
Happy River looking south at the proposed crossing location

Preliminary Engineering Report

West Susitna Access - Phase 2

Alaska Industrial Development & Export Authority

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Executive Summary

The Alaska Industrial Development and Export Authority is conducting pre-feasibility studies for a 100-mile access road from the Point Mackenzie area to the Skwentna River valley to provide a surface access route to known resource-abundant areas on the west side of the Susitna River. This project is called West Susitna Access. The proposed project route, the Port Mackenzie Route, begins at the Little Susitna River Access Road and ends near the confluence of Portage Creek and the Skwentna River.

The proposed road will have a driving surface width of 24 feet, a design speed of 45 miles per hour, a maximum running grade of less than 8.0 percent, and a gravel surface. The proposed road will be open to public use.

Geology and geotechnical considerations along the proposed route are generally favorable. Permafrost is not expected to be an issue. Subgrade support issues are somewhat mitigated by avoiding wetlands. Soil borrow, which can be used for fill purposes, is expected to be available along the entire route, although the quality will be variable. Gravel borrow, which can be used for structural material and the road surface, is expected to vary in quality and be sporadic in availability along the proposed route. Gravel borrow sources will primarily be found in alluvial fans and outwash from river floodplains, and is expected to be limited east of the Susitna River. High quality rock borrow, which can be used to make riprap for erosion and scour control, is expected to be sporadic but adequate west of the Susitna River. Rock borrow is essentially non-existent along the proposed road corridor, east of the Susitna River.

The proposed route crosses 156 known streams, creeks, and rivers, with 145 of these crossings accomplished with culverts, of which approximately 90 will need to provide fish passage. Eleven of the river/creek crossings will be bridges, with the following four crossings deemed as “complex” due to construction complexities, extensive in-water work, span length, and/or deep canyons:

- Susitna River: 2,160 feet long
- Skwentna River: 600 feet long
- Happy River: 600 feet long
- Portage Creek: 550 feet long

The opinion of probable capital cost for the project is $356,900,000. This value includes environmental and permitting, design, construction, construction administration, right-of-way survey and platting, right-of-way acquisition, and a 25 percent contingency on construction.

Recommended next steps, in terms of advancing engineering, are aimed at filling data gaps that could impact the route alignment, schedule, and opinion of probable capital cost. These next steps include fish surveys, stream surveys, cultural and historic resources studies, land ownership research, preliminary geotechnical investigations, and identification of the footprint of all temporary and permanent construction associated with the project. Advancement of bridge engineering is also recommended to refine this major cost component of the project. If the project moves forward into the National Environmental Policy Act process, alternative routes will also need to be identified and studied.

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Table of Contents

Tables

Figures

Appendices

Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADF&G	Alaska Department of Fish and Game
AFFI	Alaska Freshwater Fish Inventory
AIDEA	Alaska Industrial Development and Export Authority
AWC	Anadromous Waters Catalog
DGGS	Alaska Division of Geology and Geophysical Surveys
DOT&PF	Alaska Department of Transportation and Public Facilities
ft	feet
GDVLVLR	*Geometric Design of Very Low-Volume Local Roads*
H	Horizontal
HDR	HDR Alaska, Inc.
MP	Milepost
mph	mile(s) per hour
MSB	Matanuska-Susitna Borough
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
OHW	ordinary high water
OPCC	Opinion of Probable Capital Cost
PMR	Port Mackenzie Route
ROW	right-of-way
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	Vertical

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1.0 Introduction

The Alaska Industrial Development and Export Authority (AIDEA) is conducting pre-feasibility studies for the proposed West Susitna Access project, a 100-mile surface access road from the Point Mackenzie area to known resource-abundant areas on the west side of the Susitna River in the Skwentna River valley. AIDEA contracted HDR Alaska, Inc. (HDR) to perform preliminary engineering, wetland mapping, and strategic communications for the proposed project.

This report describes the preliminary engineering effort to develop the proposed access route, design criteria, key assumptions, opinion of probable capital cost, and recommendations for next steps of project development.

The study area is in the Matanuska-Susitna Borough (MSB; Figure 1). The study area comprises a corridor along the proposed route, beginning at the Little Susitna River Access Road and heading northwest to near the confluence of Portage Creek and the Skwentna River. The proposed route is referred to as the Port Mackenzie Route (PMR) due to its connection to Port Mackenzie via the existing road network. The PMR currently follows a portion of the Donlin Gold Project proposed natural gas pipeline corridor for approximately 57 miles between Beluga Mountain and Happy River.

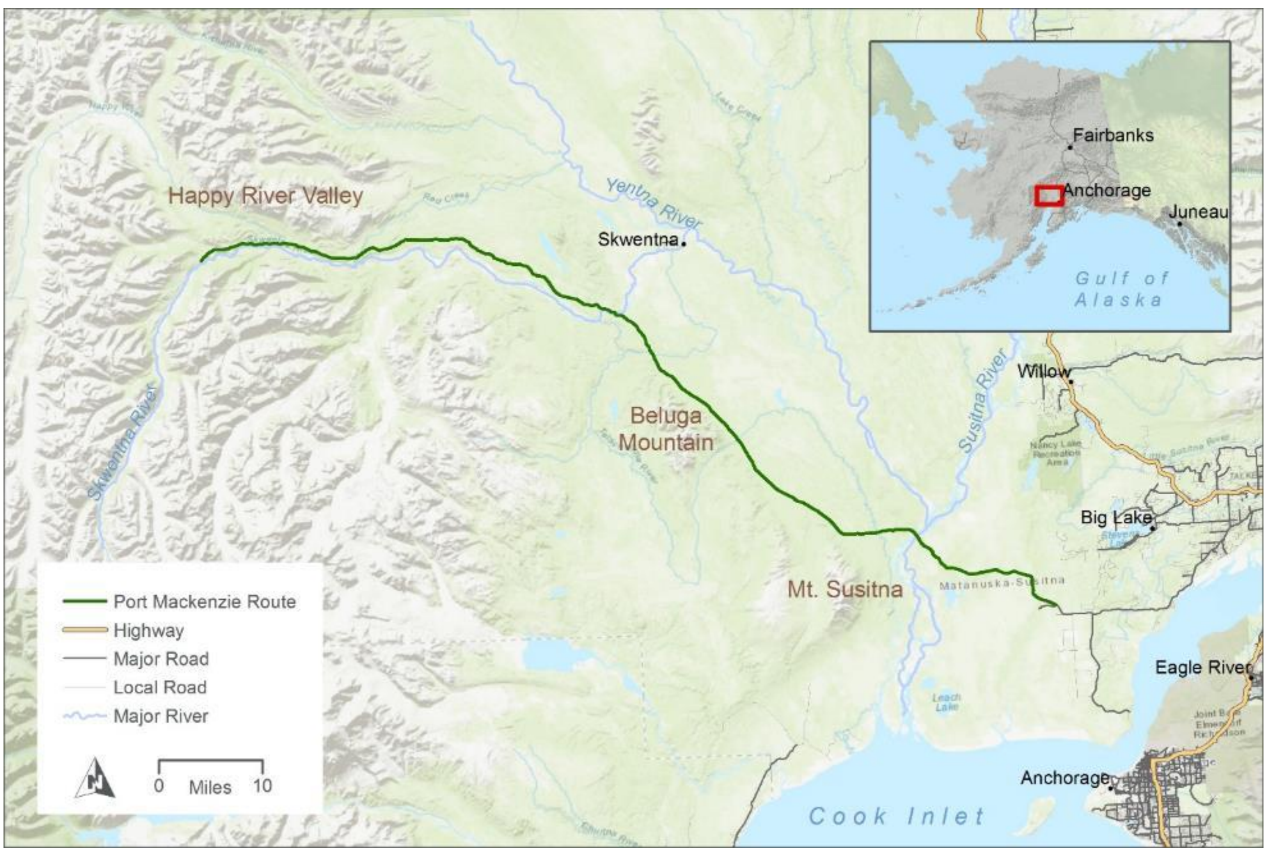

Figure 1. Study Area and Proposed Route

2.0 Roadway Design

2.1. Route Alignment Selection and Design

The route alignment for the West Susitna Access project was refined using a 1,200-foot-wide corridor of terrain data centered on the preferred PMR alignment from the *Field Reconnaissance Report for West Susitna Access Study, Phase 1* (HDR 2020). The corridor study area begins near the Little Susitna River Access Road at Milepost (MP) 0 and ends at approximately MP 100 at the tie-in with existing mineral exploration access trails after the Portage Creek crossing. This alignment was refined within the corridor limits to reduce impacts to wetlands, reduce grades, minimize impacts to Donlin Gold's proposed gas pipeline route, minimize impacts to Iditarod Trail routes, reduce impacts to private parcels, avoid large cuts and fills, cross at favorable bridge locations, reduce costs, and utilize previously identified quality material sites. The maps attached in Appendix B provide additional detail on the route, terrain, and constraints. The following subsections provide more detail on key considerations for refinement to the Phase 1 PMR alignment.

2.1.1. Stream Crossings and Wetlands

Eleven streams have been identified that may require bridge crossings. Five of these bridge crossings—the Little Susitna River, Susitna River, Skwentna River, Happy River, and Portage Creek—necessitated substantial refinement of the initial Phase 1 PMR alignment to optimize bridge lengths and crossing angles. The largest deviation from the Phase 1 PMR alignment was at the Skwentna River where the crossing was moved roughly 4,400 feet upstream to make use of a naturally narrow section of river.

Using the previously identified design controls, the Phase 1 PMR alignment was modified to avoid wetlands where possible and reduce impacts if unavoidable or costly. Flowing water crossings were identified and crossing locations were selected at the narrowest practicable locations and as close to perpendicular to the banks as possible.

2.1.2. Proposed Donlin Gas Pipeline

The PMR alignment parallels the proposed Donlin Gold gas pipeline route for approximately 57 miles. The proposed pipeline will be installed within a proposed 150-foot-wide right-of-way (ROW). The road alignment was modified to keep the roadway footprint outside of the pipeline ROW wherever feasible. In several locations where other constraints existed, it was necessary to encroach on the pipeline ROW such that the roadway centerline aligns with the edge of pipeline ROW. Pipeline crossings were minimized and crossing lengths reduced by maximizing the crossing angles.

2.1.3. Iditarod Trail Routes

The current race trail, historic routes, and prescriptive routes for the Iditarod Trail exist within the study area. The Phase 1 PMR alignment was modified near the Skwentna River, between MPs 56 and 58, to eliminate two crossings of the Iditarod Trail. This shift keeps the alignment to the south of the Iditarod Trail and near the north bluff of the Skwentna River, avoiding impacts to the Iditarod

Trail. Where Iditarod Trail crossings are unavoidable, the road profile was kept as low as possible to provide a relatively flat, at-grade crossing.

2.1.4. Private Parcels and Existing Right-of-Way

A ROW exists intermittently between MPs 0 and 12 and between MPs 60 and 64. The proposed alignment was shifted to utilize the existing ROW in these locations. The first section of ROW (MPs 0 to 12) ranges in width from 300 to 400 feet, and the proposed roadway embankment is contained completely within the ROW. The second section of ROW (MPs 60 to 64) is narrower and part of a platted subdivision near Onestone Lake. Where the proposed route leaves the existing ROW and must cross parcels, attempts were made to only impact parcels that are not privately owned. In other areas along the corridor, the alignment was shifted to avoid privately owned parcels.

One private parcel near the east bank of the Susitna River could not be avoided without adversely affecting the bridge crossing location or introducing curves into the bridge approach. With additional information and refinement of the design, it may be possible to avoid this parcel.

2.2. Roadway Design Criteria

The design criteria for the West Susitna Access project were determined by interviewing project partners to identify anticipated uses and expectations of the roadway. The project partners indicated that the initial primary use of the roadway would be for personnel and equipment access to mining claims for exploration, mine construction, and public recreational access. A roadway similar to a pioneer access road would be sufficient for these uses as long as the initial road alignment selection does not preclude future improvements that would allow for higher speeds and wider roadway top width.

2.2.1. Functional Classification, Design Speed, and Vehicle Determination

The average daily traffic is anticipated to be fewer than 400 vehicles; therefore, HDR used American Association of State Highway and Transportation Officials' (AASHTO) 2001 *Guidelines for Geometric Design of Very Low-Volume Local Roads* (GDVLVLR) for roadway design criteria (AASHTO 2001). Within the GDVLVLR, numerous functional classifications aid in determining design criteria and controls. This road is considered rural and will be primarily used for resource access. The GDVLVLR has a functional classification for Rural Resource Recovery Roads that allows for minimal sight distance with smaller horizontal curve radii and shorter vertical curves. These controls assume that the users will be familiar with the route, the road will be primarily used by professional drivers, and drivers may have some type of communication link with other users. The proposed West Susitna Access road will include some public users who may not be familiar with the roadway, may be distracted, and may not have communication with other users. With the safety of public users in mind, a functional classification of Rural Recreational and Scenic Road was selected as the best fit.

A design speed of 45 miles per hour (mph) was selected, in part, because the generally flat terrain allows a higher design speed with relatively minor cost implications. The future build out of the proposed road cannot be accomplished with ease if the horizontal alignment utilizes lower speed curve radii to avoid wetlands, the proposed Donlin Gold pipeline route, private parcels, vertical terrain features, and the Iditarod Trail.

The design vehicle selected for initial use is a Single Unit Truck that is 40 feet long. The ultimate design vehicle is not known but is assumed to be a WB-109 or similar. This will be a public road; therefore, anyone using the road will be operationally bound by Alaska statute regarding legal, permit, and divisible loads.

2.2.2. Roadway Geometrics

AASHTO's GDVLVLR gives guidance on the roadway geometry. Within this guidance, a travelled way width of 24 feet composed of two 10-foot driving lanes with 2-foot outside shoulders was selected. This is slightly wider than the minimum recommended overall width of 20 feet for the functional classification of Rural Recreational and Scenic Road. Justification for a wider road is discussed further within the clear zone requirements.

The corridor study area is a mix of flat and rolling terrain from MP 0 to 87, and rolling to mountainous terrain from MP 87 to the end of the proposed roadway at MP 100. The study area begins at elevation 100 feet near the Little Susitna River and climbs to a maximum elevation of 1,502 feet near MP 97. The largest continuous section of vertical gain occurs from MP 65 (elevation 346 feet) to MP 97 (elevation 1,502 feet). This 1,156-foot climb over 32 miles results in an average grade of less than 1.0 percent. This climb in elevation is relatively uniform throughout the corridor so a 6.0 percent grade was selected as the maximum running grade, which is consistent with guidance from AASHTO's GDVLVLR. Localized maximum grades for short distances up to 8.0 percent are required to avoid costly alignments. One exception to the maximum running grade only being for a short distance exists at MP 88 where a 0.5-mile section of grade is 7.62 percent to avoid a large cut. A minimum grade of 0.5 percent is recommended for drainage on the gravel surface.

