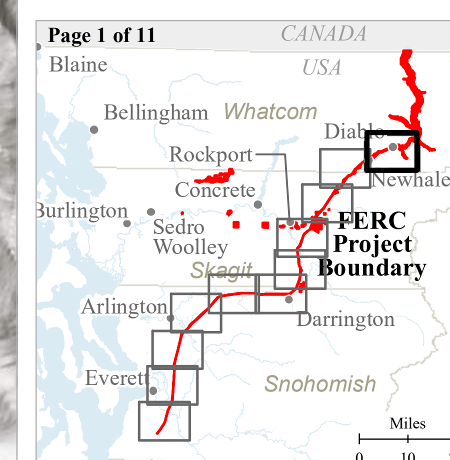
TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

- FERC Project Boundary
- Project River Miles (PRM)
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality Habitat

0 0.5 1 Miles



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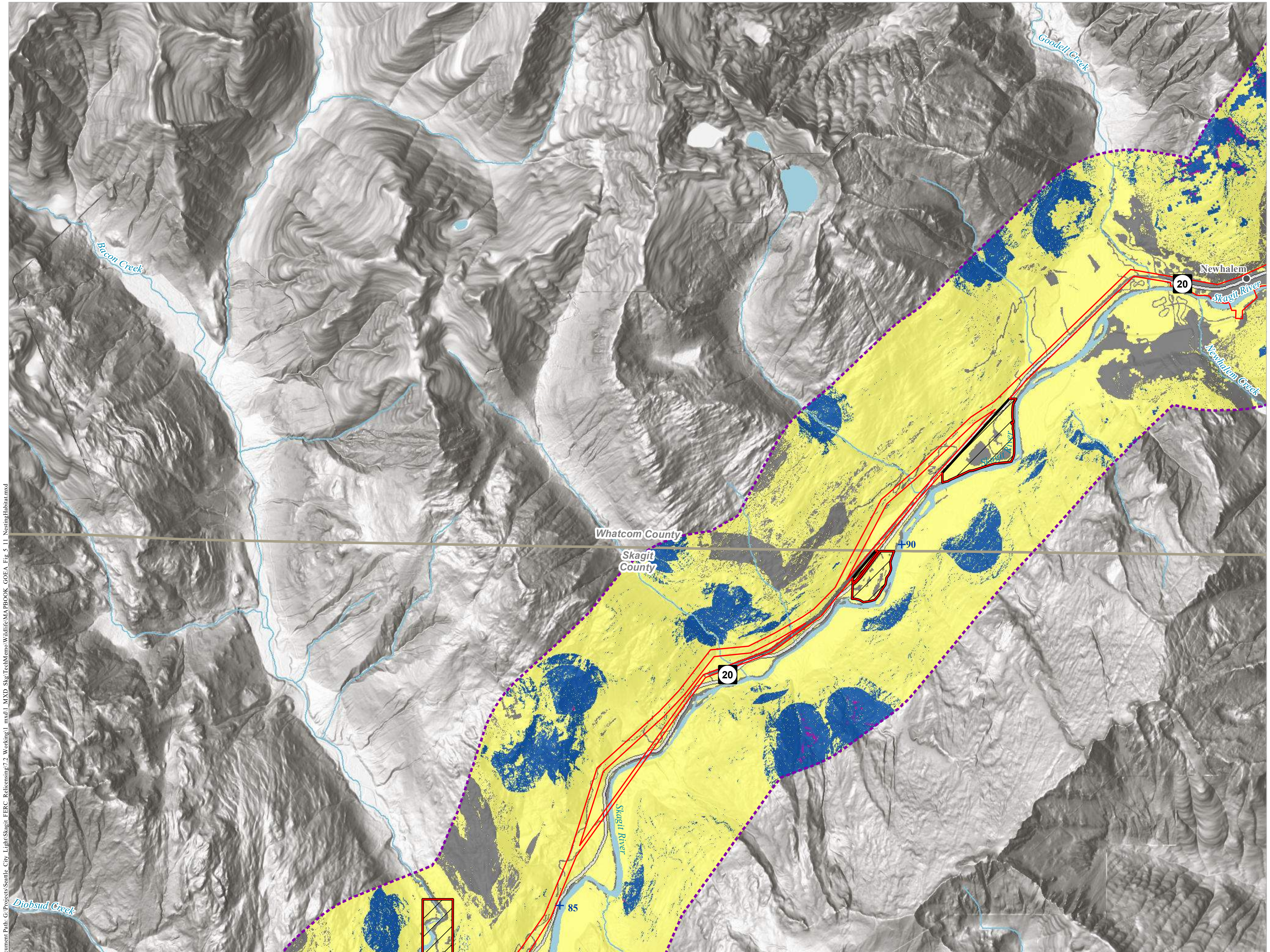
TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

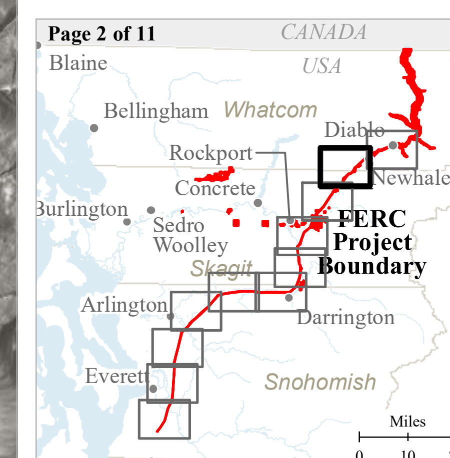


FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality Habitat

0 0.5 1 Miles



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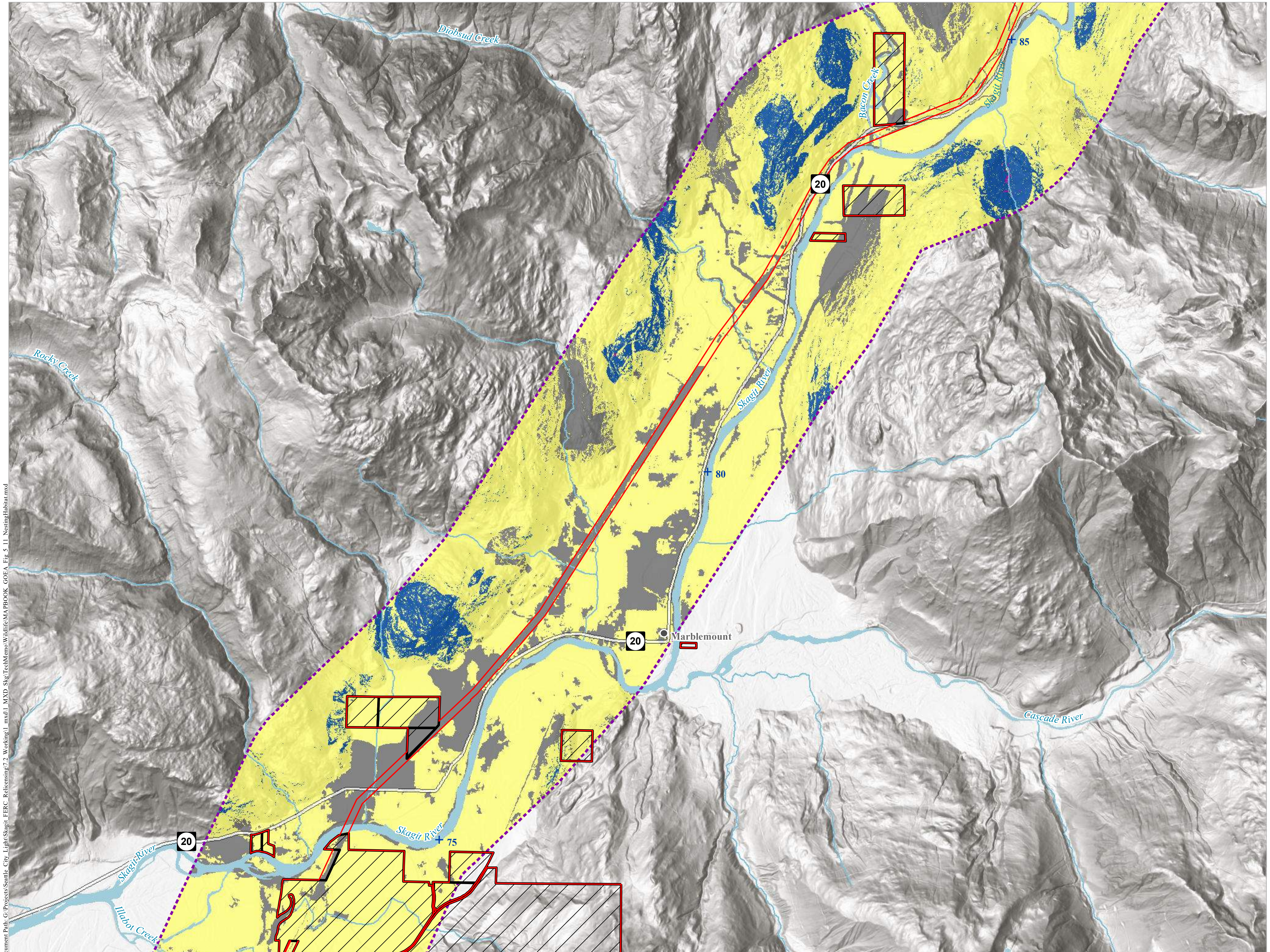


TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

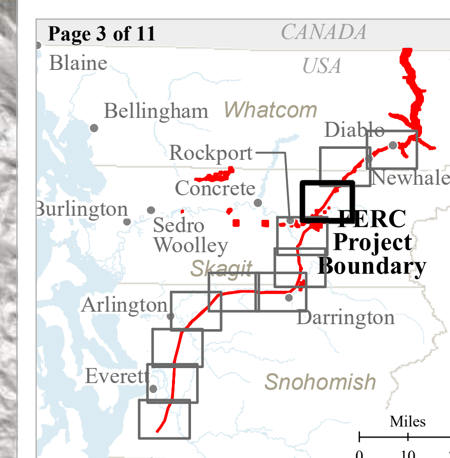
- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality Habitat

0 0.5 1 Miles

Page 3 of 11



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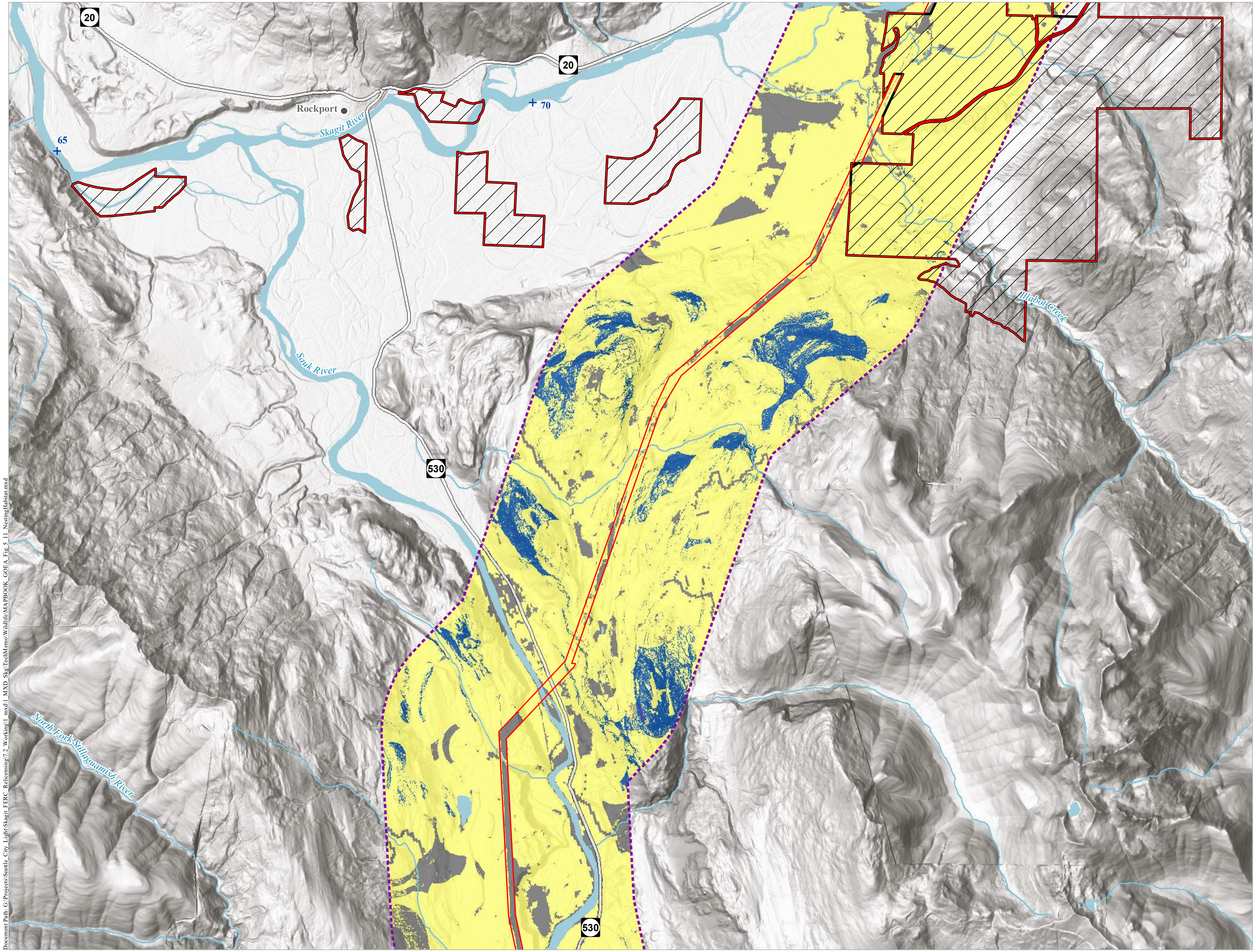
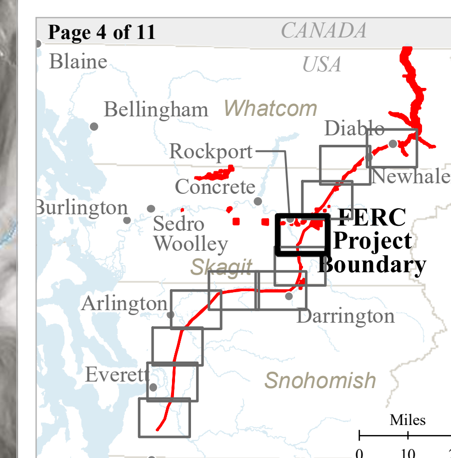


TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality Habitat



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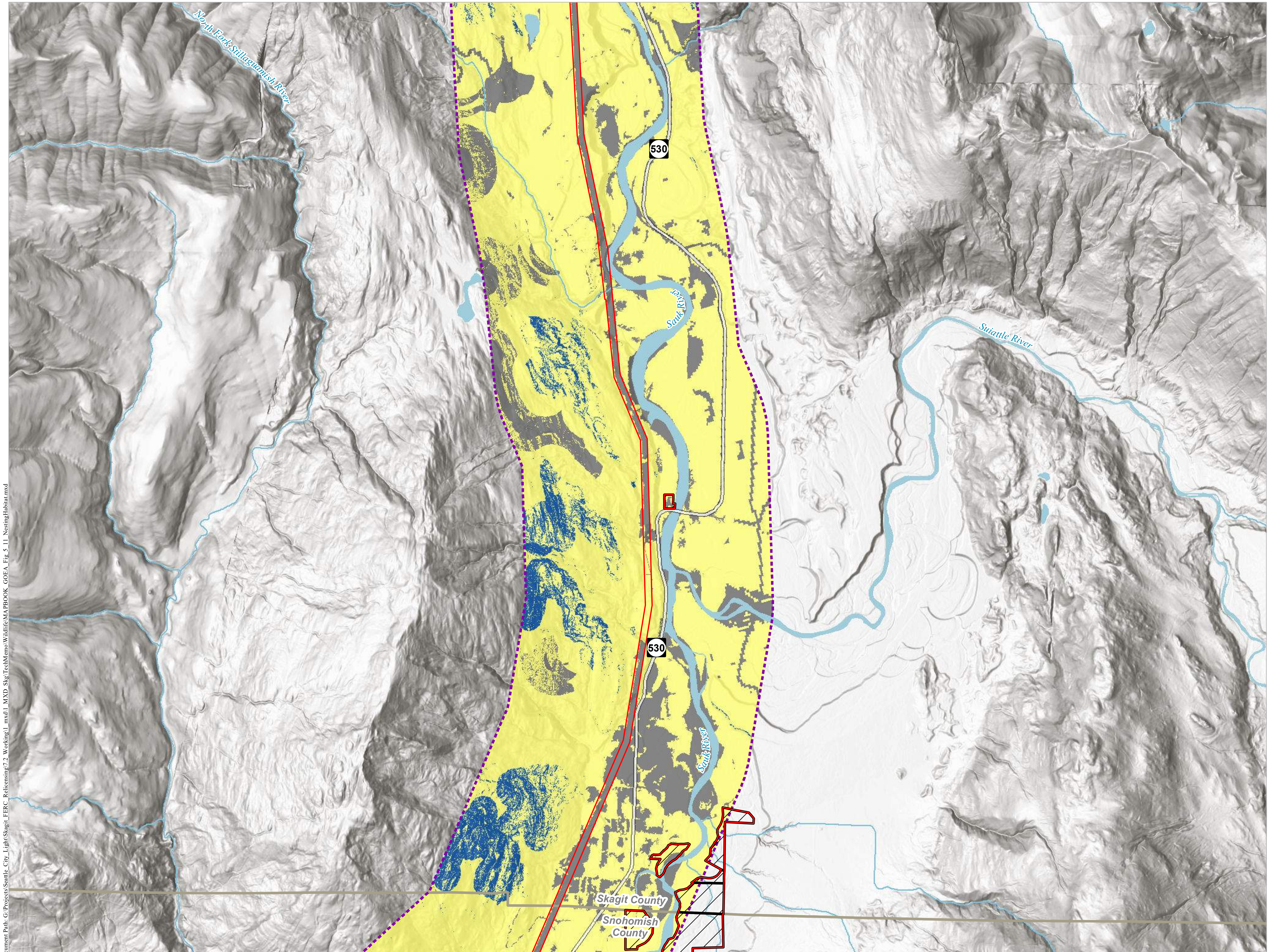
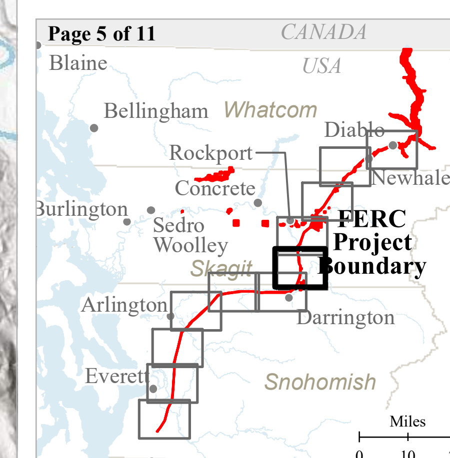


- FERC Project Boundary
- Mitigation Parcel
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat



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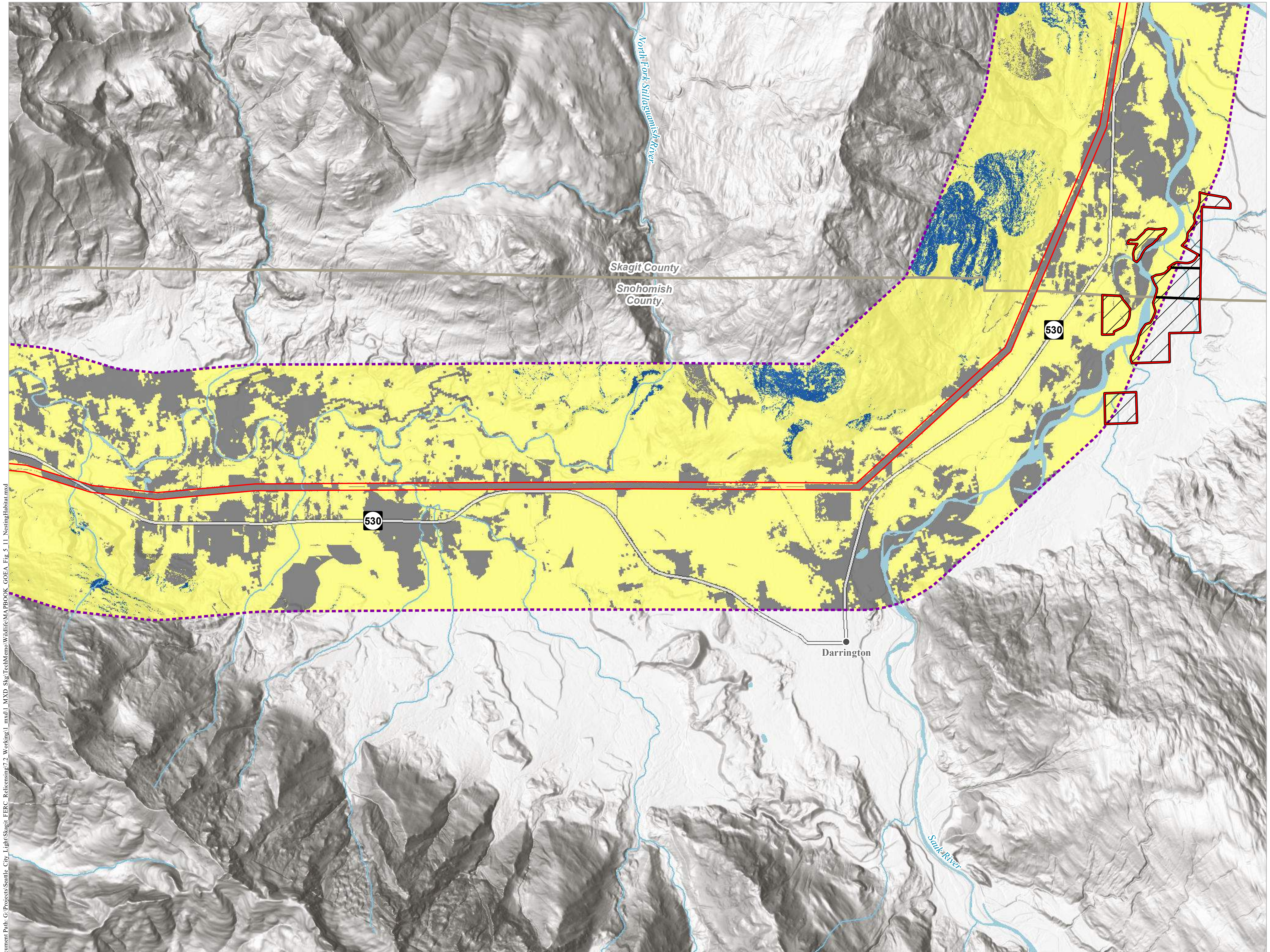

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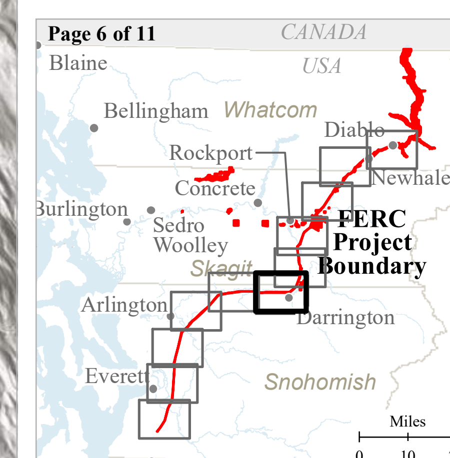
- FERC Project Boundary
- Mitigation Parcel
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat

N

0 0.5 1 Miles



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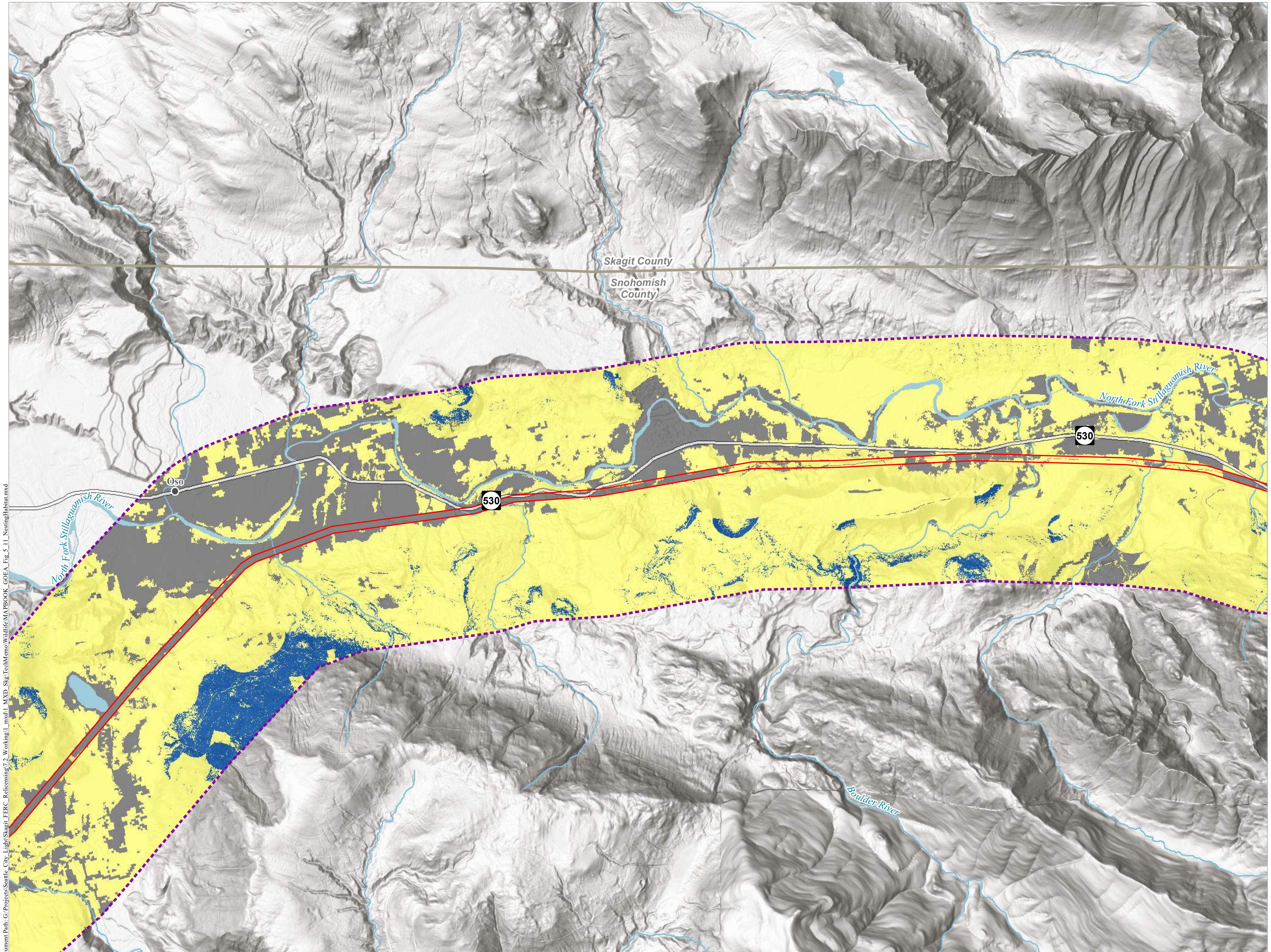
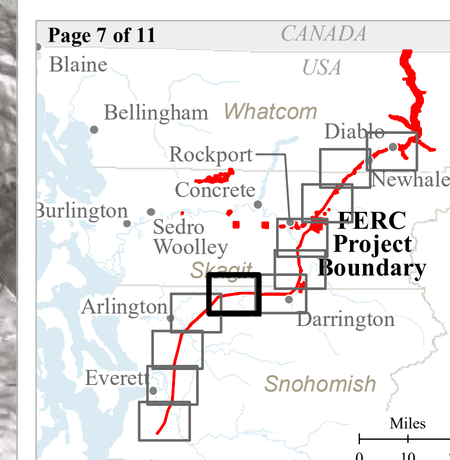


FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat

0 0.5 1 Miles



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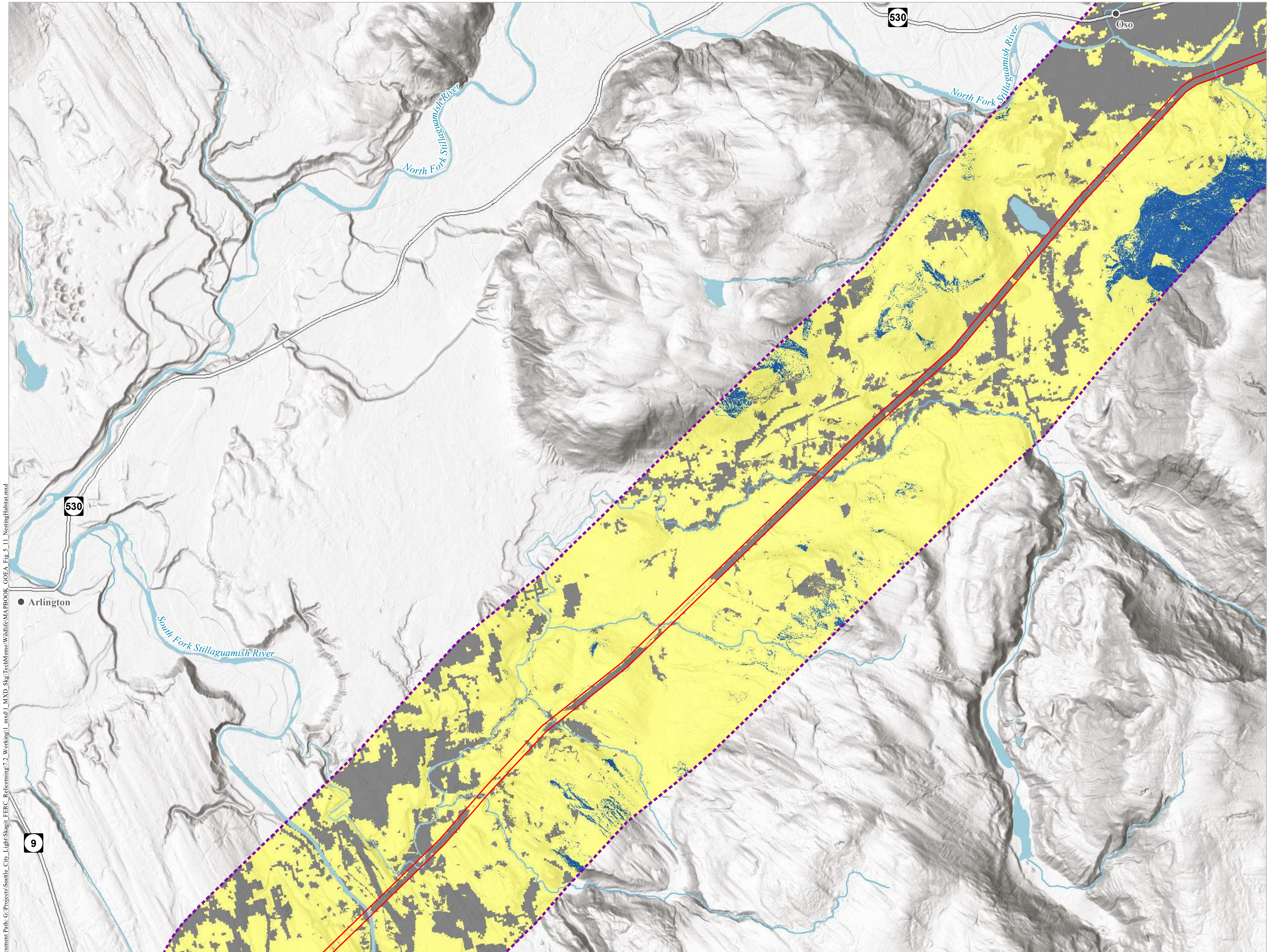
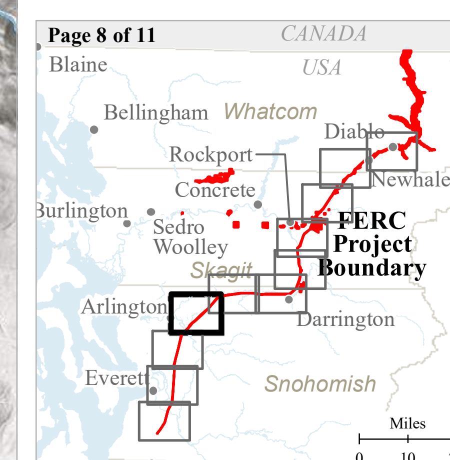
TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

- FERC Project Boundary
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat





Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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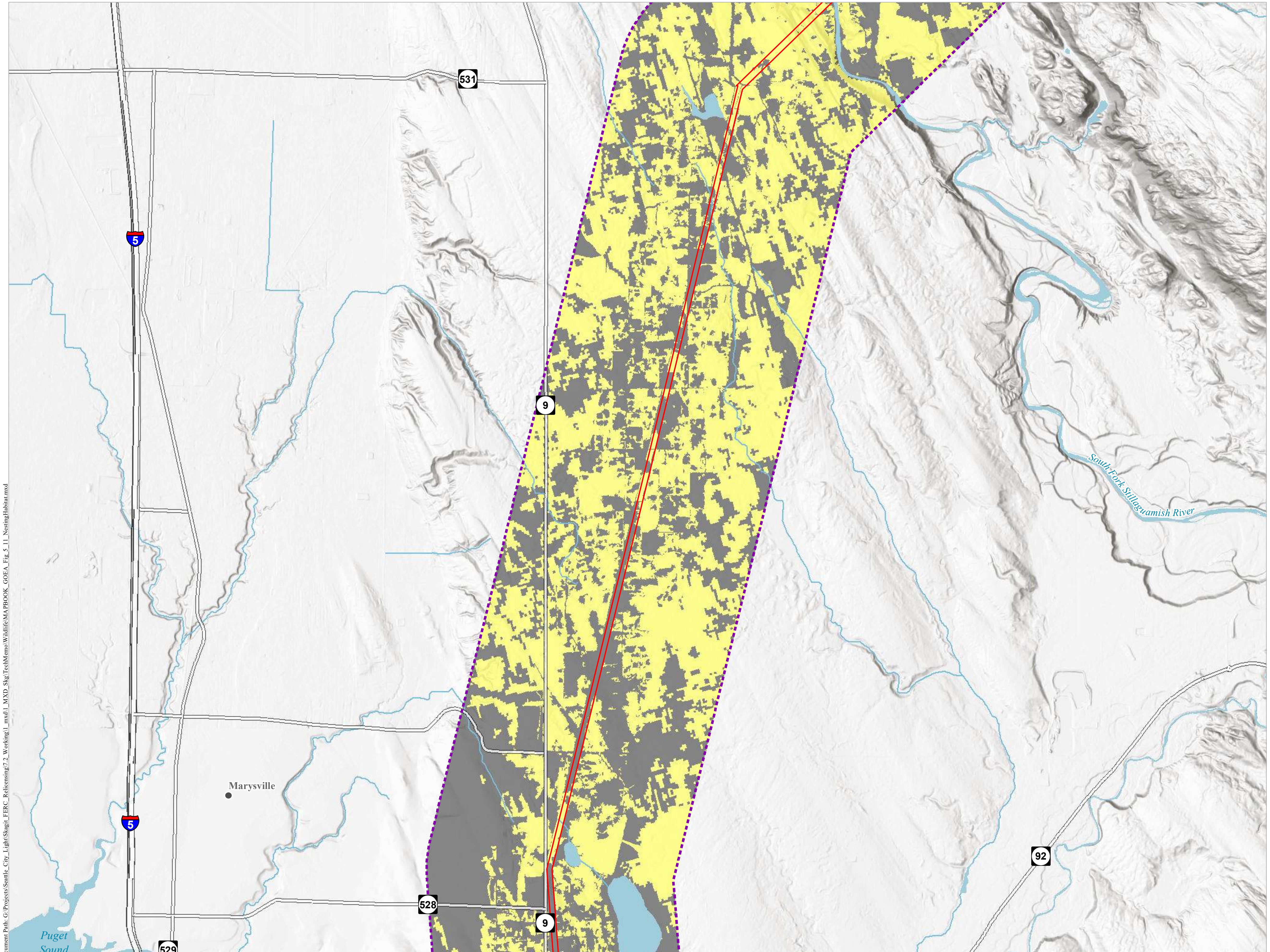

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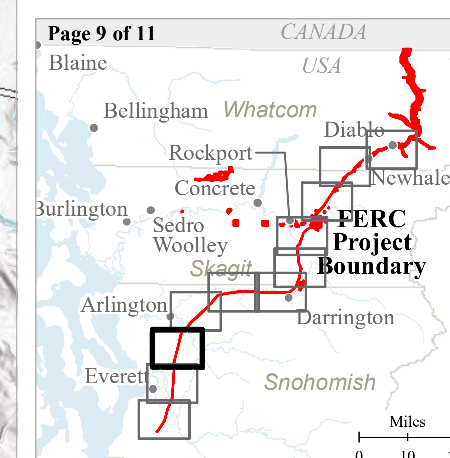
TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

FERC Project Boundary
Streams
Primary Highway
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat

0 0.5 1 Miles



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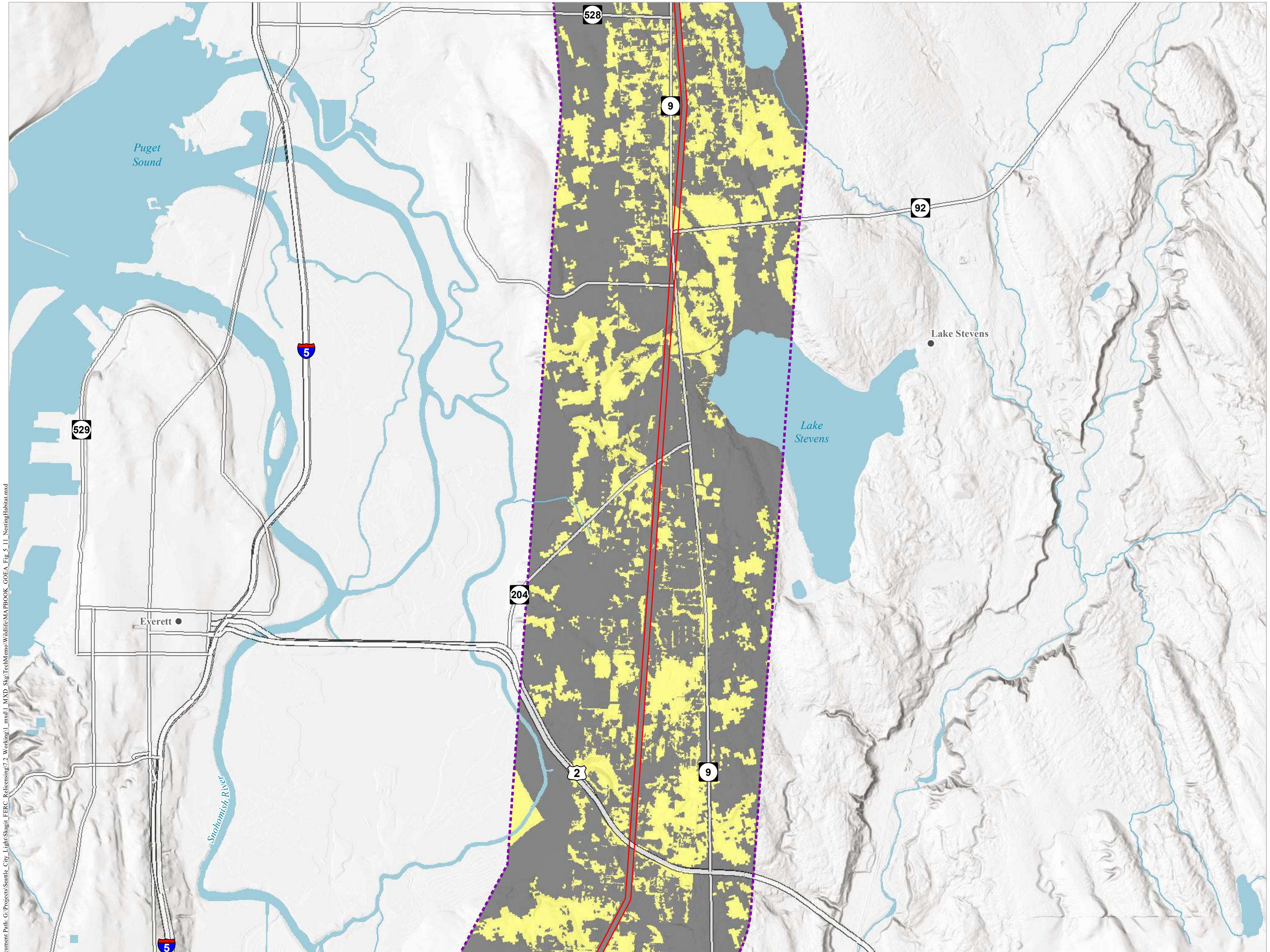
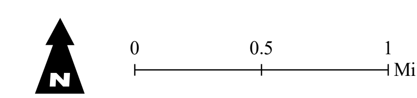
TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

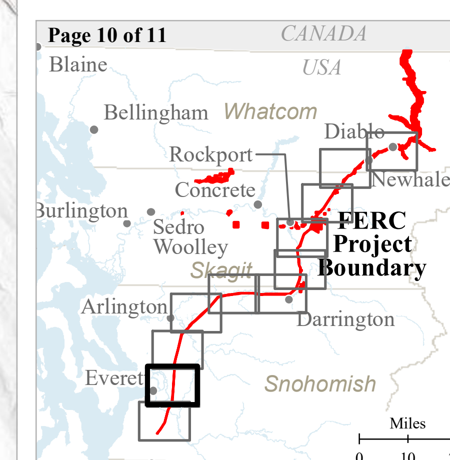


- FERC Project Boundary
- Streams
- Primary Highway
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