The roadway alignment is based on the selected 45 mph design speed and the criteria outlined in AASHTO's GDVLVLR. The minimum radius of curvature selected is 450 feet. The vertical K-Value for the vertical sag and crest curves is 79 and 42 minimum, respectively. The stopping sight distance for drivers to react to an object or vehicle in the roadway is 300 feet minimum.

AASHTO's GDVLVLR does not generally recommend a clear zone since run-off-the-road incidents on low-volume roads are rare; however, when roadside hazards are severe a clear recoverable area should be considered. The GDVLVLR also states a clear zone should be considered when it can be accomplished at low cost and with minimal social/environmental impact. Hazards may include fixed objects near the edge of road, tall embankment heights with non-recoverable side slopes steeper than a rate of 3 feet horizontal to 1 foot vertical, and water deeper than 3 feet adjacent to a non-recoverable embankment slope. These hazards are encountered throughout the corridor study area and are most common in the mountainous areas from MP 87 to the end of the alignment. The roadway top width of 24 feet includes 2 feet of clear zone on each side, representing the average clear-zone width expected throughout the entire corridor length used for this study. Additional analysis is recommended during future design stages to review and recommend locations were clear zone is not recommended and locations where a wider clear zone can be accomplished at low cost with minimal social and environmental impacts. Examples of social and environmental impacts to consider a when evaluating a wider clear recovery area are; nearby infrastructure, wetlands, private property, trail heads, artifacts of historical significance, and cost implications. Engineering judgement for site specific conditions will be needed to identify suitable clear zone widths.

The recommended cross-slope for a road with a gravel surface is 3 percent for drainage. If final design geometrics require super elevation, a maximum rate of 4 percent is recommended for snow and ice conditions and to account for vehicles with large loads.

2.2.3. Roadway Structural Section

The recommended structural section is shown in Figure 2.

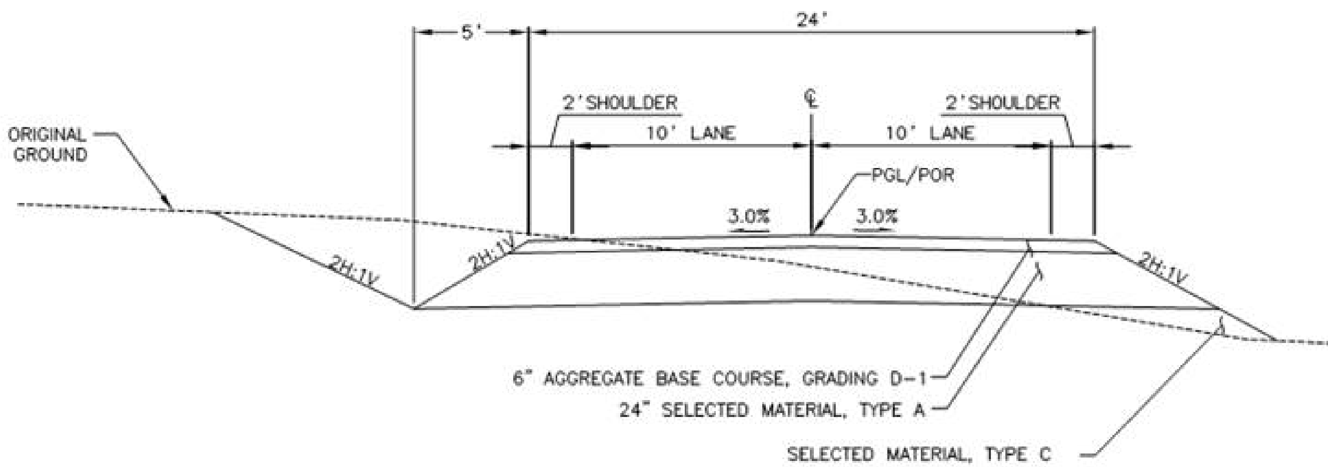

Figure 2. Roadway Typical Section

The materials shown in the typical section are standard Alaska Department of Transportation and Public Facilities (DOT&PF) materials as designated in *Standard Specifications for Highway Construction* (DOT&PF 2020a). Table 1 provides a general description of these materials.

Table 1. DOT&PF Material Descriptions

DOT&PF Standard Material Designation	Specification Section (DOT&PF 2020a)	Description
Aggregate Base Course, Grading D-1	703-2.03	Non-frost susceptible crushed stone or crushed gravel with a gradation of 1 inch minus
Selected Material, Type A	703-2.07	Non-frost susceptible aggregate containing no muck, frozen material, roots, sod, or other deleterious matter; plasticity index not greater than 6; gradation of 20–60% passing No. 4 sieve and 0–6% passing No. 200 sieve
Selected Material, Type C	703-2.07	Earth, sand, gravel, rock, or combinations thereof containing no muck, peat, frozen material, roots, sod, or other deleterious matter and that is compactable

In locations with soft spots or poor underlying material, additional Selected Material, Type A, or geo-fabric may be required.

While West Susitna Access is not a DOT&PF-led project, use of standard DOT&PF materials will benefit the project because of the familiarity with material specifications among Alaska road construction contractors.

3.0 Geotechnical Considerations

3.1. Regional Geology

Much of the West Susitna Access project study area is within an area known geologically as the Susitna Lowlands. The Susitna Lowlands are bound on the north and west by the Alaska Range, and bound on the east by the Talkeetna Mountains and Cook Inlet. The topography is generally flat to rolling hills but gains relief in the project area near the foothills of the Alaska Range. Glaciers populate the mountains and extend down valleys to near the limits of the lowlands. Numerous periods of glaciation have played a part in creation of the project area terrain and deposits that form the lowlands. Glacially carved bedrock, moraines, drumlins, and terraces are representative of the landforms occurring within the proposed road corridor. The following sections discuss the regional bedrock geology, soil stratigraphy, tectonics, seismicity, and permafrost conditions.

3.1.1. Bedrock Geology

Bedrock within the proposed road corridor east of the Susitna River is overlain by glacial drift deposits, and no outcrops or shallow occurrences are known. Bedrock outcrops at both banks of the Susitna River crossing are mapped as granodiorite. Bedrock occurrences within the proposed road corridor west of the Susitna River include plutonic and metamorphic outcrops near and within the proposed road corridor west of the Susitna River. Bedrock west of the Susitna River includes granite, granodiorite, metasedimentary rock, and some volcanic and miscellaneous intrusive rock. Notable bedrock outcrops occur at identified crossings of the Skwentna and Happy Rivers.

3.1.2. Quaternary Deposits

Quaternary sediments derived from glacial and erosional processes are characteristic within the lowlands and predominant along the road corridor. Glacially derived soil (glacial drift) materials may consist of till, outwash, and glaciolacustrine or glacioestuarine sediments. Glacial till is typically randomly sorted and consists of relatively equal fractions of silt, sand, and gravel as well as some cobble- and boulder-sized particles. Outwash materials generally consist of cleaner sand and gravels that may be well or poorly graded. Glaciolacustrine deposits of fine sand, silt, or clay occur in localized areas that were once occupied by moraine or glacially dammed lakes. Glacioestuarine deposits are composed of well-bedded and sorted medium to coarse sand with some interbeds of fine gravel.

Younger deposits of sand and gravel occur in localized areas in river or stream valleys, and in alluvial fans as mixed coarse sediments. Colluvial deposits of mixed coarse and fine soil are evident along toe slopes of Mount Susitna and Beluga Mountain. In addition, volcanic ash layers have been observed throughout the proposed road corridor, with layers up to 2 feet thick in localized areas.

The primary surficial soils occurring along the road corridor can be grouped into the following four major types based on the geologic processes involved in their formation:

- Alluvial/fluvial

- Colluvial
- Glacial outwash and glacioestuarine
- Glacial till

The following subsections summarize general descriptions of these principal soil types.

ALLUVIAL/FLUVIAL

Alluvial and fluvial soils along the proposed road corridor are generally recent sand and gravel deposits, characterized by fine to coarse gravels and sands with little to some silt. Typically, these soils will be encountered at or near active and relic stream floodplains and alluvial fans.

COLLUVIAL

Colluvial soils have been transported downslope as a result of rainwater or downhill creep. Colluvium is generally heterogeneous, unsorted material of a wide range of particle sizes, depending on the source material characteristics. Talus and landslide debris are also considered colluvial deposits. These soils may be encountered at intervals along the toe slope of Mount Susitna and Beluga Mountain. Other limited occurrences may be at the toe of Long Lake Hills.

GLACIAL OUTWASH AND GLACIOESTUARINE

Glacial outwash deposits—consisting of fans, terraces, and broad plains—along the route were generally formed by streams originating near ancestral glacial margins or by side-glacial and proglacial meltwater streams. These soils are composed of stratified drift of gravel with sand and silt lenses and glaciofluvial gravel, sand, and silt. The soil gradation covers a wide band of clast sizes, from gravel to sands and silts. Glacioestuarine deposits are predominant on the flats from the Little Susitna to the Susitna River. These deposits are described as chiefly well-bedded and sorted, medium to coarse sand, including some interbeds of fine gravel. Surface mapping indicates the presence of relic beach ridges and sand dunes.

GLACIAL TILL

Glacial till soils are generally unsorted mixtures of gravel, sand, silt, and clay deposited by glacial ice. Cobbles and boulders may be present. This soil type is predominant over much of the proposed road corridor west of the Susitna River.

3.1.3. Tectonics and Seismicity

The project region is one of the most seismically active areas in the Unites States, and has been historically subjected to relatively large earthquakes. According to the Alaska Earthquake Information Center, three large (greater than magnitude 7) earthquakes have occurred within or near the project area over the past 90 years. Hundreds of smaller earthquakes have also been recorded. Much of the information presented in this section is based on Alaska Division of Geology and Geophysical Surveys (DGGS) Miscellaneous Publication 141 (Koehler et al. 2012). In terms of engineering significance, three broad seismic sources may present hazards in the project area. Nearest the project area, the Denali Fault System was responsible for the 2002, magnitude 7.9, Denali Fault earthquake. Associated surface rupture was documented for hundreds of kilometers along the fault trace. The Alaska-Aleutian Subduction Zone, a mega-thrust source at the interface between the North American and Pacific Plates was the source of the 1964, magnitude 9.2, Great Alaska Earthquake. The 2018, magnitude 7.1, Anchorage Earthquake was centered near the east end of the project area.

Other shallow crustal sources, such as the Castle Mountain Fault on the south end of the Susitna lowlands, may also impact the project area. It is postulated that the Castle Mountain Fault can produce earthquake magnitudes up to 7.5. Displacement along the Castle Mountain Fault is visible in the landforms across the Susitna flats, and is easily identifiable as a pronounced landform feature crossed by the proposed route approximately 5 miles southeast of the Susitna River crossing location. The relatively recent Pass Creek Fault is centrally located in the Susitna lowlands, with northeast to southwest trending surface expressions mapped west of Mount Yenlo and the Kahiltna River. The fault has been identified as a northward-dipping reverse fault with displacement of fewer than 0.2 millimeter per year, and most likely will be a source of earthquakes with magnitudes between 4.0 and 6.0. In addition, the Bruin Bay Fault has been mapped along the base of Mount Susitna, trending northwest toward Beluga Mountain along the mountain front. This fault is a high-angle reverse fault with several hundred meters of displacement, but it is not considered to be an active fault system.

3.1.4. Permafrost

Permafrost is defined as soil or rock beneath the ground surface where a temperature below 32 degrees Fahrenheit has existed for 2 or more years. Permafrost within the project area is limited to isolated masses of permafrost or discontinuous permafrost of limited extent. Generally, the project area is free from significant permafrost. Isolated masses and discontinuous permafrost will likely be found in fine grained soils, while coarse grained soils are typically free from permafrost. Thick surface layers of organic soils can provide insulation for permafrost soils. Any permafrost in the project area will be relatively warm, and will begin to degrade if the thermal regime is adversely impacted by modifications to the ground surface. Depth of permafrost is variable, especially in areas of discontinuous permafrost, and depend upon exposure, ground cover, soil characteristics, and other factors. The thickness of the active layer is largely dependent on soil type, ground cover, and snow depth. In general, the active layer for any permafrost within the project is likely more than 15 feet below the ground surface.

3.1.5. Geohazards

Geohazards are geological and environmental conditions, and involve long- or short-term geological processes. Geohazards can be relatively small features, but they can also attain expansive dimensions (e.g., surface landslide). Regional geologic processes will have a significant impact on the design and performance of roads or structures in the project area. Such processes include stream icing, slope instability, flooding, and seismic influences (e.g., ground motions, liquefaction, lateral spreading, etc.). Many of these processes are complementary and should be evaluated separately as well as in relation to each other. For example, seismic influences such as liquefaction can cause damaging settlement, but can also contribute to slope instability and flooding. Similarly, flooding can produce damaging erosion and deposition of material, but can also instigate slope instabilities (in previously stable areas) through erosion. The proposed road corridor is subject to most, if not all, of these regional processes. The proposed alignment was selected to avoid or minimize the known potential hazards and no hazards, outside the ordinary, are anticipated.

3.2. Geologic Considerations

The PMR originates from the Little Susitna River Access Road and ends north of the Tordrillo Mountains, near the confluence of Portage Creek and the Skwentna River.

From the road corridor origin (MP 0) to approximately MP 5, where the route transitions into the Fish Creek watershed, the alignment passes through mixed terrain of glacial origin, including unconsolidated deposits identified as major moraine and kame deposits, modified glacial deposits, and outwash. West from MP 5 to the Susitna River (MP 17), the route is over glacioestuarine deposits consisting of mostly fine grain soils with some secondary eolian dunes composed of mostly clean sand.

At the Susitna River outcrops of bedrock on both banks are mapped as granodiorite. West of the Susitna River to the slope of Mount Susitna (MP 25), the route passes over additional terrain mapped as glacioestuarine and moraine. Some glacioalluvium is also identified in the terrace adjacent to Alexander Creek.

The lower slopes of Mount Susitna are mantled with undifferentiated glacial till that has been reworked by slope erosion and mass wasting processes. Several small drainage courses dissect the mountain slope. Some areas of shallow, metasedimentary and granitic bedrock at shallow depth may be expected, but are not considered a significant factor in road design or construction.