- Unsuitable
- Low-quality Habitat





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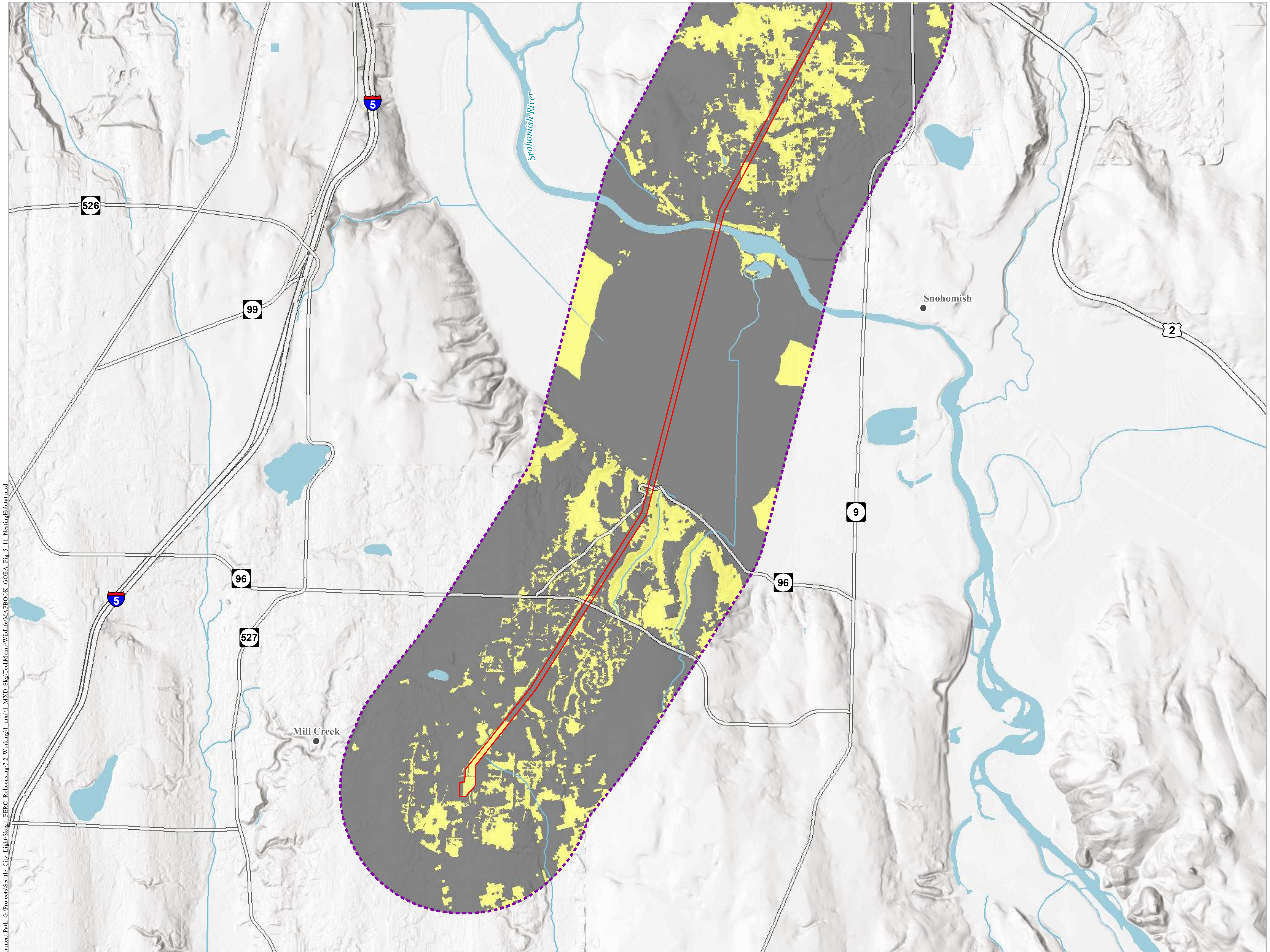


TR-06 GOLDEN EAGLE NESTING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

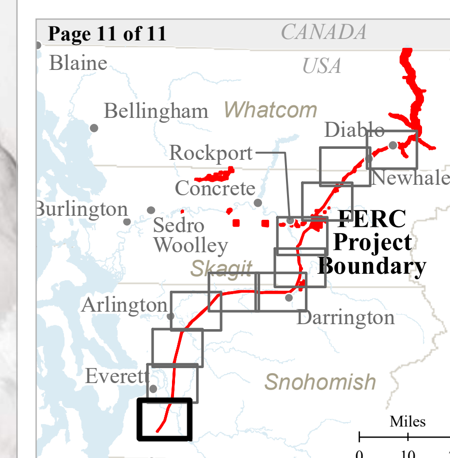
FERC Project Boundary
Streams
Primary Highway
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Nesting Habitat

Unsuitable
Low-quality Habitat

0 0.5 1 Miles

Page 11 of 11



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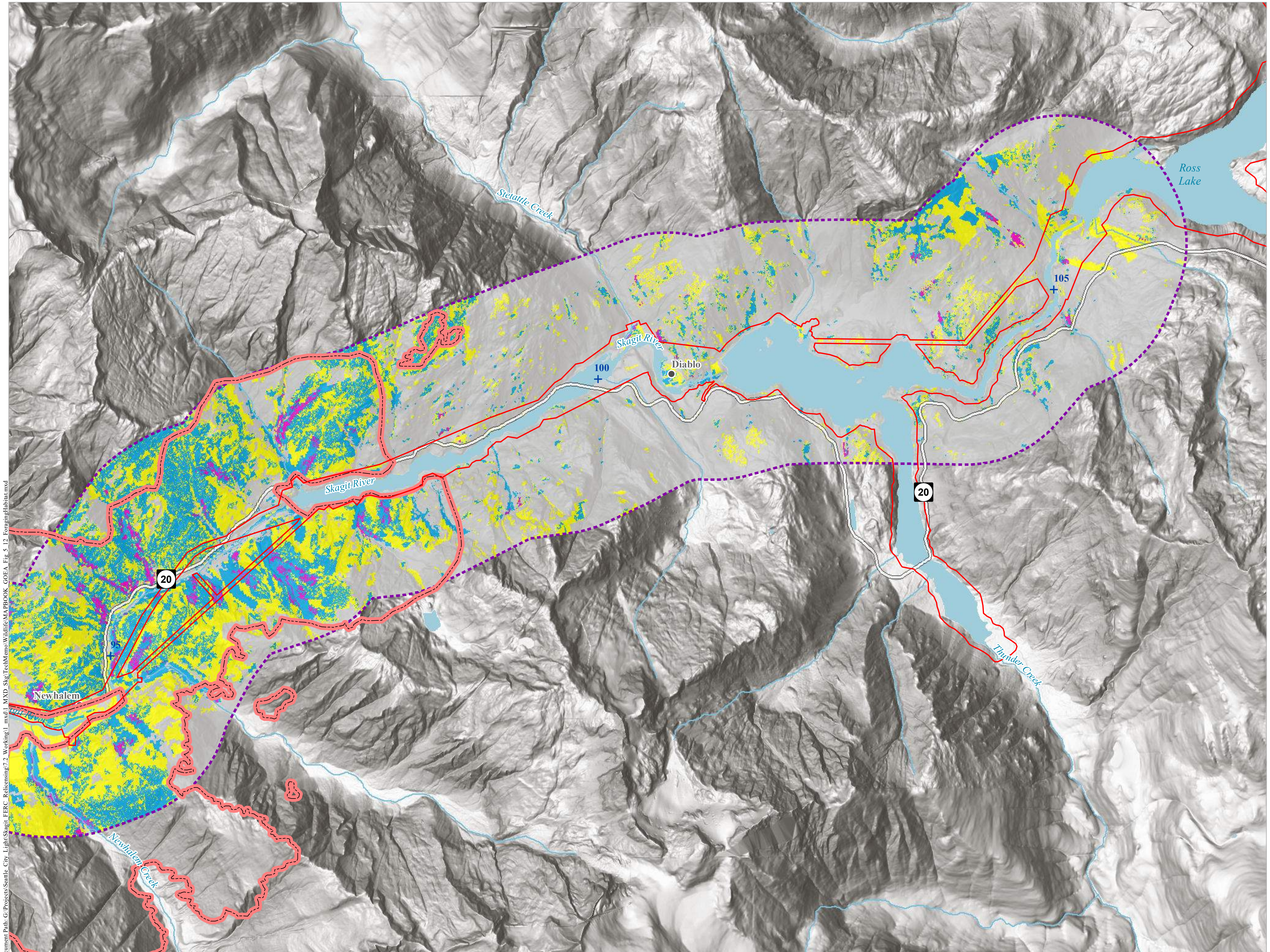
GOLDEN EAGLE HABITAT ANALYSIS DRAFT REPORT

ATTACHMENT C

GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA MAPBOOK

TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

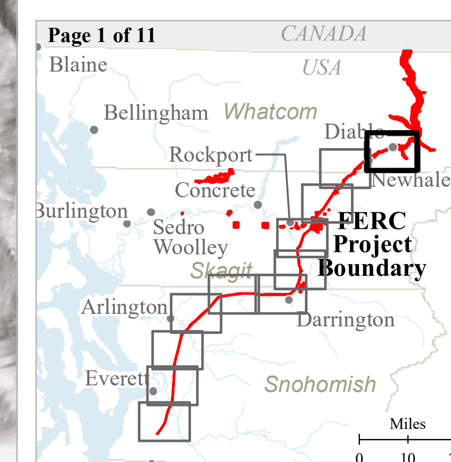


- FERC Project Boundary
- Project River Miles (PRM)
- Streams
- Secondary Highway
- Goodell Fire Boundary
- Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality

0 0.5 1 Miles



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SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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Data Source: ESRI (2021), City Light (2022), HDR (2021).

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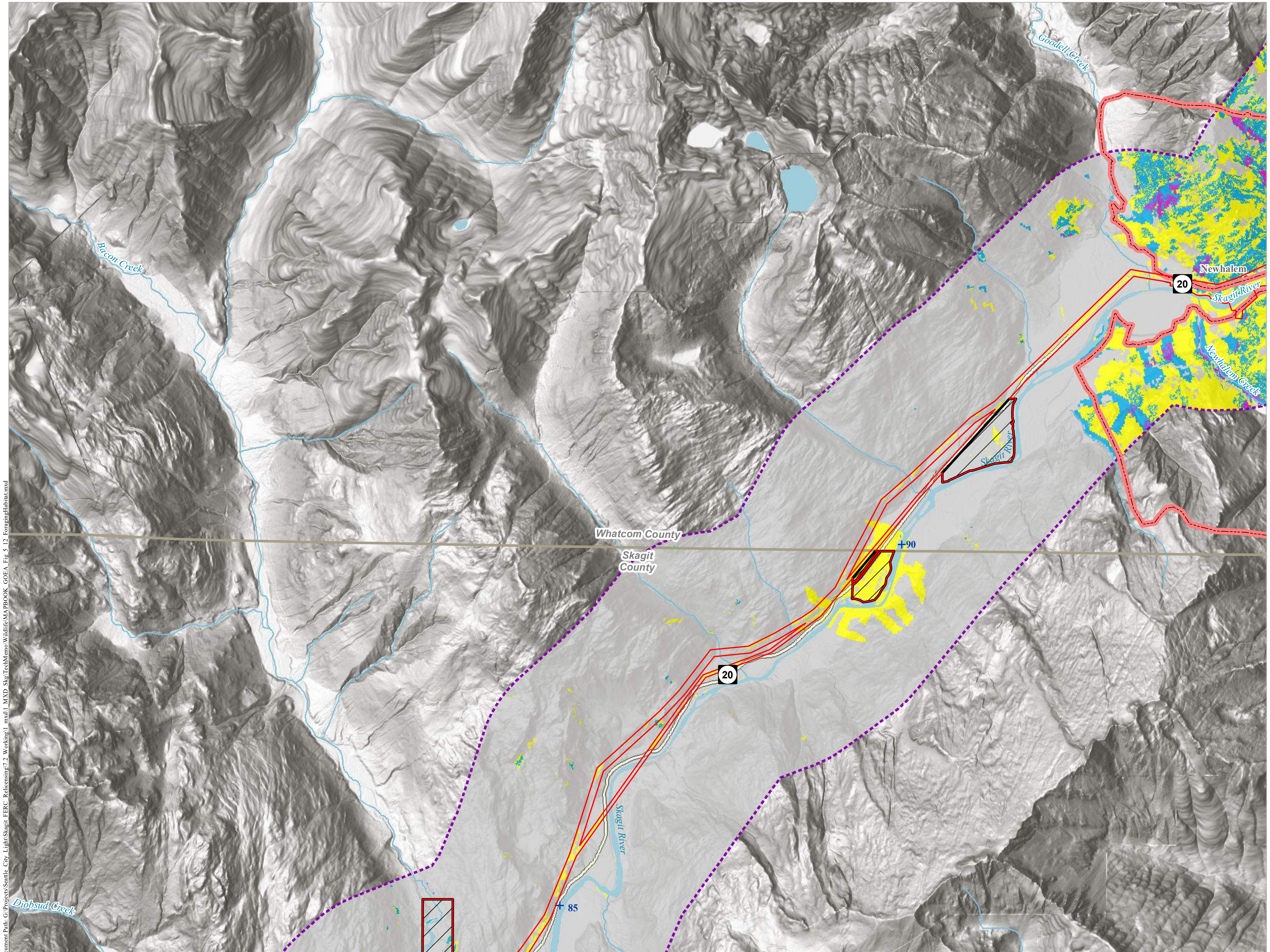


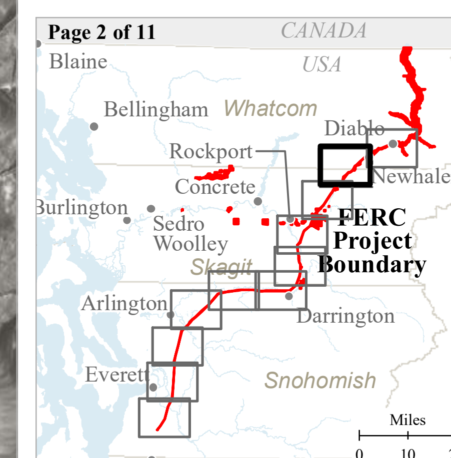
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

FERC Project Boundary
Mitigation Parcel
Project River Miles (PRM)
Streams
Secondary Highway
Goodell Fire Boundary
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

0 0.5 1 Miles



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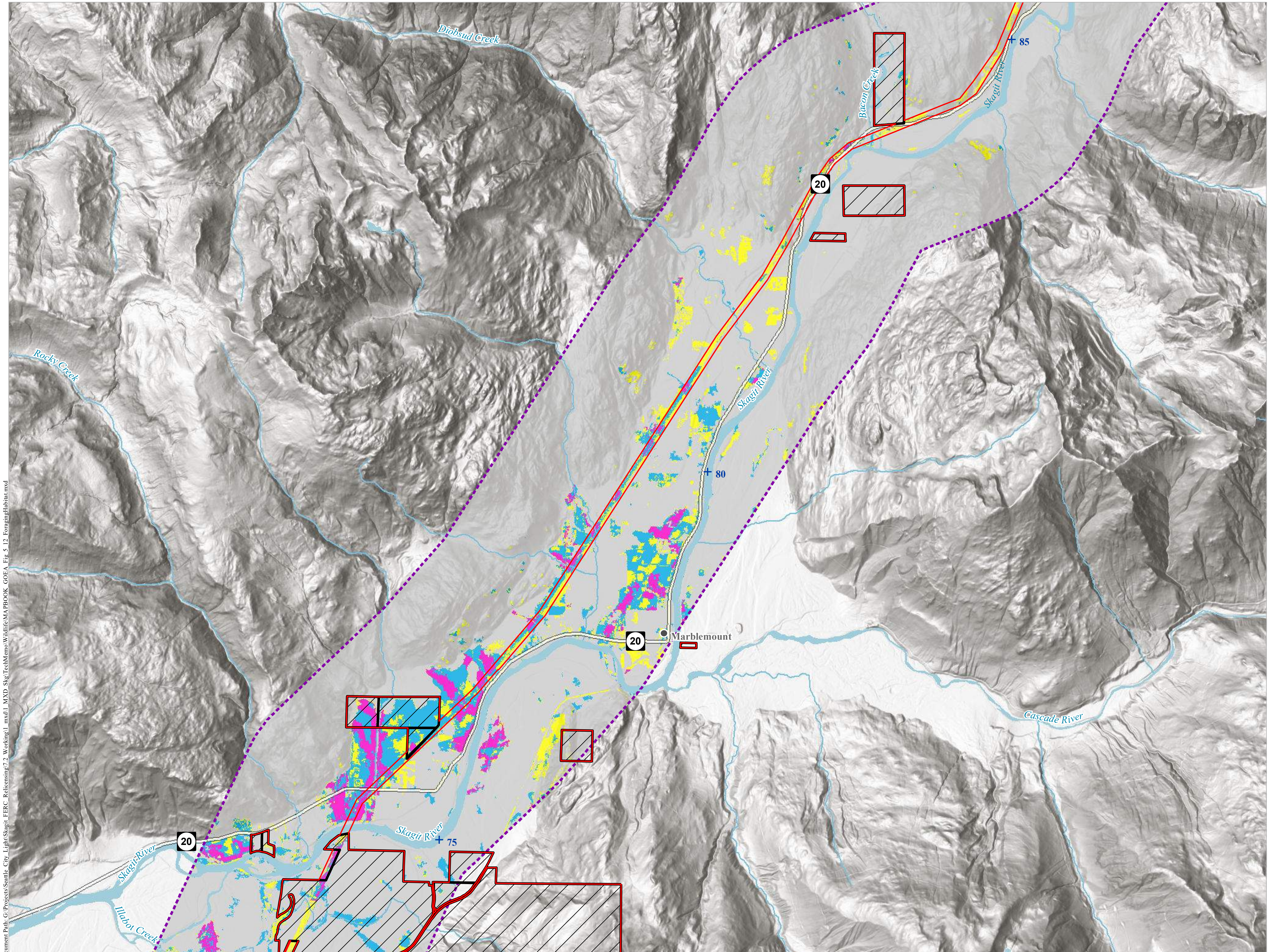
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

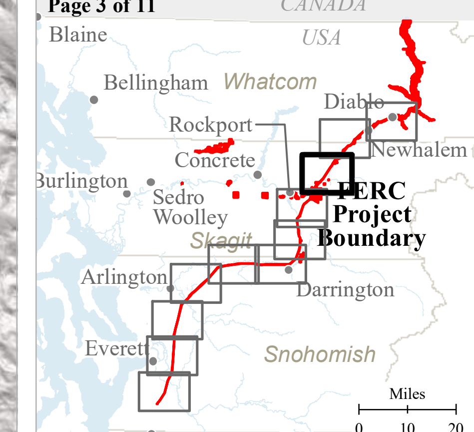


- FERC Project Boundary
- Mitigation Parcel
- + Project River Miles (PRM)
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality

0 0.5 1 Miles



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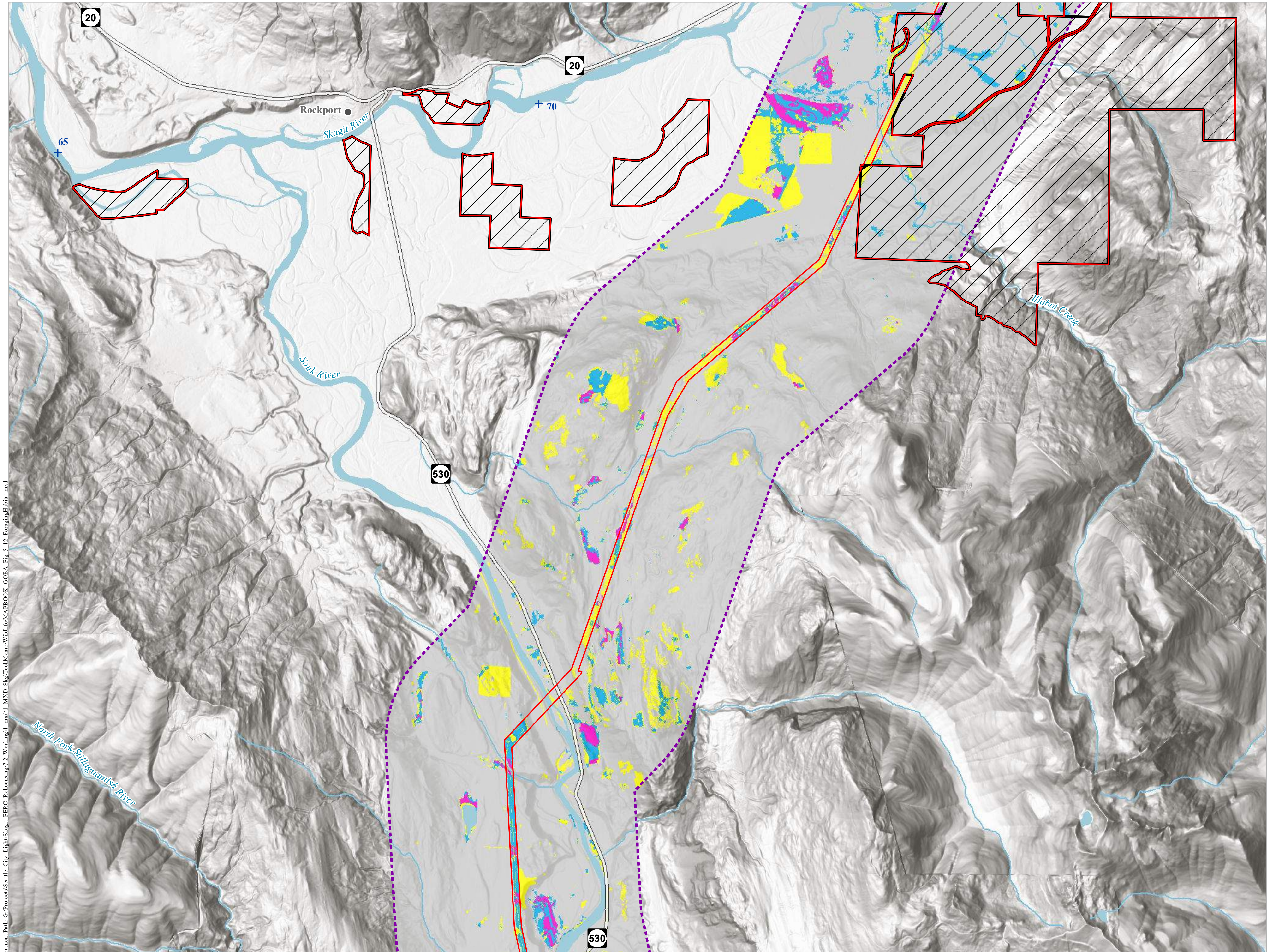
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

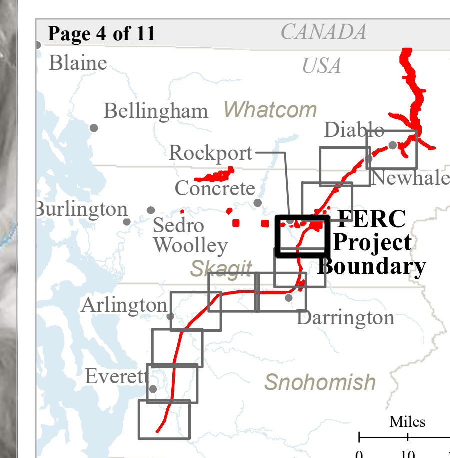


- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality

0 0.5 1 Miles



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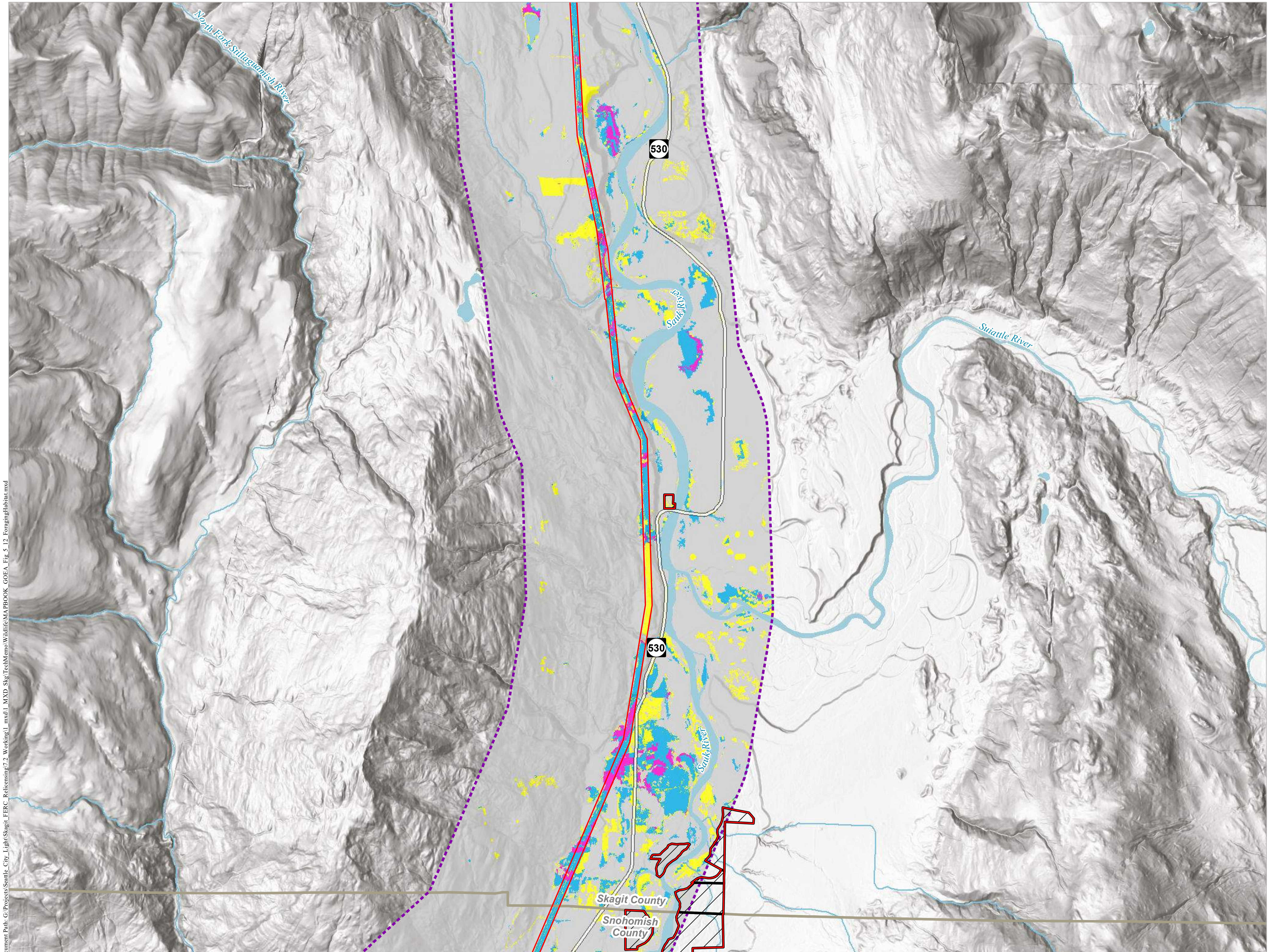

TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

FERC Project Boundary
Mitigation Parcel
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