Further to the north, the route crosses the lower slopes of Beluga Mountain (MP 38 to 49) through primarily modified ground moraine, several glacial outwash terraces, and more recent alluvial creek channels. North of Beluga Mountain, the moraine is hummocky, with some outwash terraces to a few miles beyond the Skwentna River crossing.

From the Skwentna River crossing (MP 56), the route roughly parallels the Skwentna River, trending with a fluted till plain or drumlin field comprising low, elongate, streamlined hills with intervening, similarly elongated swamps and small lakes that reflect the direction of ice flow during the last glacial advance. Several linear features are crossed that appear to relic channels containing deposits of glacioalluvium.

The land beyond the area of Finger Lake (MP 82) is considered the Alaska Range physiographic region, where the route proceeds along a broad, glaciated valley drained by the Skwentna River and continues along the south toe slope of Long Lake Hills (MP 98) to the crossing of Portage Creek (MP 99). The valley bottom is predominantly covered by ground moraine consisting of gravelly (sometimes cobbly) silt and sand till that has been sculpted into long, streamlined hills or drumlins with intervening elongate ponds and boggy areas. Bedrock may be shallow in some areas beneath till in this glacial scoured valley.

3.2.1. Soil Borrow Availability

In general, soil borrow materials, which should be suitable for Selected Material, Type A, and Type C, are available along the proposed road corridor. Most cuts will produce material that can be used as Selected Material, Type C, for fills.

3.2.2. Soil Borrow Quality

Quality of soil borrow is expected to be good to excellent over much of the PMR alignment.

3.2.3. Gravel Borrow Availability

In general, gravel borrow materials suitable for Aggregate Base Course, Gradation D-1, are available at select locations along the proposed road corridor. The haul distance from suitable sources will vary and may exceed 5 miles. Specific locations for gravel borrow will include alluvial fan deposits at the base of Beluga Mountain and Mount Susitna, outwash deposits in the major river floodplains, and select glaciofluvial deposits.

3.2.4. Gravel Borrow Quality

Quality of soil borrow is expected to be good to excellent from select locations within or near the PMR alignment.

3.2.5. Rock Borrow Availability

Rock borrow is considered to be a source of riprap, which is used for erosion and scour protection. Rock borrow sources are generally locations with bedrock outcrops or shallow bedrock. Rock borrow sources within the road corridor are essentially non-existent east of the Susitna River, except for a potential source immediately adjacent to the river. Rock sources are generally available along the route at select locations west of the Susitna River, except for roughly 28 miles between the Skwentna River crossing and Red Creek (MPs 56 to 84). Short spur roads may be required to access suitable rock sources.

3.2.6. Rock Borrow Quality

There is good potential for high quality rock borrow sources at select locations west of the Susitna River.

3.2.7. Foundation Support

In general, foundation support conditions are anticipated to be favorable. Conventional pad and/or pile foundations for bridge structures will be appropriate, and no unreasonable conditions are anticipated. Stream crossings were located to avoid unfavorable foundation conditions. Permafrost will not be a concern at structure foundations.

3.2.8. Permafrost

The potential for permafrost along the proposed road corridor is expected to be limited. Permafrost soils can be expected in higher elevations and on the north side of topographic high areas, especially at the northern extent of the route. Some of the low, poorly drained, boggy areas may also be underlain by permafrost soils, but known permafrost soils were largely avoided in selection of the route.

3.2.9. Subgrade Support

In general, subgrade support is anticipated to be variable but typically good to excellent over most of the proposed route. Limited crossings of marshy areas will require application of appropriate embankment designs typical for crossing of soft subgrades with peat and ash.

3.2.10. Drainage

Given that the selected route is predominantly on upland terrain with reasonable slopes, drainage issues will be minimal. Application of typical drainage plans and structures will be all that is required.

3.3. Geotechnical Engineering Considerations

3.3.1. Susitna Flats Segment (23 Miles)

This segment extends west from the origin point on Little Susitna River Access Road to Alexander Creek (MP 21), west of the Susitna River. Existing mapping shows the alignment crossing almost exclusively glacial moraine and kame deposits, except for alluvial terrace deposits adjacent to Alexander Creek and the Susitna River. It is also evident from U.S. Geological Survey (USGS) mapping that the land between the Little Susitna River and Susitna River contains of many scattered, low-lying, poorly drained, boggy areas that have been mostly avoided by careful alignment selection across the low Fish Creek Terrace. The road segment traversing the glacioestuarine deposits between the Little Susitna River (MP 1) and Susitna River (MP 17) may require a full structural embankment constructed of imported material. Sources of material borrow along much of this alignment segment are anticipated to be available; however, the quality of the material yielded from these sources (other than those in alluvium near the Susitna River and Alexander Creek, and reworked glacial deposits east of the Little Susitna River) may be relatively low with elevated fines contents. The only potential source for rock that is evident along the alignment is mapped as a granodioritic pluton on the west side of the Susitna River crossing, and possibly on the east side as well.

Given the presence of a few interspersed boggy areas along this alignment, variable subgrade support conditions and a few transitions between soft and firm subgrades are anticipated. Foundation conditions for the crossing at the Susitna River appear to be relatively favorable, with the potential for shallow bedrock at both banks. It is possible that foundations on the east and west side of the Susitna River could be cast directly on shallow bedrock if soil overburden is thin at the chosen abutment location. The crossing of Alexander Creek appears as though it will be supported by alluvial soils on both sides. Pile foundation depth will be dictated by anticipated loads, soil density, scour depth, and liquefaction potential, but will likely need to be set to significant depth.

Permafrost soils are not anticipated along this segment of the alignment. Other geologic hazards along this alignment appear to be limited to potentially liquefiable soils near the river crossings and bluffs adjacent to the Susitna River floodplain. The Castle Mountain Fault is crossed at a skew near MP 12. The proposed Little Susitna River and Susitna River bridge crossing locations are approximately 7 and 5 miles, respectively, from the Castle Mountain Fault and approximately 10 and 23 miles, respectively, from the magnitude 7.1 2018 Anchorage Earthquake epicenter. These seismic factors will need to be considered when designing these bridges.

3.3.2. Mount Susitna/Beluga Mountain Segment (33 Miles)

This segment from Alexander Creek (MP 21) to the Skwentna River (MP 56) trends along the bases of Mount Susitna, Little Mount Susitna, and Beluga Mountain. Based on mapping, the alignment generally traverses the boundary between exposed or shallow bedrock in uplands to the southwest and various glacial deposits in lowlands to the northeast. Mapping and landforms suggest that borrow material deposits are variable, ranging from glacial tills, outwash, and isolated alluvial deposits, which should yield a variety of materials with variable quality. The road embankment over some intervals may be constructed using soil taken from cuts or exposed by topsoil removal. In other areas over till with high fines content, the embankment will require imported fill. Most of the alignment traverses sloping terrain, and the ground is generally well drained, except for a few isolated, low-lying, boggy areas near the middle and north end of the alignment. Mapping shows that most of the rock materials that comprise the hills to the southwest consist of metamorphosed volcanic and sedimentary rocks. Rock quality and durability from these types of rock can be highly variable, but at a minimum they should provide materials suitable for embankment development.

Numerous minor stream crossings exist along this segment of the alignment. Most of the stream crossing structures may be supported on good soils using conventional foundation systems.

Permafrost is not anticipated to be an issue along this segment of the alignment. Geologic hazards to consider may include aufeis at stream crossings and proximity to faults, which if they become active could induce ground motion affecting structures as well as stability of slopes and embankment fills.

3.3.3. Skwentna River to Red Creek Segment (28 Miles)

This alignment segment (MPs 56 to 84) generally trends east to west, and typically follows topographic highs associated with linear moraines that roughly parallel the Skwentna River. In addition to utilizing the morainal ridges, the alignment also trends close to the Skwentna River Bluffs and near the head of many minor drainages that shed into the Skwentna River. This takes advantage of better drained terrain and helps to avoid wetlands. In general, the alignment is well drained due to natural slopes and selection of a route on favorable soils. The few marshy areas that must be crossed will require an elevated embankment and a design that accommodates a layer of peat in the subgrade.

Borrow material availability is anticipated to be relatively abundant along this alignment segment given the terrain features and proximity to Skwentna River floodplain, which includes abundant, accessible alluvial gravel. The alignment should be able to take advantage of numerous short cut sections that are likely adjacent to short fill sections over boggy areas. However, given that much of the soil is glacial till, it is likely that the soil quality will be variable and could have elevated fines contents. The glacial outwash and alluvial deposits mapped along the alignment may yield potentially high quality, low fines content, well-graded sands, and gravels that could be used as structural fill for road sections. Rock materials are not available along this alignment section, and if required will have to be imported from sources in the Skwentna River Valley segment or possibly from near the Skwentna River crossing.

Foundation conditions at the Shell Creek crossing (MP 58) are not anticipated to be on bedrock, but are likely good given that much of the soils along the alignment have been glacially overridden. It is likely that the structure will need to be supported by pile foundations, but piles will likely not need to be driven to great depths (more than approximately 60 to 80 feet) to reach competent support soils.

The potential for permafrost along this segment of the alignment is minimal. However, some of the low, poorly drained, boggy areas may also be underlain by permafrost soils. Isolated areas of potentially liquefiable soils that may be susceptible to lateral spreading or seismically induced settlement may exist, and can be addressed in design. In addition, although the surrounding terrain is generally subdued along the alignment, there may be isolated areas of slope instability in soil slopes near deeply incised river channels (or river terraces near major rivers) that will also need to be addressed in design.

3.3.4. Skwentna River Valley Segment (16 Miles)

The Skwentna River segment generally trends east-west along the north side of Skwentna River on benches and terraces between the river and mountains (MPs 84 to 100). This segment generally traverses well-drained, alluvial terraces and morainal ridges. It is likely that borrow materials along most of this alignment segment are abundant and of relatively high quality. In addition, rock materials are available in the adjacent mountains and likely at shallow depth on low ridges transected by the alignment. Rock type appears to consist of a mixture of igneous and metamorphosed sedimentary rocks. In general, it is likely that the igneous rock will yield higher quality, more durable material than the metamorphic rocks.

This segment of the alignment contains major stream crossings at Happy River (MP 92) and Portage Creek (MP 99). The foundation support conditions for these crossings will likely be relatively favorable, and may consist of pad foundations in alluvial soil or pile foundations in alluvial soil founded on bedrock. At the Happy River crossing, bedrock, consisting of turbiditic sedimentary rock of variable quality, is exposed in the canyon walls and appears to be overlain by outwash gravels to depths of 50 to 100 feet.

Isolated occurrences of permafrost soils may be encountered along the western half of this segment of the alignment where it crosses low areas between ridges. However, if permafrost soils are present, they are likely thaw stable and should not be difficult to account for in the design. No other specific geohazards have been identified within this alignment segment.

4.0 Stream Crossing Design

Minimizing and, where possible, completely avoiding impacts to fish habitat, especially anadromous fish, is a concern for permitting any road project in Alaska. Environmental permits require that bridges and culverts located in fish bearing streams be designed to allow fish passage. Fish passage culverts are more difficult and expensive to build than drainage-only culverts. Therefore, there is a large cost benefit to determining early in the design which streams crossed by the proposed road are likely to have fish.

4.1. Stream Crossing Categorization Methodology

Fish presence information for streams along the proposed route varies and is discontinuous. The Alaska Department of Fish and Game (ADF&G) Alaska Freshwater Fish Inventory (AFFI) contains fish presence data collected and maintained by ADF&G (2020a). The ADF&G Anadromous Waters Catalog (AWC) is a similar dataset covering anadromous fish presence, spawning, and rearing habitat data collected and maintained by ADF&G (2020b). The National Hydrography Dataset (NHD) is a database of a variety of waterbody information maintained by USGS (2020). The AWC, AFFI, and NHD were used as the primary sources of information for determining if streams crossed by the proposed PMR alignment need to accommodate fish passage.

For this effort, HDR first developed a geodatabase listing all 156 streams crossed by the proposed route, assigning a unique identifier code for each crossing, and estimating the stream width at each crossing. Select information from the database is provided in Appendix A. For the purpose of this study, a stream is defined as any flowing waterbody that is either documented in existing mapping and databases or is visually apparent as a flowing waterway based on aerial imagery and topographical data. It is anticipated that the 156 identified streams can be described as perennial, intermittent, and possibly ephemeral. By definition, creeks and rivers are included as streams.

The stream width was determined from wetland and waterbody map data using an algorithm that automatically measured waterbody polygon width within the database. The resulting measurement approximates stream width at ordinary high water (OHW) level. The stream width values were then spot-checked by manual measurement of stream width from aerial imagery, especially the larger stream crossings. HDR decided on use of a culvert or bridge based on the OHW stream widths, stream characteristics, and various topographic considerations. Eleven of the 156 crossings were determined to require bridges, and the rest culverts.

To determine the size and type of culvert needed for each crossing, HDR populated the database with available fish presence information from the AWC, AFFI, and NHD. Many streams along the proposed route have never been studied for fish presence. If a stream is not indicated as fish bearing by AWC, AFFI, or NHD, that does not necessarily mean the stream does not have fish. Therefore, HDR evaluated those streams not indicated as fish bearing by AWC, AFFI, or NHD and labeled them as “probable” fish presence if the stream had a direct connection to a known fish bearing stream and no apparent barriers to fish passage visible in aerial imagery.

The results of this analysis are not conclusive and should be used for planning purposes only. As the West Susitna Access project advances, field studies will be needed to verify fish presence and other stream characteristics.

4.2. Culvert Categorization

Culvert crossings are categorized based on stream width and fish presence to simplify stream crossing selection around a series of standardized, conceptual, culvert design categories as shown in Table 2. Categorization of streams and design of stream crossings could change based on the results of future field studies, especially the verification of fish presence. Fish presence increases permitting efforts and drives the requirement for fish passage design, which increases design effort and construction costs.

Table 2. Culvert Categories

Culvert Category #	Crossing Type & Size	Mapped Stream Width at Ordinary High Water (OHW)	Design for Fish Passage?
1	Circular culvert 3-foot diameter	Installed as needed during road construction for cross drainage; not for mapped streams	No
2	Circular culvert 4-foot diameter	Up to 2 feet	No
3	Circular culvert 8-foot diameter	>2 to 6 feet	No
4	Circular culvert 8-foot diameter	Up to 6 feet	Yes
5	Pipe arch culvert 8 feet tall by 14 feet wide	>6 to 10 feet	No
6	Pipe arch culvert 8 feet tall by 14 feet wide	>6 to 10 feet	Yes
7	Structural plate pipe arch or aluminum box culvert; site-specific size	>10 feet	Yes

Culvert design for this project has been broken into two broad categories: drainage culverts (Categories 1, 2, 3, and 5) and fish passage culverts (Categories 4, 6, and 7). Table 3 provides a breakdown of the numbers of culverts in each category.

Table 3. Culvert Counts by Category

Culvert Category #	Drainage vs. Fish Passage	Count
1	Drainage	Determined in final design
2	Drainage	31
3	Drainage	24
4	Fish Passage	72
5	Drainage	0
6	Fish Passage	12
7	Fish Passage	6
	Total Drainage Culverts	**55**
	Total Fish Passage Culverts	**90**
	Total Culverts	**145**

4.2.1. Drainage Culverts

The design basis for drainage culverts (Categories 1, 2, 3, and 5) is the *Alaska Highway Preconstruction Manual* (DOT&PF 2020b) and *Alaska Highway Drainage Manual* (DOT&PF 2006). These manuals require drainage culverts to pass a specified design flood event without major impacts. HDR's experience from road drainage design statewide indicates that for similar streams, if the culvert diameter is greater than the OHW width, then the design criteria in these DOT&PF manuals will be met. This method is applied for this effort to simplify design, improve constructability, and allow for additional capacity should ice form in the culverts. Additional Category 1 culverts may be required to equalize water levels on either side of the road prism in isolated locations without defined channels. These locations will be defined during the final design phase of the project. It should be noted that the *Alaska Highway Preconstruction Manual* requires a minimum drainage culvert 2 feet in diameter. The minimum size proposed for this project is 3 feet in diameter to minimize ponding potential, improve constructability, and allow for break-up flow capacity if ice forms in the culverts.

4.2.2. Fish Passage Culverts

Since the West Susitna Access project is a state-led project, the minimum design basis for fish passage culverts is assumed to be the *Alaska Highway Preconstruction Manual* and the Memorandum of Agreement between ADF&G and DOT&PF for the Design, Permitting, and Construction of Culverts for Fish Passage (ADF&G and DOT&PF 2001). Fish passage culverts should also be designed in accordance with the standards developed by the U.S. Fish and Wildlife Service (USFWS 2020) and the MSB (2020). The standards for the design of fish passage culverts in the above guidance documents are intended to be the minimum standards. Site-specific improvements should be incorporated during the final design and permitting phases of the project. Fish passage culverts are identified in Table 2 as Categories 4, 6, and 7. In general, engineered substrate designed to remain stable during design flood events will be placed inside the culverts to construct a stream channel closely matching the dimensions up and down stream of the crossing. See Figure 3 for an illustration of a Category 6 fish passage culvert.

Fish passage culvert planning and design should use the following criteria:

- Culvert width not less than the greater of: 1.2 times OHW width or 1.0 times bankfull width
- Culvert slope should be equal to channel bed slope, but no greater than channel bed slope plus 1 percent
- Culvert invert burial: 0.4 times culvert diameter for circular culverts or 0.2 times culvert height for arch culverts; burial is measured at the channel bottom
- Substrate will remain stable up to and including the 50-year discharge
- Culverts will span the entire roadway toe of fill width plus one-half of the culvert diameter beyond the toe of fill
- Inlet and outlet protection should extend 2 times the culvert diameter from culvert ends

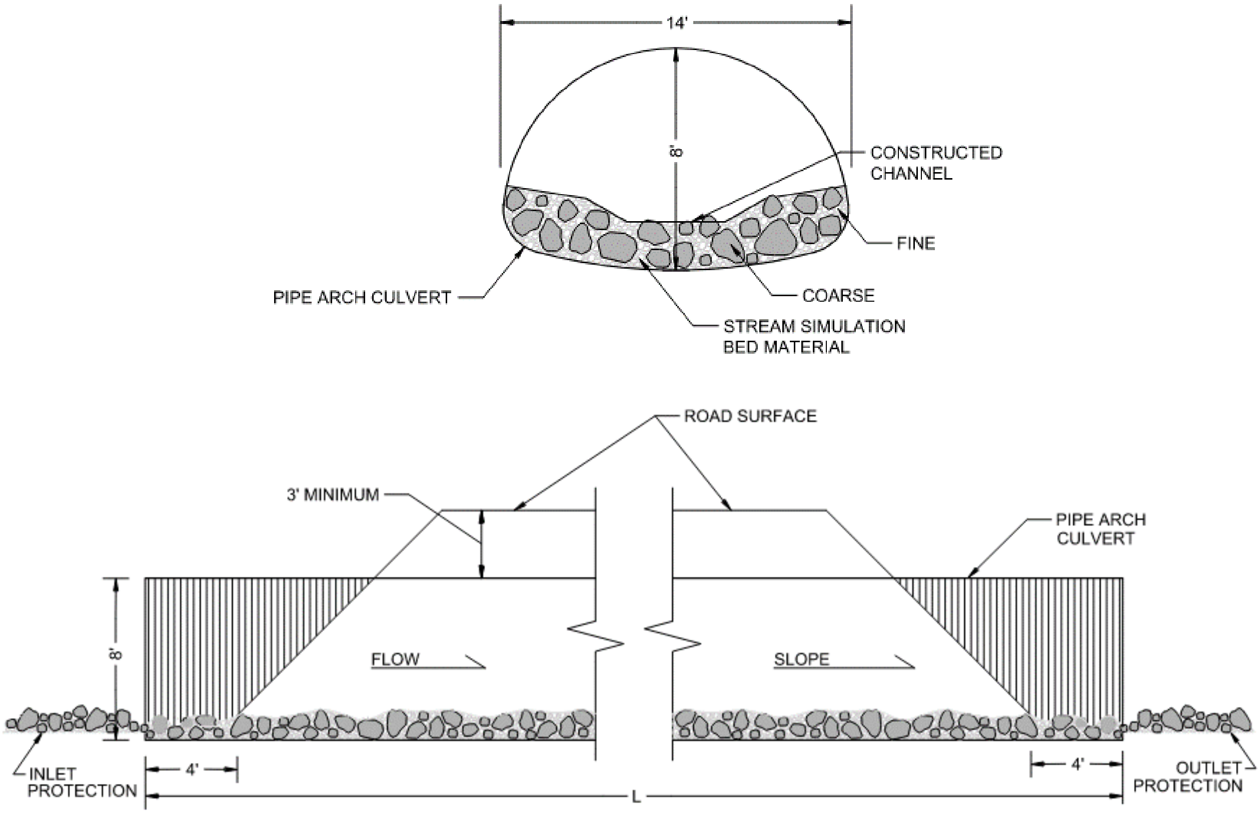

Figure 3. Typical Section and Profile of a Category 6 Fish Passage Culvert (not to scale)

4.3. Bridges

Eleven streams along the proposed route will require bridge crossings. These locations are shown in Table 4.

Table 4. Bridge Crossings

Stream Name	Approximate Milepost	Approximate Length (feet)	Approximate Number of Spans	Comments
Little Susitna River	1	250	3	Routine bridge; will require a U.S. Coast Guard (USCG) permit
Fish Creek	7	140	1	Routine bridge
Susitna River	17	2,160	15	Complex bridge; multiple in-water piers; likely will require long span for a navigational opening; will a require USCG permit
Alexander Creek	21	260	3	Routine bridge; may require a USCG permit
Wolverine Creek	28	140	1	Routine bridge
Bear Creek	38	120	1	Routine bridge
Upper 8 Mile Creek	50	200	3	Routine bridge
Skwentna River	56	600	3	Complex bridge; high banks; will require a USCG permit
Shell Creek	58	190	3	Routine bridge
Happy River	92	600	3	Complex bridge; high banks
Portage Creek	99	550	3	Complex bridge; high banks

4.3.1. Bridge Width

Bridges will initially be constructed to accommodate two 12-foot-wide lanes with 2-foot shoulders, resulting in an overall width of approximately 31 feet to allow for a railing system on each side.

4.3.2. Bridge Length

Bridge lengths were approximated using the following methodology and assumptions.

Aerial photography and topography were examined to identify approximate bankfull width of waterways. A 25-foot setback from the bankfull edge of the waterway or adjacent wetland boundary was maintained to the toe of end slopes. End slopes are proposed to be 2 Horizontal (H):1 Vertical (V).

Example: The bankfull width of a hypothetical stream is 20 feet. The vertical distance from existing ground at the toe of the end slopes to finished grade is 15 feet. The total bridge length required is calculated as follows:

20-foot bankfull width + (2 * 25-foot setbacks) + [2H/1V * 15 feet] * 2 end slopes = 130 feet

This method of approximating bridge length is suitable for conceptual cost estimating purposes. As the project progresses, bridge lengths will be refined with more detailed topographic survey, hydraulic analysis, regulatory agency consultation, and structural/geometric optimization.

4.3.3. Bridge Clearances

Bridges over jurisdictional waters in Alaska typically do not have prescribed horizontal and vertical clearance requirements. Instead, these clearances are usually negotiated on a case-by-case basis during the permitting process with the governmental authority having jurisdiction. The U.S. Coast Guard (USCG) has jurisdiction over navigable waterways, and a Rivers and Harbors Act Section 9 permit will be required to construct the proposed bridges over navigable waterways. Navigable waterways within the proposed road corridor include the Little Susitna River, Susitna River, Alexander Creek, and Skwentna River.

For the purpose of this study, the minimum vertical clearance (OHW elevation to the lowest bridge superstructure member) is assumed to be 15 feet. This assumption is based on the need to allow passage of recreational traffic (e.g., boats, airboats, snow machines, mushers, etc.). For the Susitna River, the minimum vertical clearance is assumed to be 35 feet to allow for the passage of commercial vessels (e.g., barges). The Susitna River bridge is also likely to be required to include at least one wider navigation span, possibly as wide as 250 feet, for horizontal clearance of commercial vessels. Navigation span clearances for bridges over navigable waterways will be evaluated and refined through the USCG consultation and permitting process.

4.3.4. Bridge Types

Bridges were categorized as either routine or complex. A bridge location was deemed to be complex if there were observed features at the site that may lead to construction complexities that will in turn affect the probable construction costs. Some of these complexities may include a deeply incised stream, tall piers, long spans, or extensive in-water construction work. For the purpose of this study, the following four bridges were deemed to be complex: Susitna River, Skwentna River, Happy River, and Portage Creek. The remaining bridges were deemed to be routine.

4.3.5. Bridge Spans and Construction Methods

Routine bridges will be constructed using DOT&PF-standard precast deck bulb-tee girders, which allow spans up to approximately 140 feet. Some of the shorter crossings (Fish Creek, Wolverine Creek, and Bear Creek) can be accomplished with a single span. The longer routine bridges (Little Susitna River, Alexander Creek, Upper 8 Mile Creek, and Shell Creek) range in length from 190 to 260 feet. These crossings will generally be accomplished with a longer center span (to avoid in-water piers) and two shorter end spans.

The Susitna River bridge is envisioned to consist of up to fourteen shorter spans (approximately 130 to 140 feet) using DOT&PF-standard precast deck bulb-tee girders and one longer navigation span of 250 feet using structural steel plate girders. Bridge piers will be relatively tall and will require in-water construction work. Future engineering studies should explore the tradeoff of using longer-span structural steel plate girders for all of the spans to reduce the number of piers and possibly reduce cost. See Figure 4 and Figure 5 for helicopter-view photographs of the proposed Susitna River crossing location.

The three shorter complex bridges (Skwentna River, Happy River, and Portage Creek) range in length from 550 to 600 feet. Each of these crossings will likely consist of three long spans, approximately 180 to 220 feet per span. These streams are in deeply incised canyons, which will necessitate tall and expensive piers. Using longer spans reduces the number of tall piers required. These longer spans will be accomplished with structural steel plate girders and a cast-in-place concrete deck. As currently designed, the approximate bridge heights (bridge deck elevation to water surface elevation) of these three crossings are:

- Skwentna River: 140 feet
- Happy River: 160 feet
- Portage Creek: 100 feet

See Figure 6 through Figure 8 for helicopter-view photographs of the proposed crossing locations of Skwentna River, Happy River, and Portage Creek, respectively.

Figure 4. Susitna River, Looking West, in Approximate Alignment with the Proposed Route

Figure 5. Susitna River, Looking North (upstream) at the Proposed Crossing Location

Figure 6. Skwentna River, Looking South (upstream) at the Proposed Crossing Location

Figure 7. Happy River, Looking North (upstream) at the Proposed Crossing Location

Figure 8. Portage Creek, Looking West (upstream) at the Proposed Crossing Location

5.0 Opinion of Probable Capital Cost

An Opinion of Probable Capital Cost (OPCC) was prepared for the PMR alignment, detailed in the previous sections, by quantifying major components and applying average unit costs. Average unit prices were gathered from historical bid prices and adjusted to match the quantities of scale expected on this project. Roadway items that were quantified were: clearing and grubbing, excavation, embankment, structural section, guardrail, topsoil, and seeding. These items, combined with the bridge and multi-plate arch quantities, were used to establish a basis of estimate.

Estimated bridge construction costs of $350 and $450 per square foot of deck area were used for routine and complex bridges, respectively. These values were selected from Table 8-1 of the *Alaska Bridges and Structures Manual* (DOT&PF 2017), which lists the range for prestressed concrete deck bulb-tee girder bridges as $250 to $350 and the range for steel plate girder bridges as $300 to $450. Maximum values were used in each case to account for cost inflation since 2017.

Ancillary construction items such as drainage measures, erosion and pollution control, surveying, construction traffic control, contractor furnished items, and mobilization were computed as a percentage of the estimate basis. These items were computed using historical average percentages from Alaska highway projects and adjusted slightly to better match the specific characteristics of this project. For instance, drainage measures have historically added an average of 3 percent of the estimate basis to the overall construction costs, but this percentage was increased to 5 percent to account for the high amount of wet areas the roadway will encounter and the additional cost and complexity of fish passage culverts. Similarly, traffic control historically adds 3 percent to the estimate basis, but this was reduced to 1 percent on this project due to the lack of existing traffic. The estimate basis and ancillary items account for the total construction costs for the project. A contingency was added to the construction subtotal of 25 percent to account for this high-level preliminary study. Construction administration costs of 15 percent, environmental and permitting costs of 3 percent, design costs of 8 percent (reduced from the historical average of 10 percent due to less complexity), a budget for ROW survey and platting, and a budget for ROW acquisition were added to the construction total to generate the total project cost of $356,900,000 as shown in Table 5.