0 0.5 1 Miles

Page 5 of 11

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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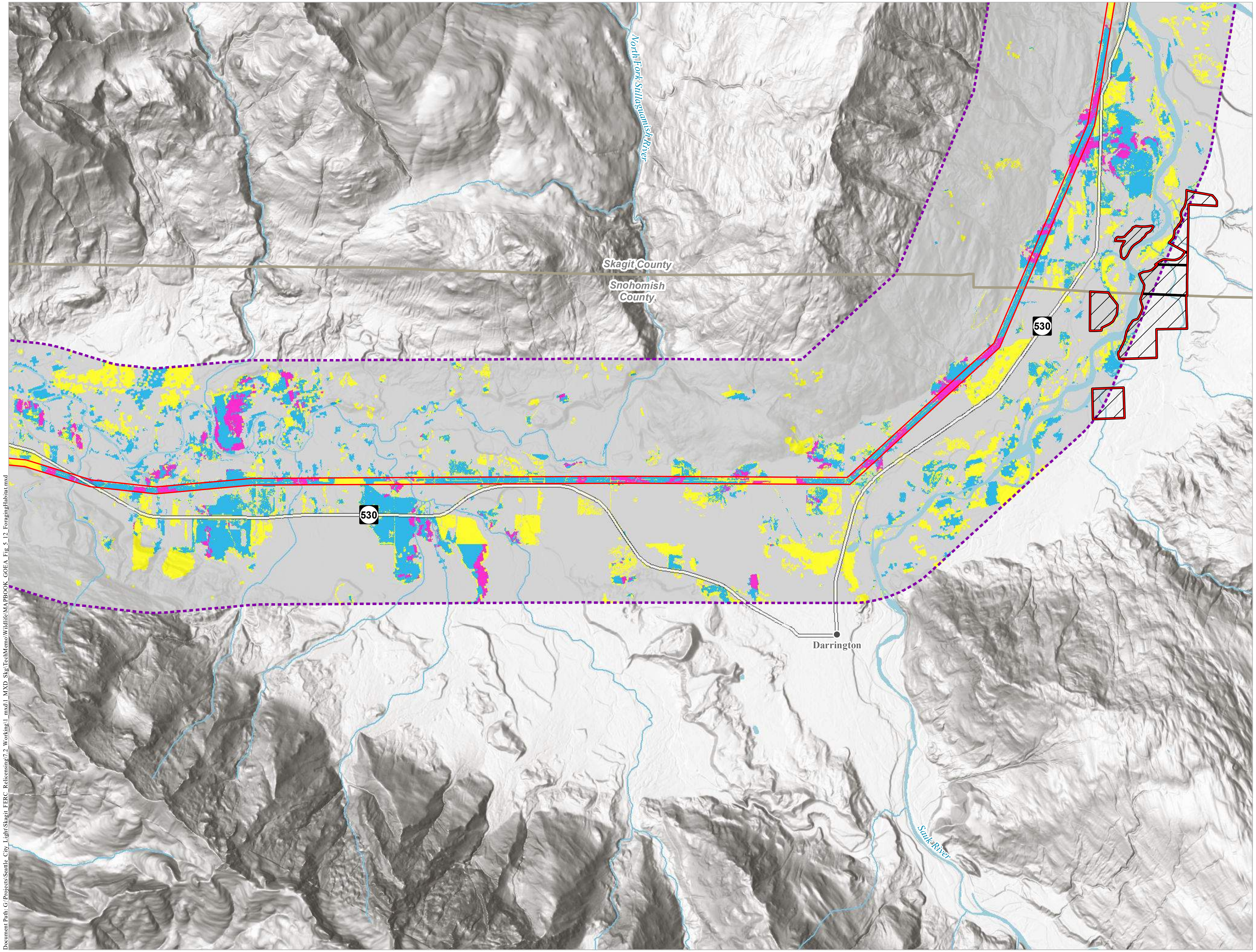
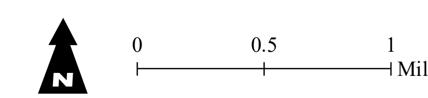


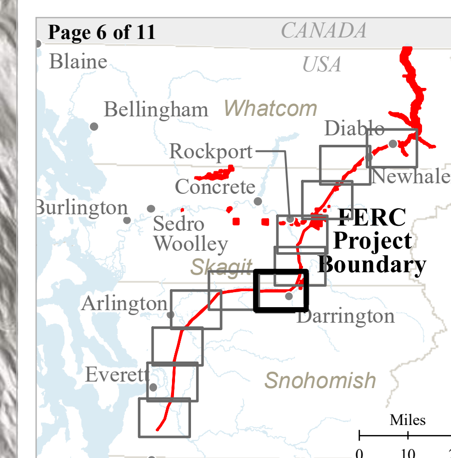
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

- FERC Project Boundary
- Mitigation Parcel
- Streams
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality





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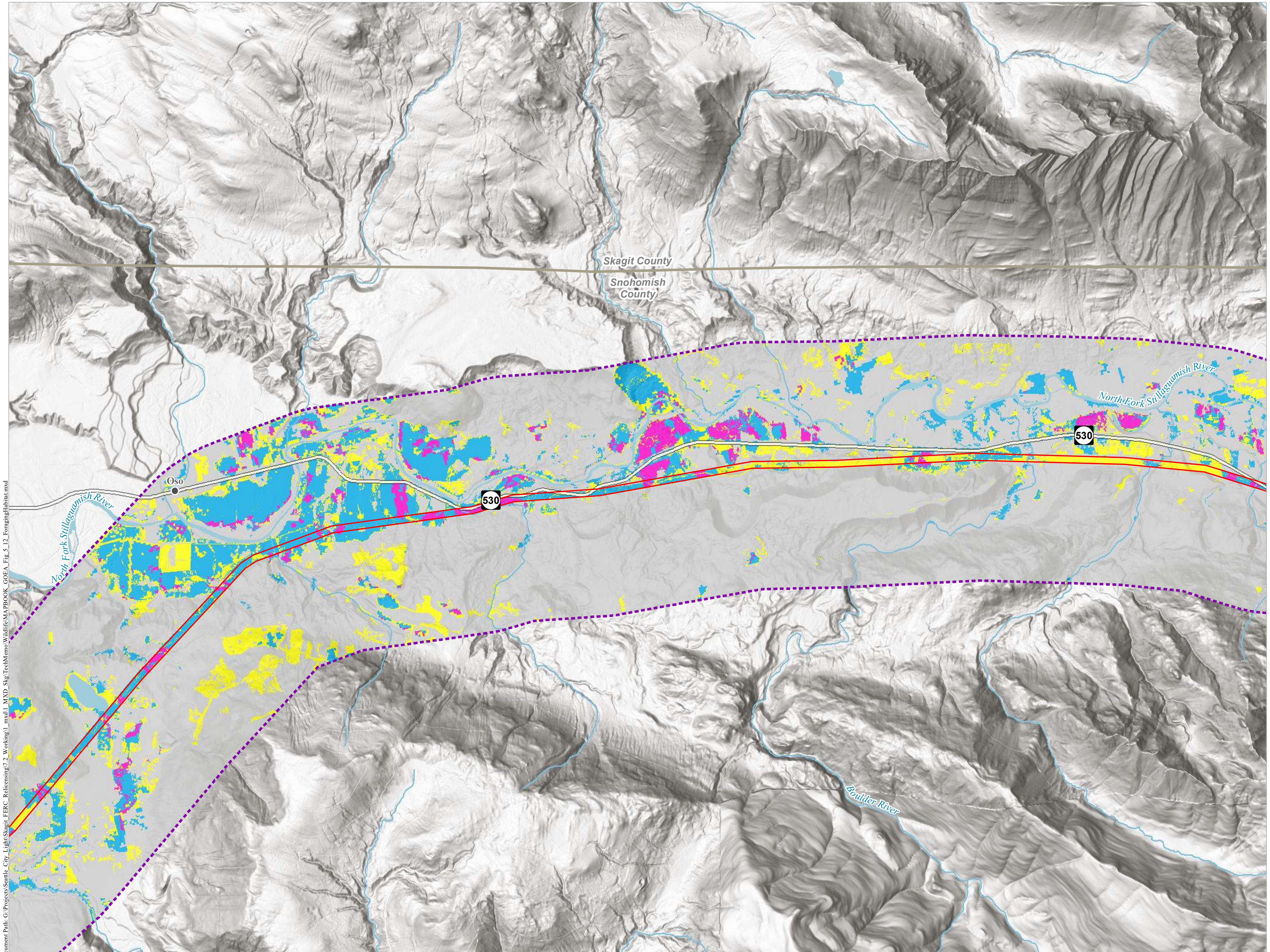
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

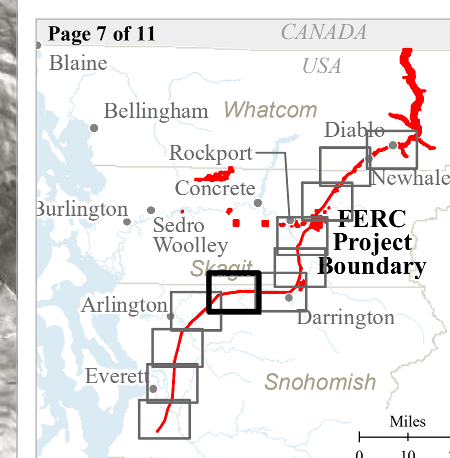


FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

0 0.5 1 Miles



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SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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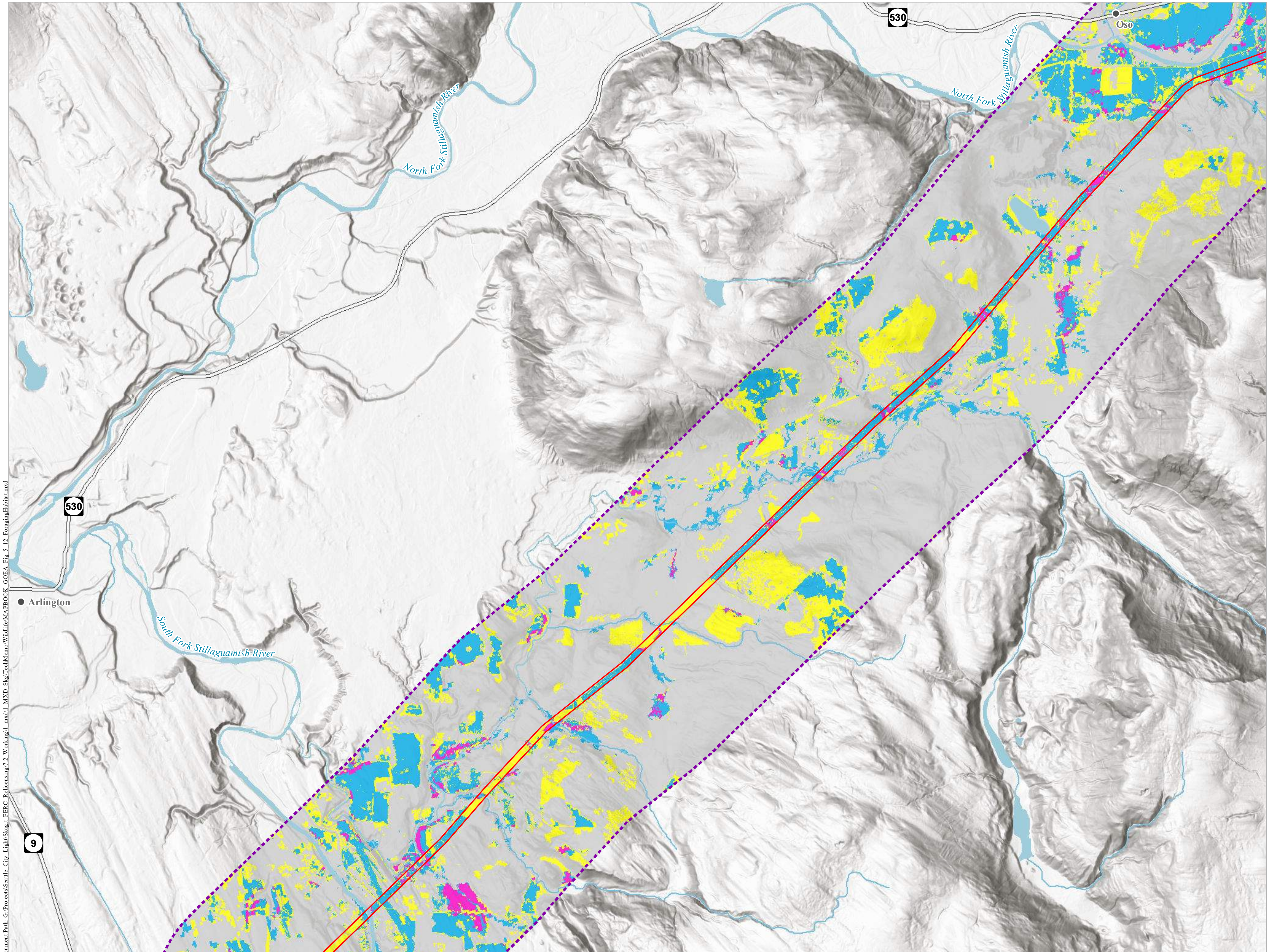


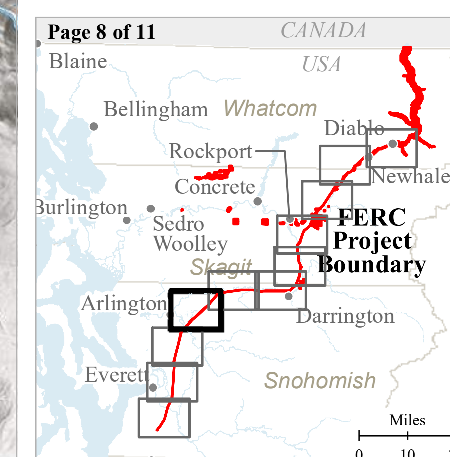
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

FERC Project Boundary
Streams
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