Table 5. Opinion of Probable Capital Cost

Item	Amount
Roadway Construction	$100,898,806
Structures-Bridge and Multiplate Arch	$70,569,500
Ancillary Items	$50,600,000
Contingency (25%)	$55,517,076
Construction Subtotal	$277,586,000
Construction Administration (15%)	$41,638,000
Environmental, Permitting and Surveying (5%)	$13,880,000
Design (8%)	$22,207,000
ROW Survey and Platting	$1,000,000
ROW Acquisition	$500,000
Total	**$356,900,000**

6.0 Recommendations and Next Steps

The following are recommendations for next steps of project development:

- Environmental baseline studies are a major next step of project development to support the National Environmental Policy Act (NEPA) process and environmental permitting. However, some of the necessary environmental baseline study components will fill gaps in data needed to support preliminary engineering of the route. Conducting the following environmental baseline surveys is recommended as data from these surveys could impact the route alignment, stream crossing engineering, and the OPCC:
    - Fish surveys: This is especially needed for streams that are not currently mapped in the AFFI or AWC. Identification of fish-bearing streams could impact the number of fish passage culverts, a cost consideration.
    - Stream surveys: This is especially needed for larger streams and streams for which the digitally measured width is uncertain. Field verification of stream width, hydraulic characteristics, and terrain could result in culverts changing to bridges or vice-versa.
    - Cultural and historic resources surveys: These resources are known to exist in the project area. For example, a better understanding of the Iditarod Trail, including historical routes, the race trail, and associated easements, is needed to know how the road alignment may need to be modified to avoid impacts and what ROW might need to be acquired from the Bureau of Land Management.
    - Recreational and socioeconomic resources: There are numerous recreational trails, winter roads, and other recreational and socioeconomic resources in the project area. These will need to be mapped and studied so that impacts and mitigation measures can be properly considered in future design refinement.
    - Land ownership research: This is especially needed in terms of private property, Alaska Native allotments, village corporation lands, and restrictions that may exist on land use. For example, a better understanding of the ROW restrictions on Donlin Gold's proposed gas pipeline is needed to verify decisions made regarding the road alignment and avoiding the pipeline.
- Advancement of bridge engineering, at least for the complex crossings and navigable waterways, is needed to gain better certainty in costs. Bridges, especially the complex bridges, are a major component of the project OPCC. A modest investment in hydraulics and hydrology studies, site surveys, and bridge engineering studies would strengthen accuracy in the overall project OPCC. Also, bridges over navigable waterways will require USCG Rivers and Harbors Act Section 9 permits, which may require an additional level of design detail and a longer permitting timeline.
- Preliminary geotechnical investigation is needed to verify initial design assumptions, inform the process prior to permitting, and confirm material borrow availability and quality.
- The footprint of all temporary and permanent construction needs to be identified in order to capture the entire project footprint for a complete Section 404 permit application to the U.S. Army Corps of Engineers. Besides the road itself, permanent construction that needs to be identified would include maintenance facilities, and other similar ancillary facilities.

Temporary construction would include material borrow sites, temporary access roads, winter roads, temporary stream diversions, cofferdams for bridge construction, man camps, airstrips, and construction laydown areas.

- Identification of alternative routes is needed to prepare for the NEPA process. The NEPA and permitting processes require identification and comparison of alternative routes. By identifying alternative routes and performing conceptual engineering and basic baseline study of them, AIDEA will have increased input into the alternatives evaluated during the NEPA review process and can help avoid schedule delays during the NEPA process. Alternative identification and analysis will also help AIDEA confirm its preferred route from an environmental impact and cost perspective.

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Appendix A – Stream Crossing Data

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Stream Crossings

Stream Crossing ID	Stream Name	Fish Presence	Anadromous Fish Presence	Stream Width at OHW (ft)	Crossing Type	Culvert Category	Bridge Length (ft)	Bridge Spans
PMRA101.0		Yes	Yes	25	Culvert	7		
PMRA102.0		Probable	Probable	3	Culvert	4		
PMRA103.0	Little Susitna River	Yes	Yes	95	Bridge		250	3
PMRA104.0	Fish Creek	Yes	Yes	15	Bridge		140	1
PMRA105.0		Probable	Probable	5	Culvert	4		
PMRA106.0		Probable	Probable	3	Culvert	4		
PMRA107.0		Probable	Probable	3	Culvert	4		
PMRA108.0		Probable	Probable	15	Culvert	7		
PMRA109.0		Yes	Yes	4	Culvert	4		
PMRA110.0		Probable	Probable	2	Culvert	4		
PMRA111.0		Probable	Probable	8	Culvert	6		
PMRA112.0		No	No	2	Culvert	2		
PMRA113.0		No	No	2	Culvert	2		
PMRA114.0		No	No	4	Culvert	3		
PMRA115.0		No	No	2	Culvert	2		
PMRA116.0	Susitna River	Yes	Yes	1850	Bridge		2160	15
PMRA117.0		No	No	2	Culvert	2		
PMRA118.0		No	No	1	Culvert	2		
PMRA119.0		Probable	Probable	2	Culvert	4		
PMRA120.0		Probable	Probable	3	Culvert	4		
PMRA121.0		Probable	Probable	1	Culvert	4		
PMRA122.0	Anderson Creek	Yes	Yes	12	Culvert	7		
PMRA123.0		Probable	Probable	3	Culvert	4		
PMRA124.0		No	No	2	Culvert	2		
PMRA125.0		No	No	3	Culvert	3		
PMRA126.0		No	No	1	Culvert	2		
PMRA127.0		Probable	Probable	1	Culvert	4		
PMRA128.0		Probable	Probable	4	Culvert	4		
PMRA129.0	Alexander Creek	Yes	Yes	100	Bridge		260	3
PMRA130.0		No	No	2	Culvert	2		
PMRA131.0		Probable	Probable	1	Culvert	4		
PMRA132.0	Trail Creek	Yes	Yes	12	Culvert	7		
PMRA133.0		Probable	Probable	3	Culvert	4		
PMRA134.0		Yes	Yes	4	Culvert	4		
PMRA135.0		Probable	Probable	3	Culvert	4		
PMRA136.0		Probable	Probable	3	Culvert	4		
PMRA137.0		Probable	Probable	4	Culvert	4		
PMRA138.0		Probable	Probable	4	Culvert	4		
PMRA139.0		No	No	3	Culvert	3		
PMRA140.0		No	No	3	Culvert	3		
PMRA141.0		Probable	Probable	4	Culvert	4		
PMRA142.0		Probable	Probable	2	Culvert	4		
PMRA143.0		Probable	Probable	1	Culvert	4		
PMRA144.0		Probable	Probable	2	Culvert	4		
PMRA145.0		No	No	2	Culvert	2		
PMRA146.0		No	No	2	Culvert	2		
PMRA147.0		No	No	3	Culvert	3		
PMRA148.0	Wolverine Creek	Yes	Yes	25	Bridge		140	1
PMRA149.0		Probable	Probable	5	Culvert	4		
PMRA150.0		No	No	3	Culvert	3		
PMRA151.0		No	No	2	Culvert	2		
PMRA152.0		No	No	3	Culvert	3		
PMRA153.0		Probable	Probable	6	Culvert	4		
PMRA154.0	Upper Sucker Creek	Probable	Probable	12	Culvert	7		
PMRA155.0		No	No	2	Culvert	2		
PMRD156.0		Probable	No	6	Culvert	4		
PMRD157.0		No	No	2	Culvert	2		
PMRA158.0		Probable	Probable	8	Culvert	6		
PMRD159.0		Yes	Yes	8	Culvert	6		
PMRD160.0		No	No	1	Culvert	2		

Stream Crossings

Stream Crossing ID	Stream Name	Fish Presence	Anadromous Fish Presence	Stream Width at OHW (ft)	Crossing Type	Culvert Category	Bridge Length (ft)	Bridge Spans
PMRD161.0		Yes	Probable	3	Culvert	4		
PMRD162.0		Probable	Probable	7	Culvert	6		
PMRD163.0		Yes	Probable	8	Culvert	6		
PMRD164.0		No	No	3	Culvert	3		
PMRD165.0		No	No	3	Culvert	3		
PMRD166.0	Bear Creek	Yes	Yes	20	Bridge		120	1
PMRD167.0		Probable	Probable	3	Culvert	4		
PMRA168.0		Probable	Probable	2	Culvert	4		
PMRD169.0		Yes	No	1	Culvert	4		
PMRD170.0		Yes	No	3	Culvert	4		
PMRD171.0		No	No	3	Culvert	3		
PMRD172.0		Probable	Probable	3	Culvert	4		
PMRA173.0	Texas Creek	Probable	Probable	1	Culvert	4		
PMRD174.0		Yes	No	7	Culvert	6		
PMRD175.0		No	No	2	Culvert	2		
PMRD176.0		No	No	1	Culvert	2		
PMRD177.0		No	No	2	Culvert	2		
PMRD178.0		No	No	2	Culvert	2		
PMRD179.0		No	No	3	Culvert	3		
PMRD180.0		No	No	3	Culvert	3		
PMRD181.0		No	No	2	Culvert	2		
PMRD182.0		Yes	No	3	Culvert	4		
PMRD183.0		Yes	No	2	Culvert	4		
PMRD184.0	Clear Creek	Yes	No	10	Culvert	6		
PMRD185.0		Probable	Probable	3	Culvert	4		
PMRD186.0		No	No	2.5	Culvert	3		
PMRD187.0		No	No	3	Culvert	3		
PMRD188.0		No	No	1	Culvert	2		
PMRD189.0		Yes	No	4	Culvert	4		
PMRD190.0		Yes	No	8	Culvert	6		
PMRA191.0		Probable	Probable	1	Culvert	4		
PMRD192.0		Yes	No	5	Culvert	4		
PMRD193.0		Yes	No	4	Culvert	4		
PMRD194.0		No	No	3	Culvert	3		
PMRD195.0		Probable	Probable	3	Culvert	4		
PMRD196.0		Probable	Probable	3	Culvert	4		
PMRD197.0		Probable	Probable	2	Culvert	4		
PMRD198.0		Probable	Probable	2	Culvert	4		
PMRD199.0		Probable	Probable	2	Culvert	4		
PMRD200.0		Yes	Probable	5	Culvert	4		
PMRD201.0		Yes	Probable	5	Culvert	4		
PMRD202.0		Yes	Probable	10	Culvert	6		
PMRD203.0		Yes	Yes	1	Culvert	4		
PMRD204.0		Yes	Yes	3	Culvert	4		
PMRD205.0		No	No	1	Culvert	2		
PMRD206.0	Upper 8 Mile Creek	Yes	Yes	13	Bridge		200	3
PMRA207.0		No	No	2	Culvert	2		
PMRD208.0		No	No	3	Culvert	3		
PMRA209.0		No	No	0.5	Culvert	2		
PMRD210.0		No	No	3	Culvert	3		
PMRD211.0		No	No	3	Culvert	3		
PMRA212.0		Probable	Probable	3	Culvert	4		
PMRA213.0	Skwentna River	Yes	Yes	240	Bridge		600	3
PMRD214.0		Probable	Probable	5	Culvert	4		
PMRD215.0	Shell Creek	Yes	Yes	18	Bridge		190	3
PMRA216.0		No	No	2	Culvert	2		
PMRD217.0		No	No	2	Culvert	2		
PMRD218.0		Probable	Probable	1	Culvert	4		
PMRA219.0		Probable	Probable	1.5	Culvert	4		
PMRD220.0		Probable	Probable	1.5	Culvert	4		

Stream Crossings

Stream Crossing ID	Stream Name	Fish Presence	Anadromous Fish Presence	Stream Width at OHW (ft)	Crossing Type	Culvert Category	Bridge Length (ft)	Bridge Spans
PMRA221.0		Probable	Probable	1	Culvert	4		
PMRD222.0		Yes	Yes	5	Culvert	4		
PMRD223.0		Probable	Probable	1	Culvert	4		
PMRD224.0		Probable	Probable	1	Culvert	4		
PMRD225.0		Yes	Yes	6	Culvert	4		
PMRD226.0		No	No	4	Culvert	3		
PMRD227.0		No	No	2	Culvert	2		
PMRD228.0		Yes	Yes	15	Culvert	7		
PMRD229.0		Yes	Yes	3	Culvert	4		
PMRD230.0		Yes	Yes	10	Culvert	6		
PMRD231.0		Probable	Probable	1	Culvert	4		
PMRD232.0		No	No	4	Culvert	3		
PMRD233.0		Yes	Yes	3	Culvert	4		
PMRD234.0		Yes	Yes	10	Culvert	6		
PMRA235.0		No	No	1	Culvert	2		
PMRD236.0		Probable	Probable	2.5	Culvert	4		
PMRD237.0		Yes	Yes	3	Culvert	4		
PMRD238.0		No	No	3	Culvert	3		
PMRD239.0		Yes	Probable	4	Culvert	4		
PMRA240.0		No	No	2	Culvert	2		
PMRD241.0		Yes	Yes	7	Culvert	6		
PMRD242.0		No	No	1	Culvert	2		
PMRD243.0		No	No	2.5	Culvert	3		
PMRD244.0		Yes	Probable	3	Culvert	4		
PMRD245.0		No	No	1	Culvert	2		
PMRD246.0		Yes	No	1	Culvert	4		
PMRA247.0		No	No	2	Culvert	2		
PMRD248.0		No	No	3	Culvert	3		
PMRD249.0		Probable	Probable	4	Culvert	4		
PMRD250.0		Yes	Probable	6	Culvert	4		
PMRD251.0	Happy River	Yes	Yes	41	Bridge		600	3
PMRA252.0		No	No	3	Culvert	3		
PMRA253.0		Probable	Probable	3	Culvert	4		
PMRA254.0		Probable	Probable	4	Culvert	4		
PMRA255.0		Probable	Probable	3	Culvert	4		
PMRA256.0	Portage Creek	Yes	Yes	20	Bridge		550	3

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Appendix B – Route Maps

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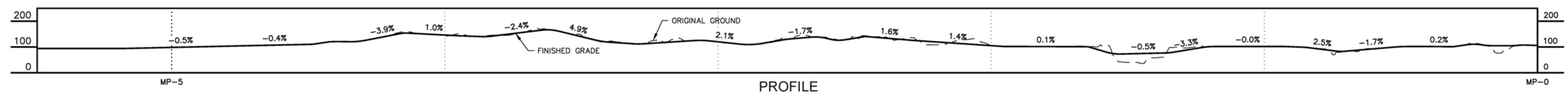
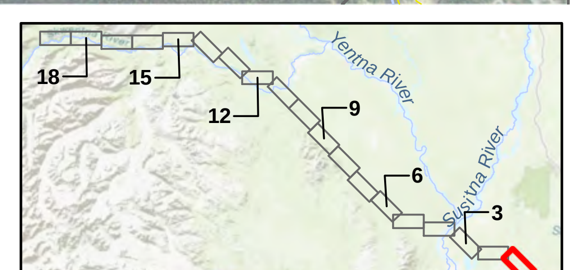


PROFILE

- Mile Posts
- Port Mackenzie Route
- Cut/Fill Footprint
- Section
- Existing ROW
- Parcel
- Iditarod Trail Historic Routes
- Major Road
- Streams (NHD)

Stream Crossing
- Bridge
- Culvert

Stream Mapping
- Perennial Stream



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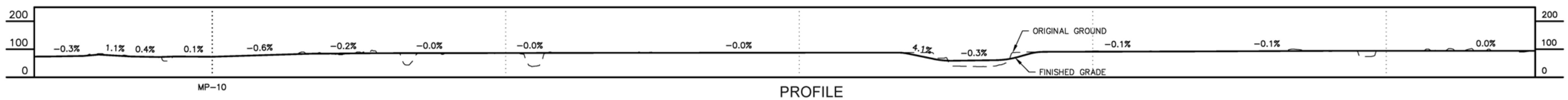

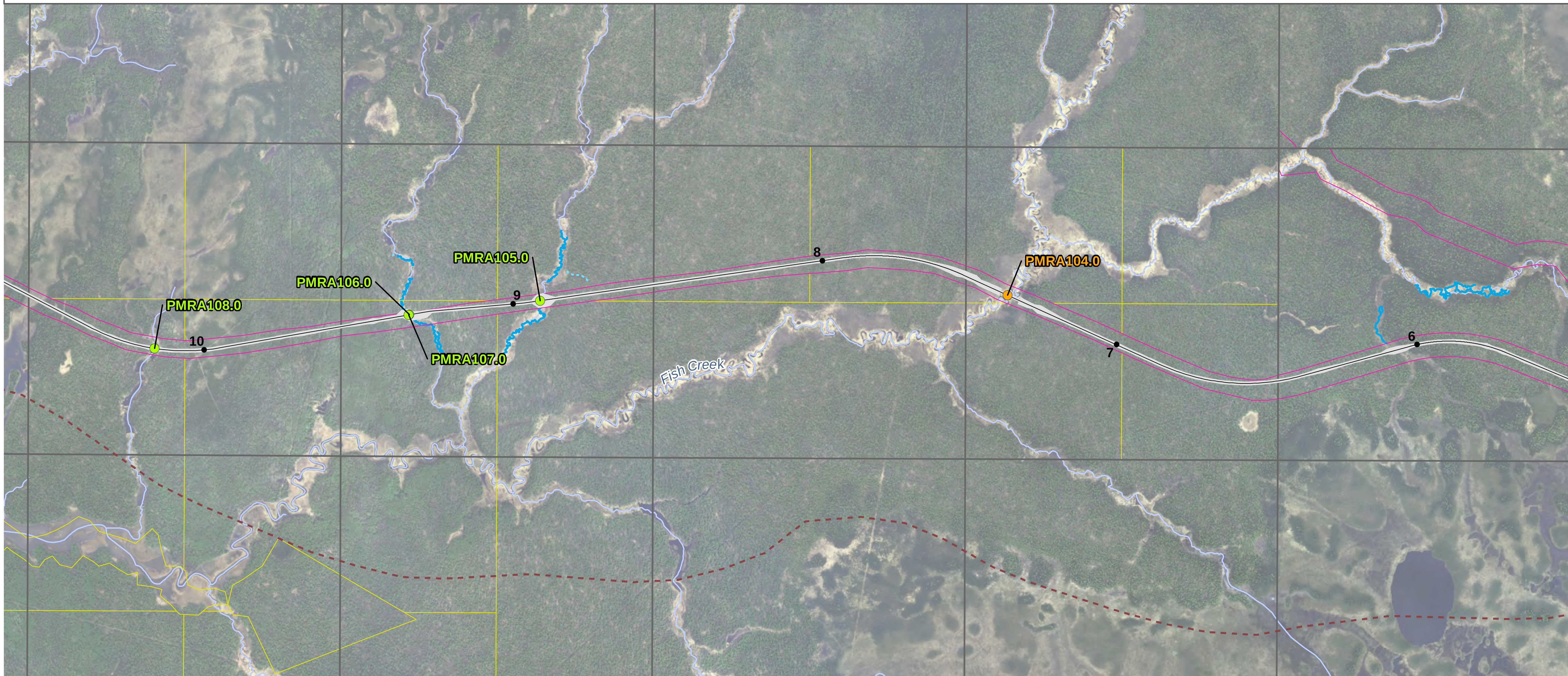

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Stream Crossing
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- Culvert

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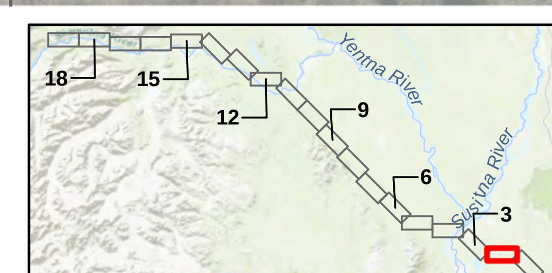
- Seasonal Stream



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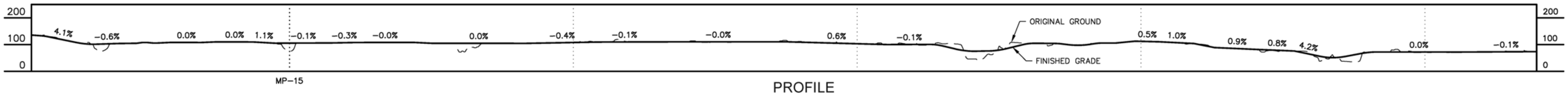

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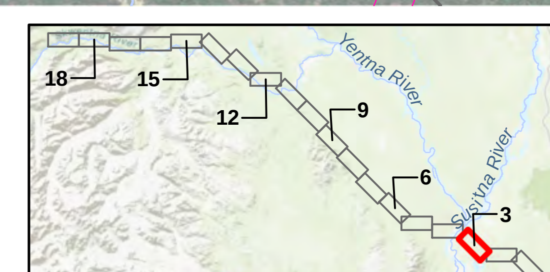
HDR



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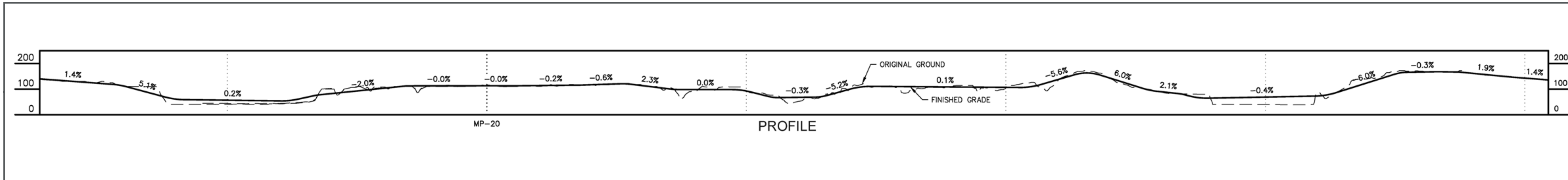

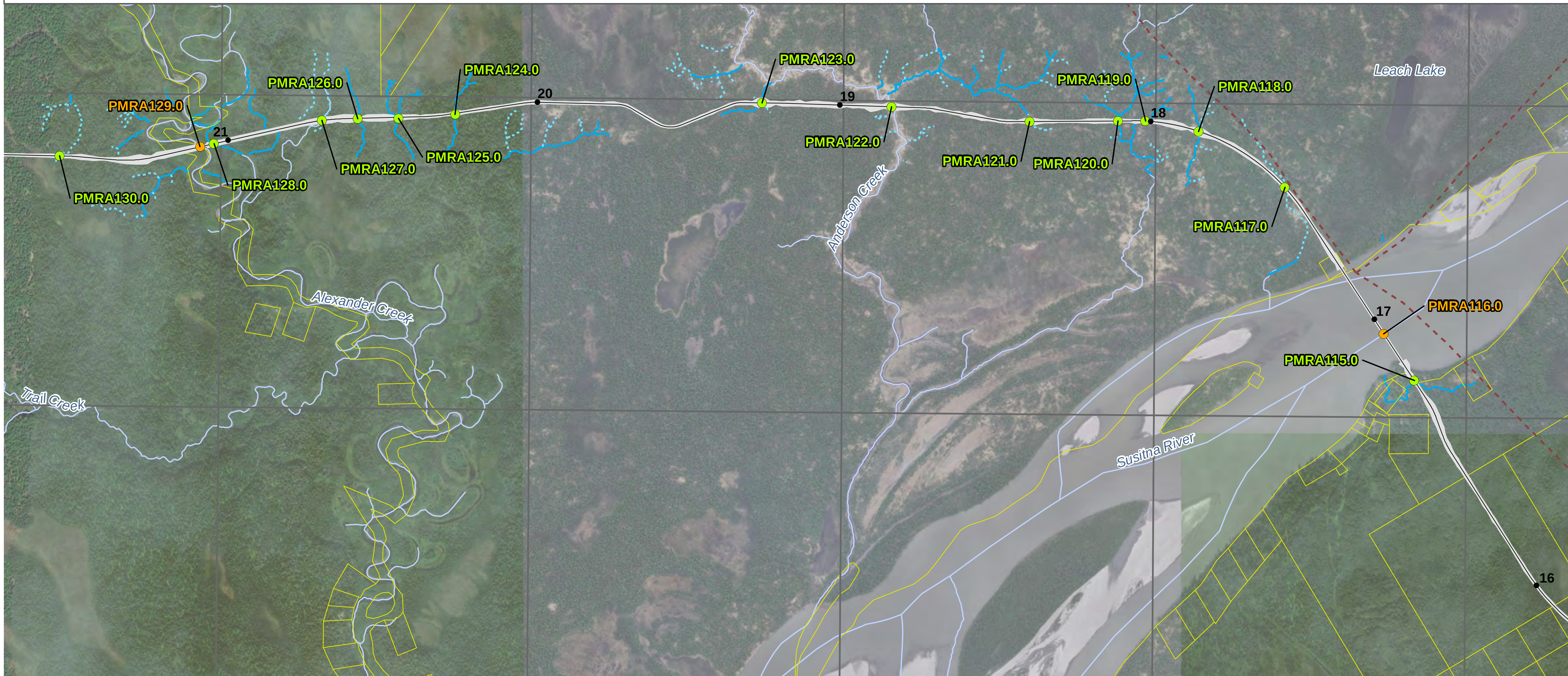

Mile Posts
Port Mackenzie Route
Cut/Fill Footprint

Section
Parcel
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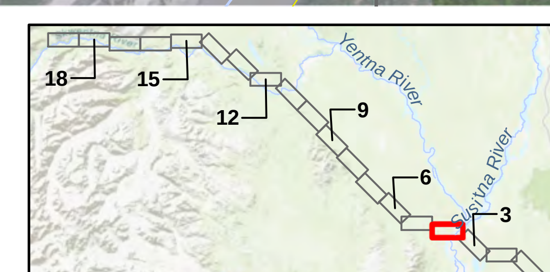
Streams (NHD)

Stream Crossing
Bridge
Culvert

Stream Mapping
Perennial Stream
Seasonal Stream



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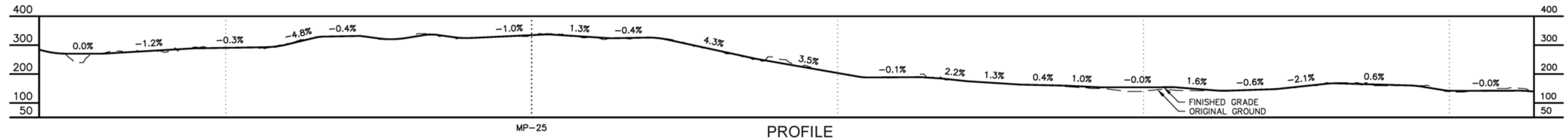

Mile Posts
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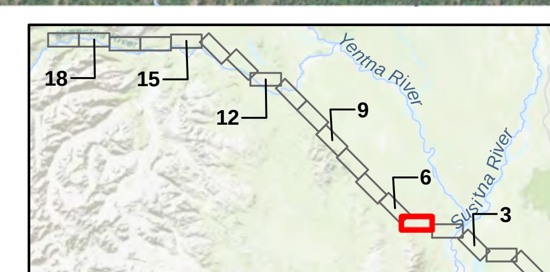

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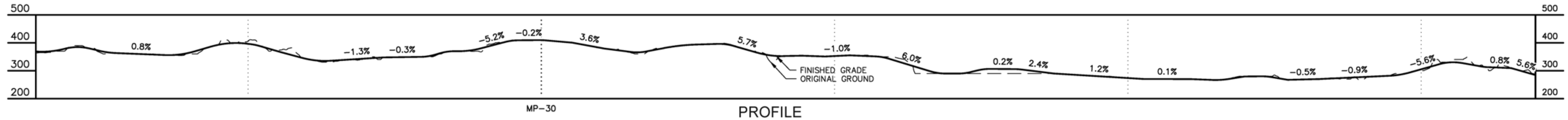