0 0.5 1 Miles



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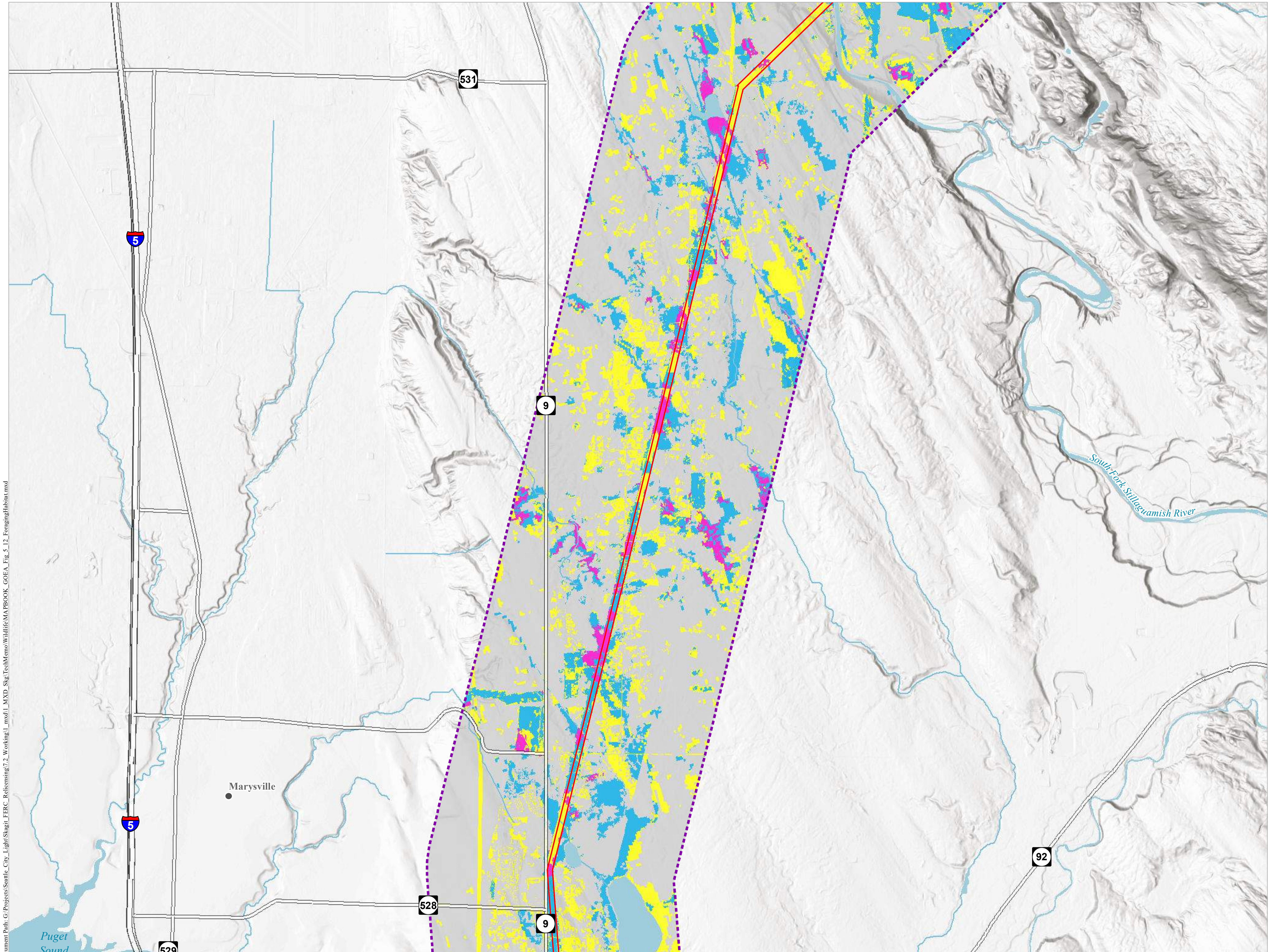
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)



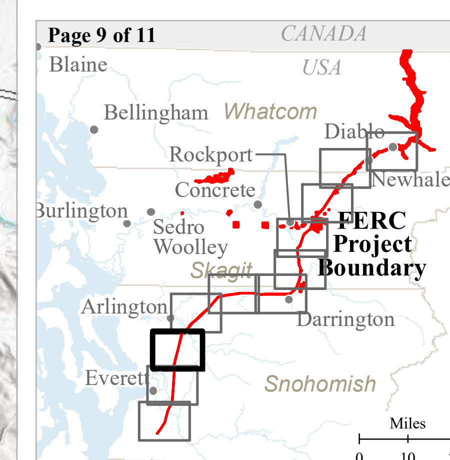
- FERC Project Boundary
- Streams
- Primary Highway
- Secondary Highway
- Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

- Unsuitable
- Low-quality Habitat
- Moderate-quality Habitat
- High-quality

N

0 0.5 1 Miles



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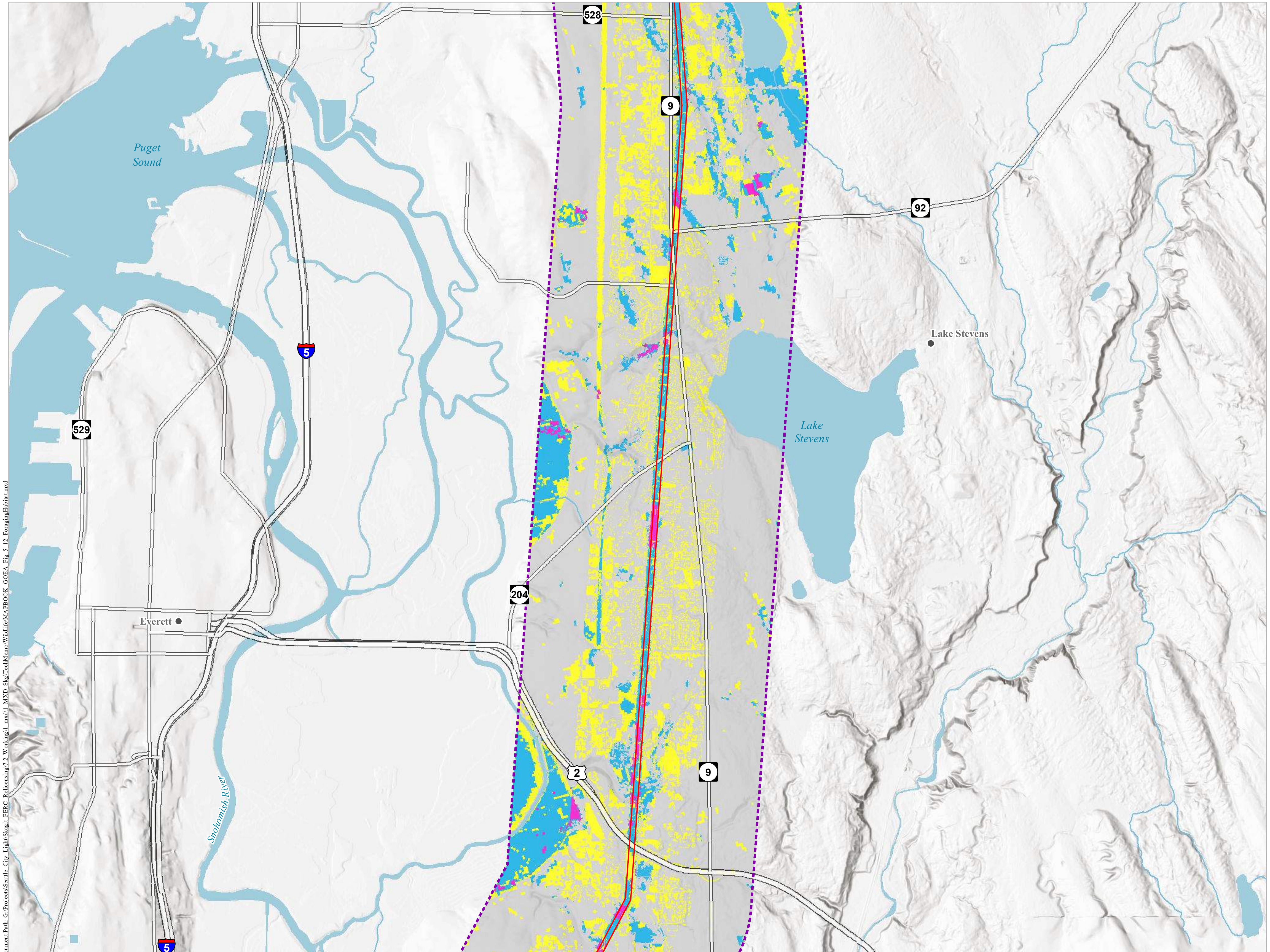


TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)

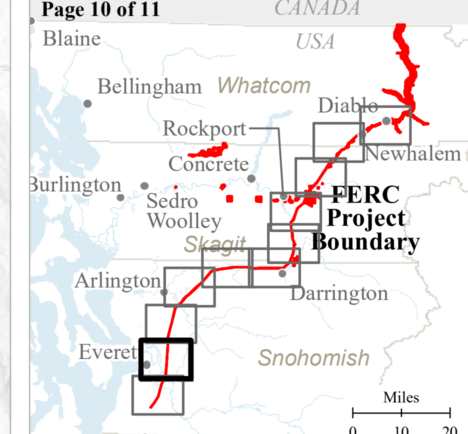
FERC Project Boundary
Streams
Primary Highway
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

N

0 0.5 1 Miles



Seattle City Light

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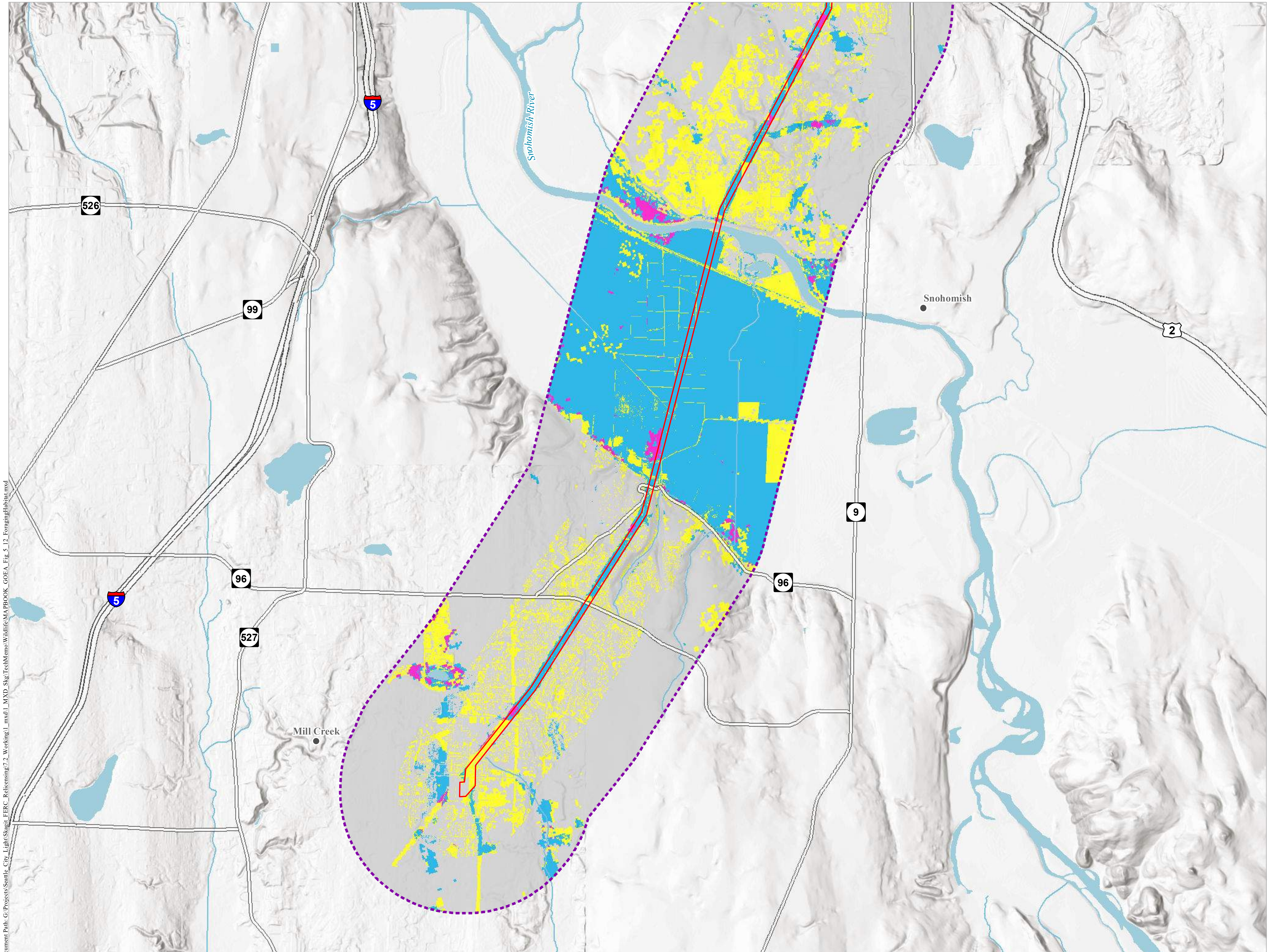
TR-06 GOLDEN EAGLE FORAGING HABITAT MODELED IN THE STUDY AREA (1:48,000 SCALE)



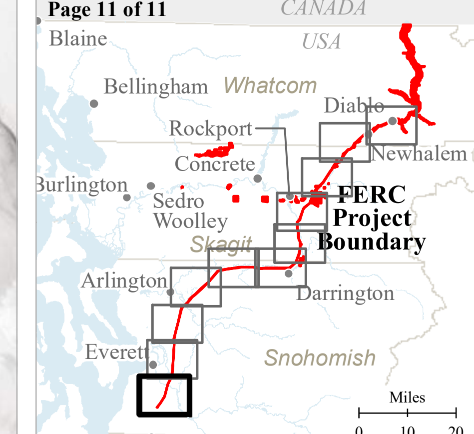
FERC Project Boundary
Streams
Primary Highway
Secondary Highway
Golden Eagle Study Area