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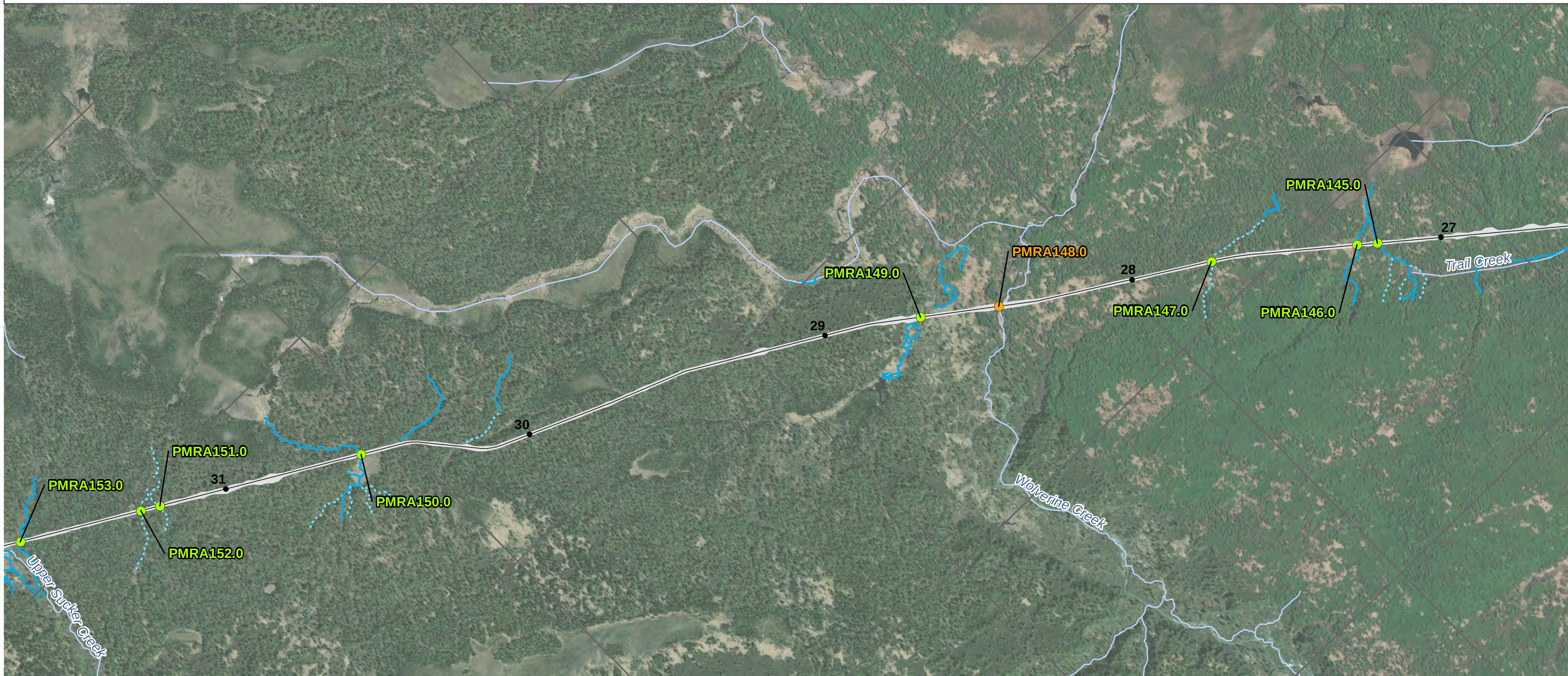

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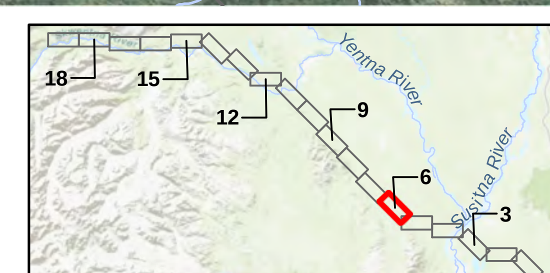

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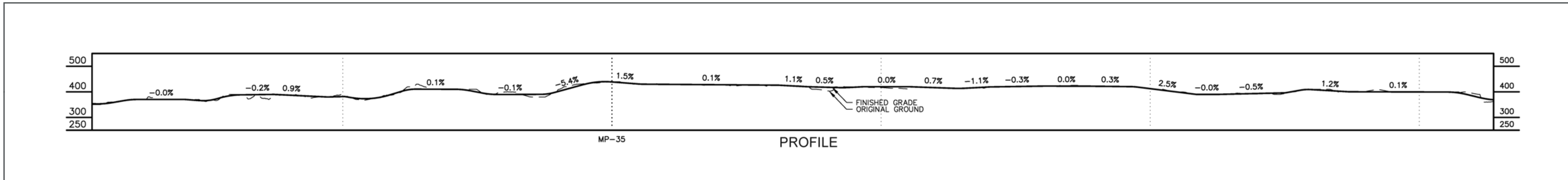

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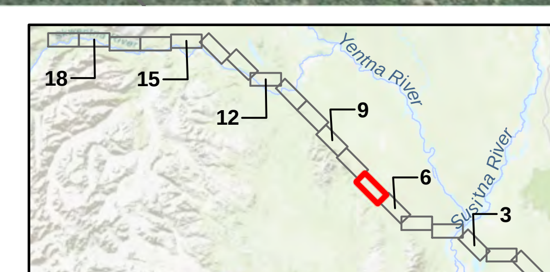

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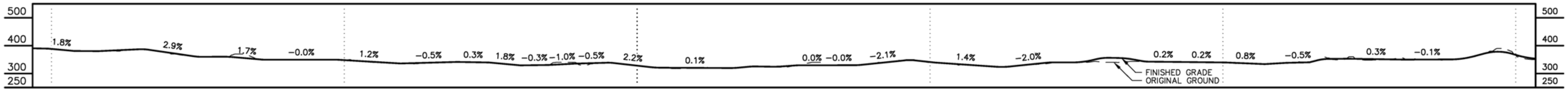

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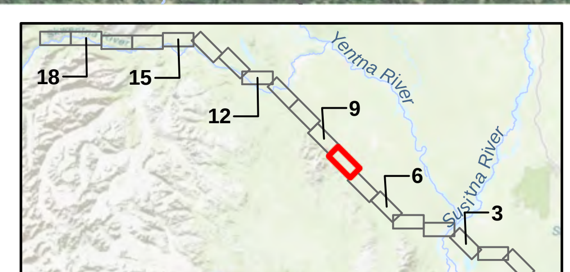

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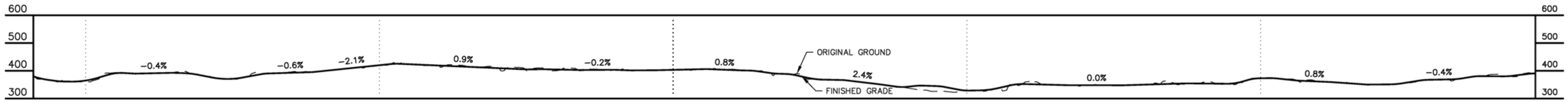

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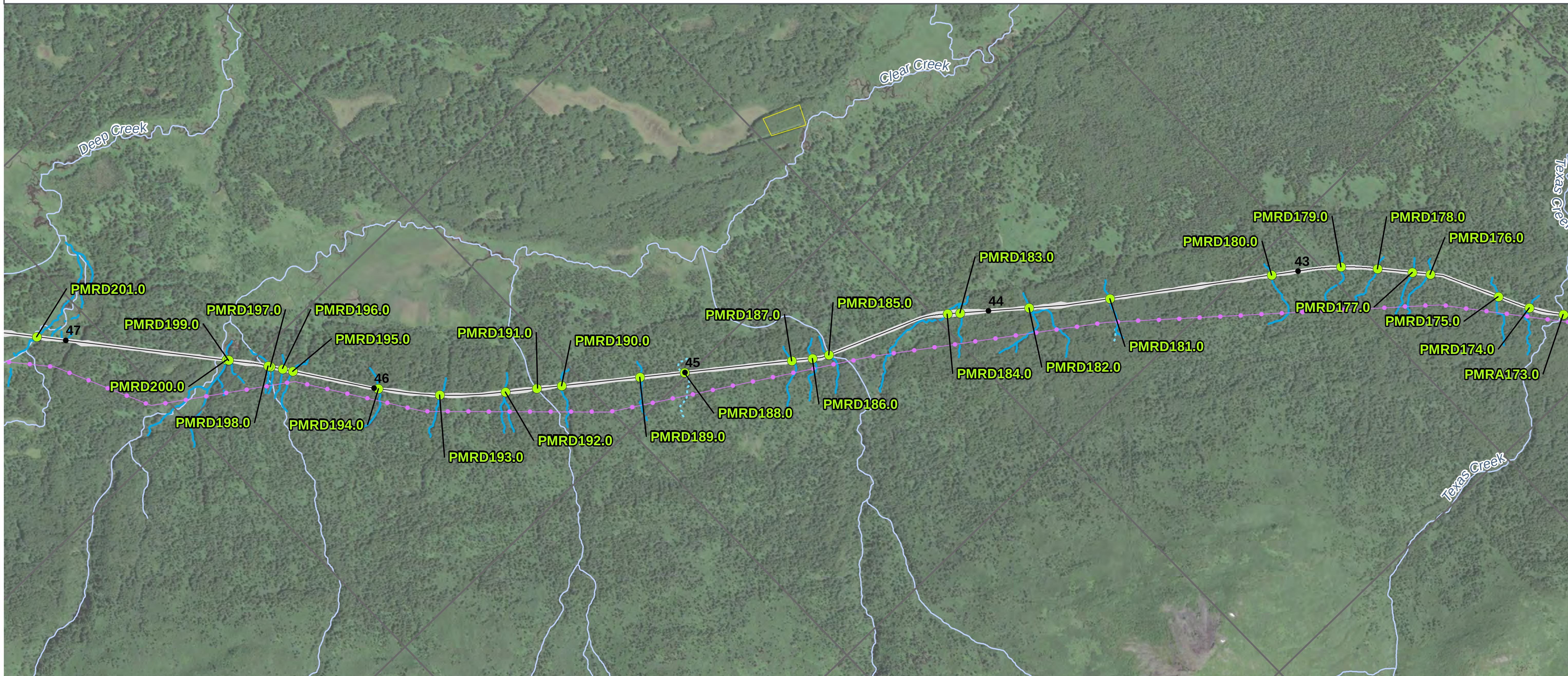

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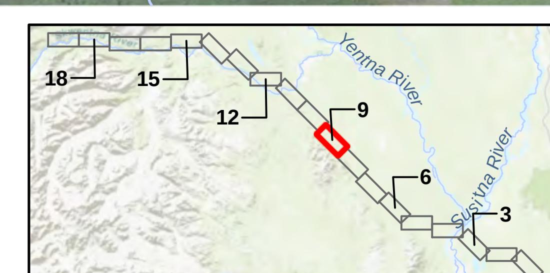

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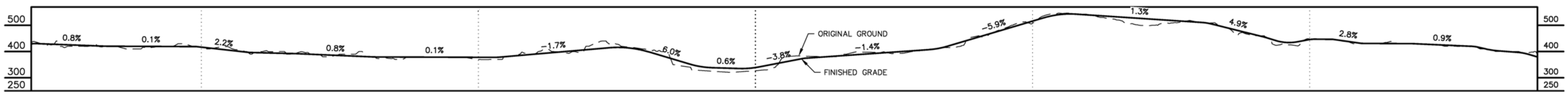

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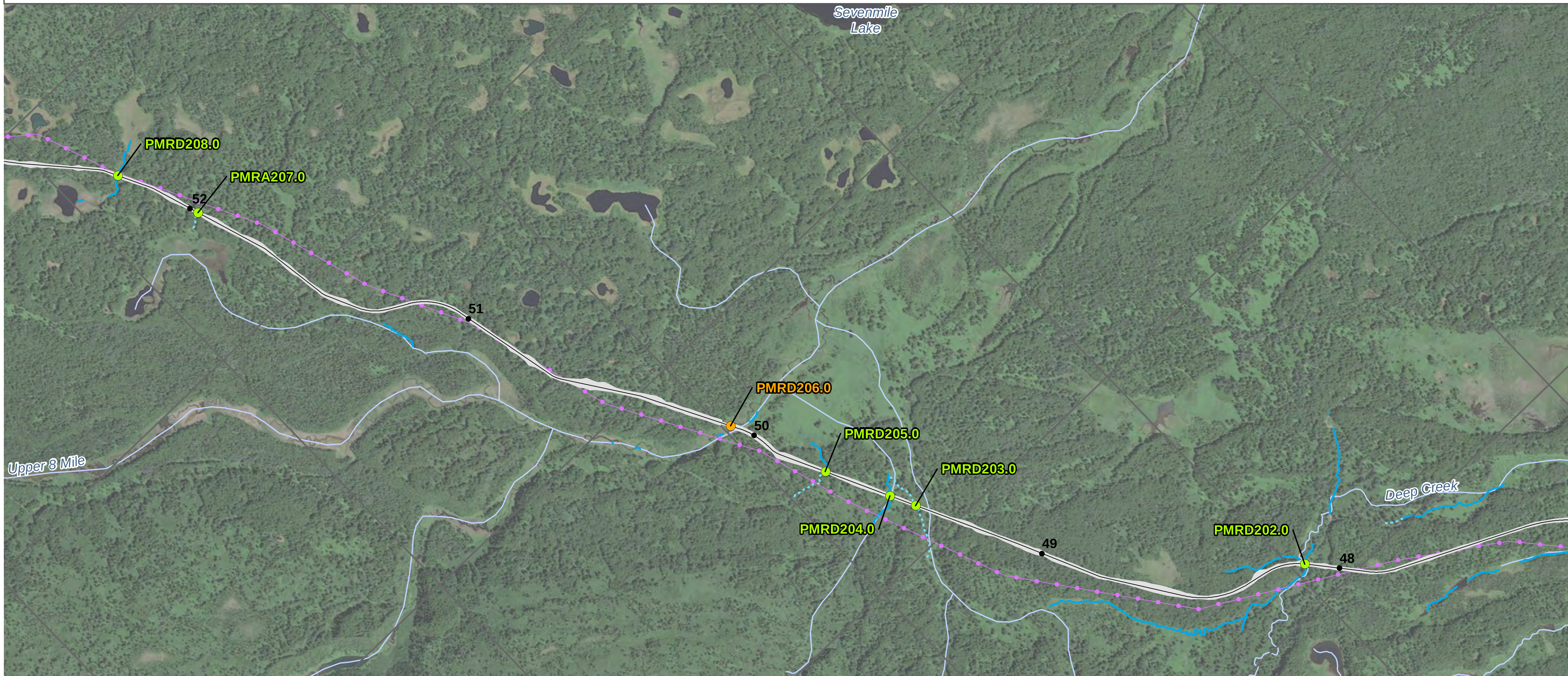

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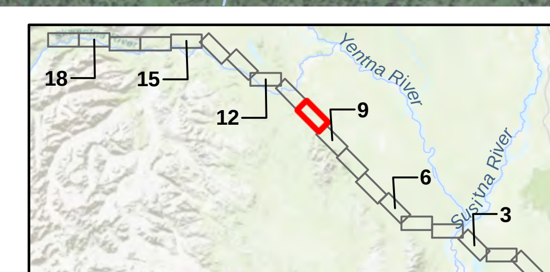