Modeled Golden Eagle Foraging Habitat

Unsuitable
Low-quality Habitat
Moderate-quality Habitat
High-quality

0 0.5 1 Miles

Page 11 of 11



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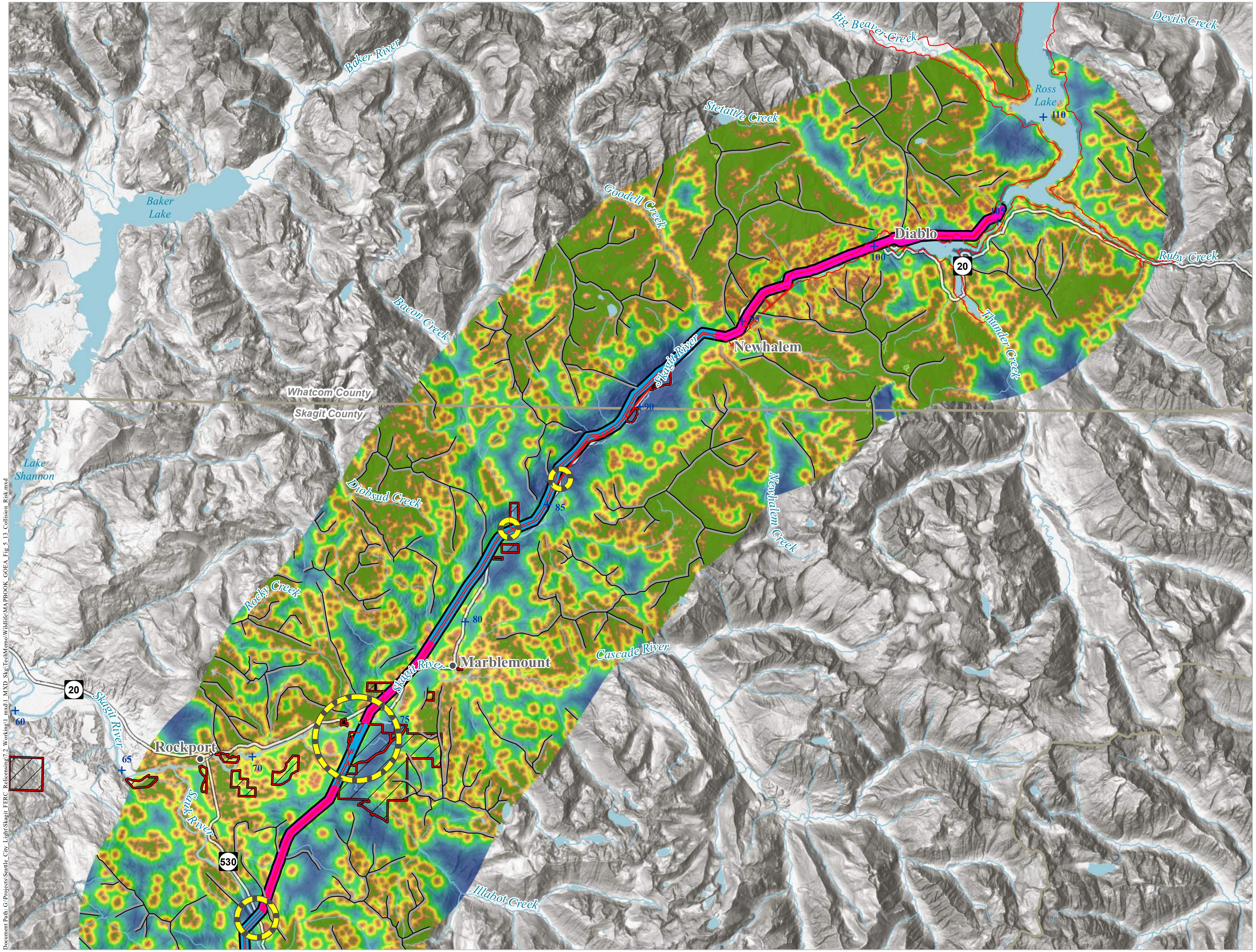
GOLDEN EAGLE HABITAT ANALYSIS DRAFT REPORT

ATTACHMENT D

RELATIVE RISK OF GOLDEN EAGLE COLLISION WITH TRANSMISSION LINES IN THE STUDY AREA MAPBOOK

TR-06 RELATIVE RISK OF GOLDEN EAGLE COLLISION WITH TRANSMISSION LINES IN THE STUDY AREA (1:175,000 SCALE)



- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Ridgelines
- Secondary Highway
- Avian Flight Diverters/Markers
- Potential Golden Eagle Source Habitat

Relative Transmission Line Collision Risk

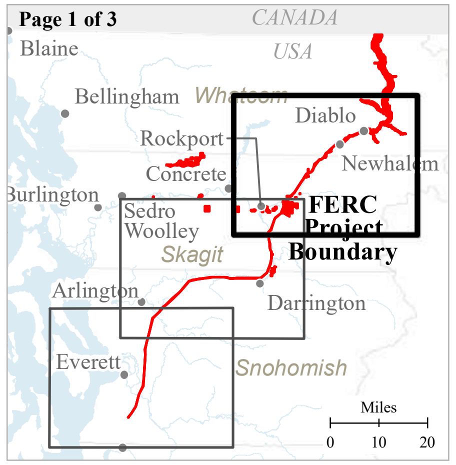
- High
- Medium

Distance Between Source Habitats

High

Low

0 2 4 Miles



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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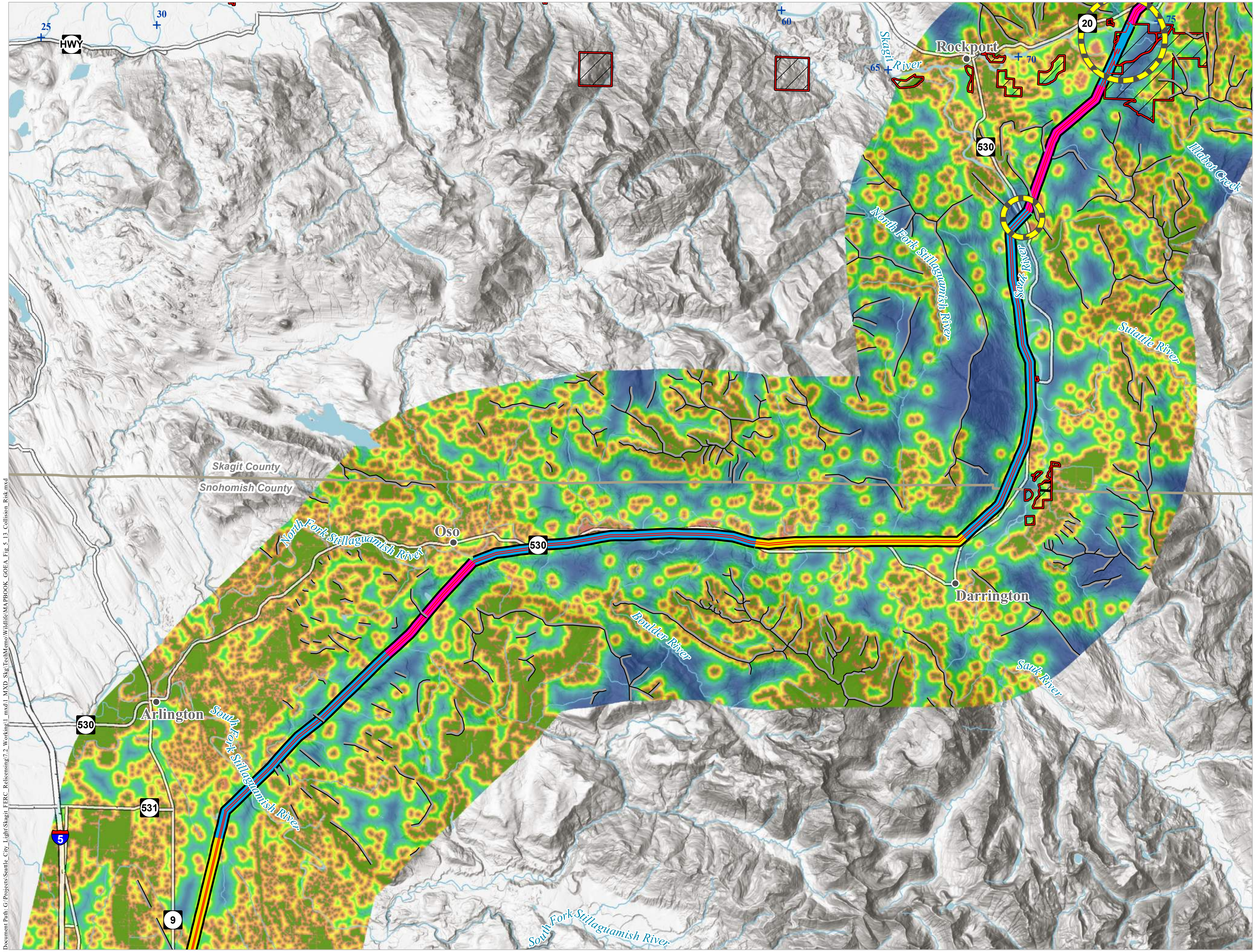
Document Path: G:\Projects\Seattle_City_Light\Skagit_FERC_Relicensing\7.2_Working\1_mxd\1_MXD_Skg\TechMemo\Wildlife\MAPBOOK_GOEA_Fig_5_13_Collision_Risk.mxd

TR-06 RELATIVE RISK OF GOLDEN EAGLE COLLISION WITH TRANSMISSION LINES IN THE STUDY AREA (1:175,000 SCALE)



- FERC Project Boundary
- Mitigation Parcel
- Project River Miles (PRM)
- Ridgelines
- Primary Highway
- Secondary Highway
- Avian Flight Diverters/Markers
- Potential Golden Eagle Source Habitat

Relative Transmission Line Collision Risk

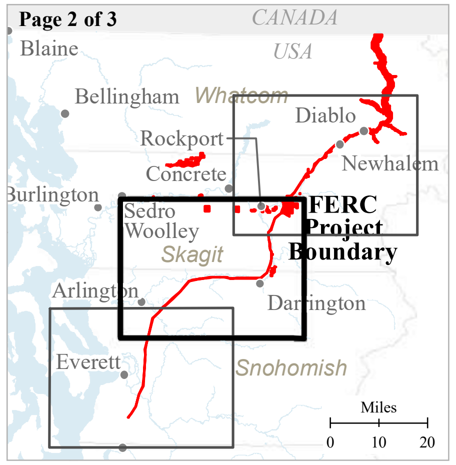
- High
- Medium
- Low

Distance Between Source Habitats

High

Low

0 2 4 Miles



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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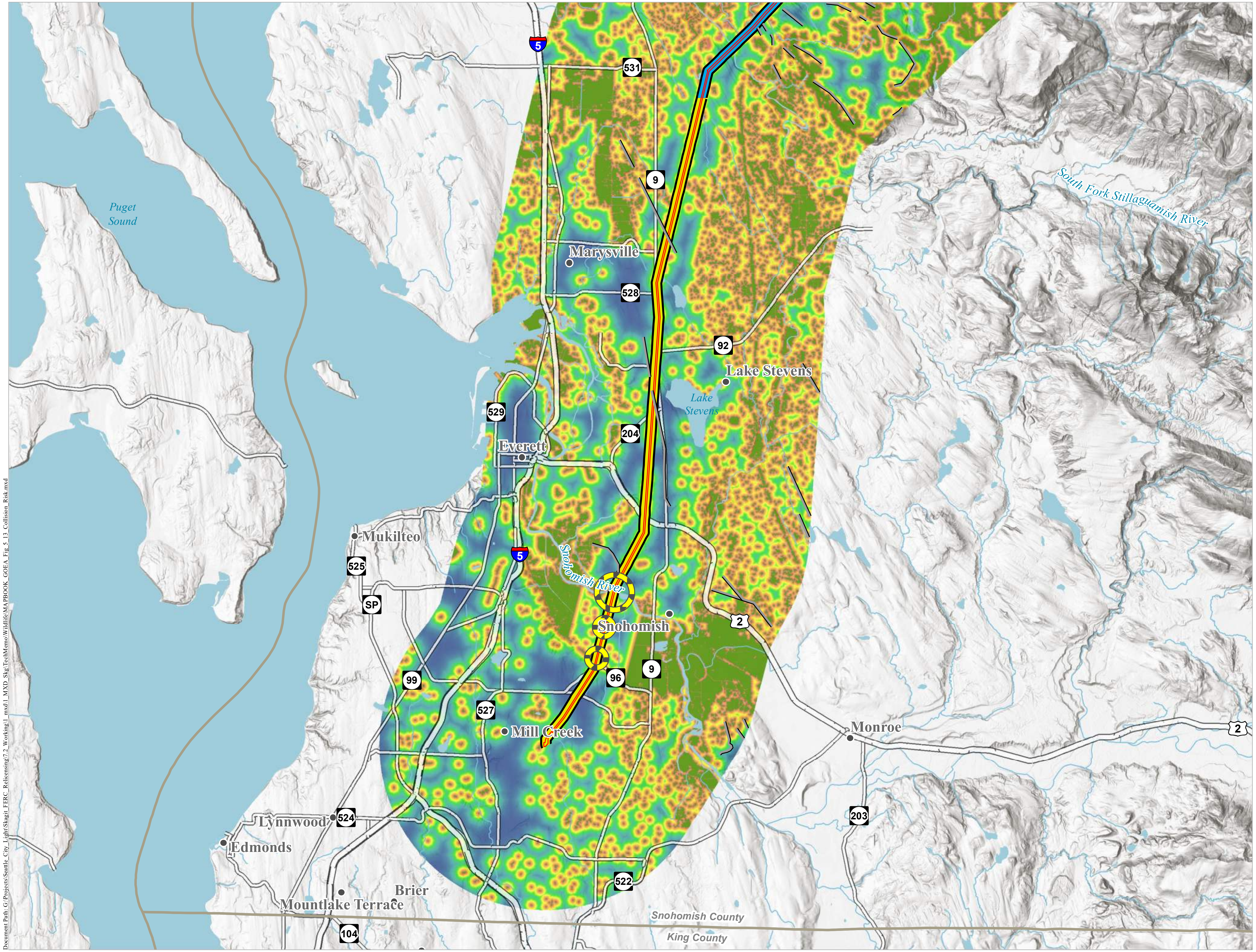
Data Source: ESRI (2021), City Light (2022), HDR (2021).

TR-06 RELATIVE RISK OF GOLDEN EAGLE COLLISION WITH TRANSMISSION LINES IN THE STUDY AREA (1:175,000 SCALE)



FERC Project Boundary
Ridgelines
Primary Highway
Secondary Highway
Avian Flight Diverters/Markers
Potential Golden Eagle Source Habitat

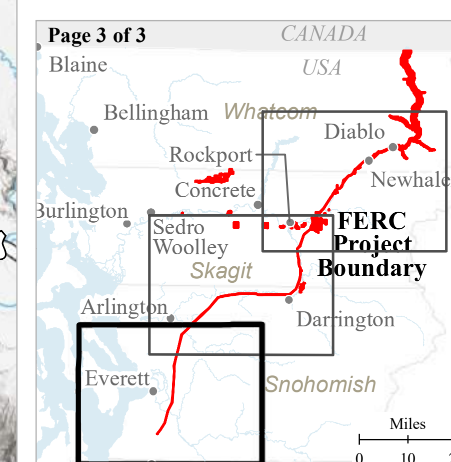
Relative Transmission Line Collision Risk

Medium
Low

Distance Between Source Habitats

High
Low

0 2 4 Miles



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