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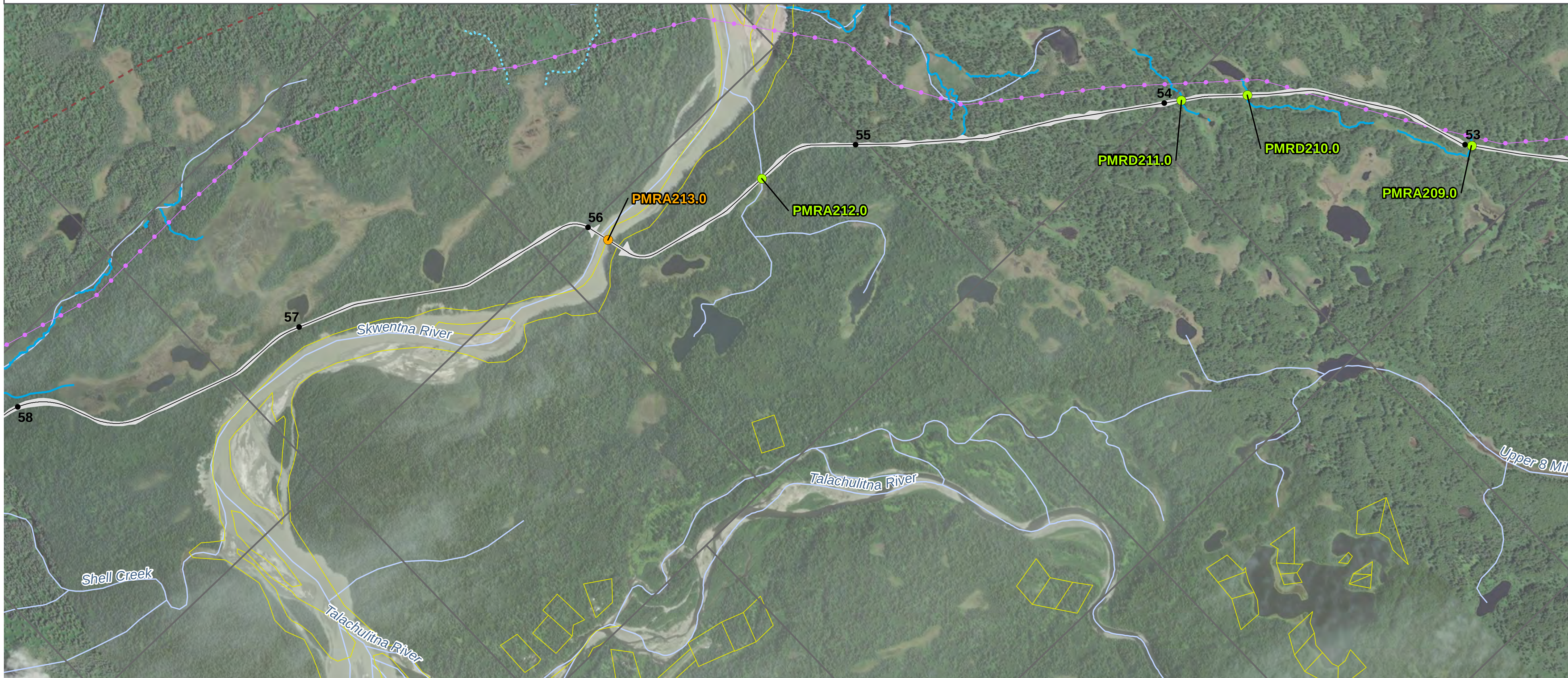

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Stream Mapping
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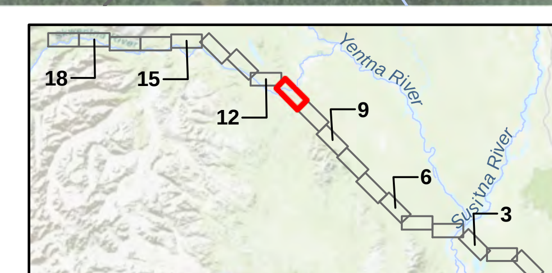

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WEST SUSITNA ACCESS PHASE 2

PRELIMINARY ROAD ENGINEERING MAPBOOK

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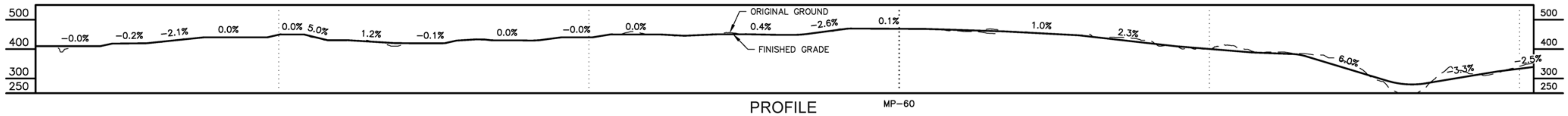

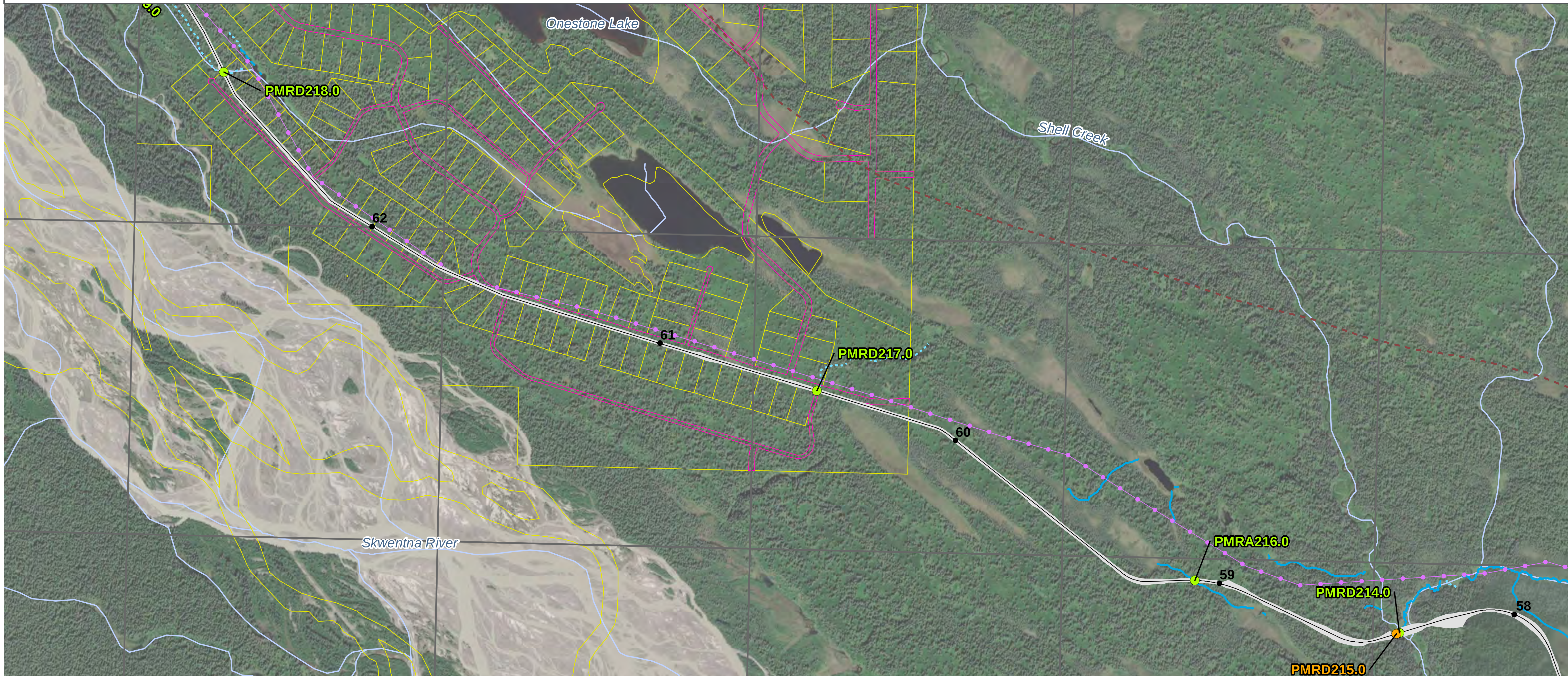

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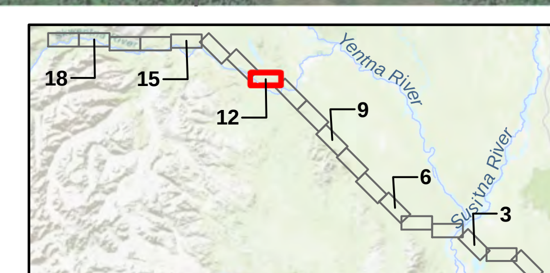

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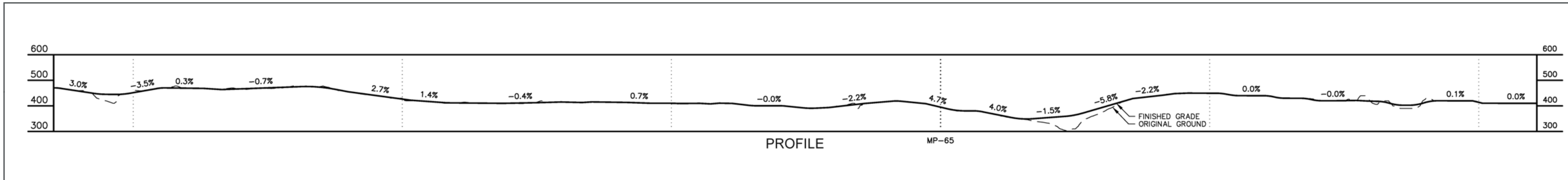

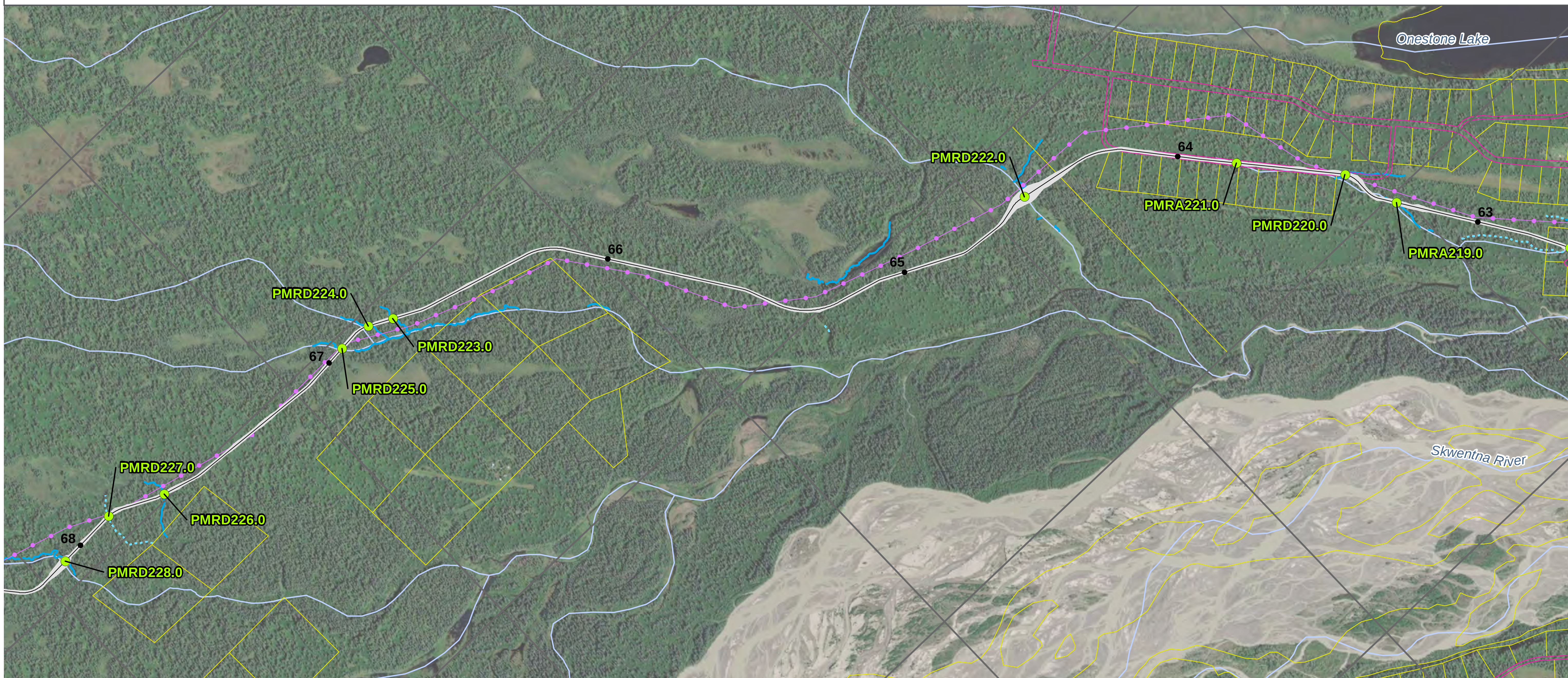

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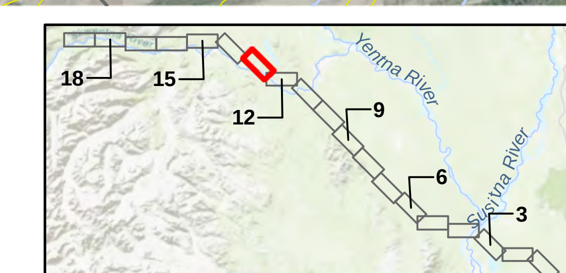

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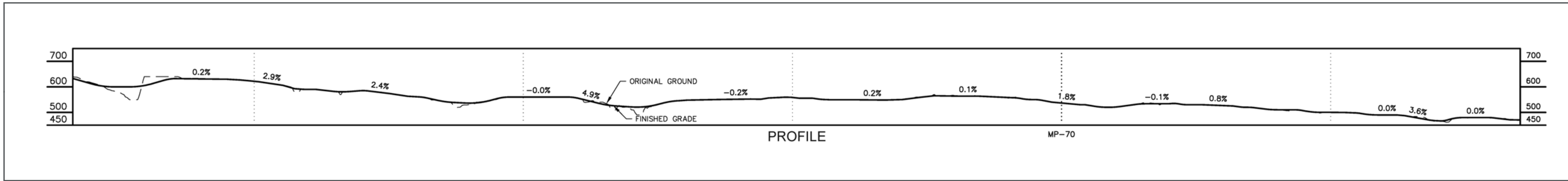

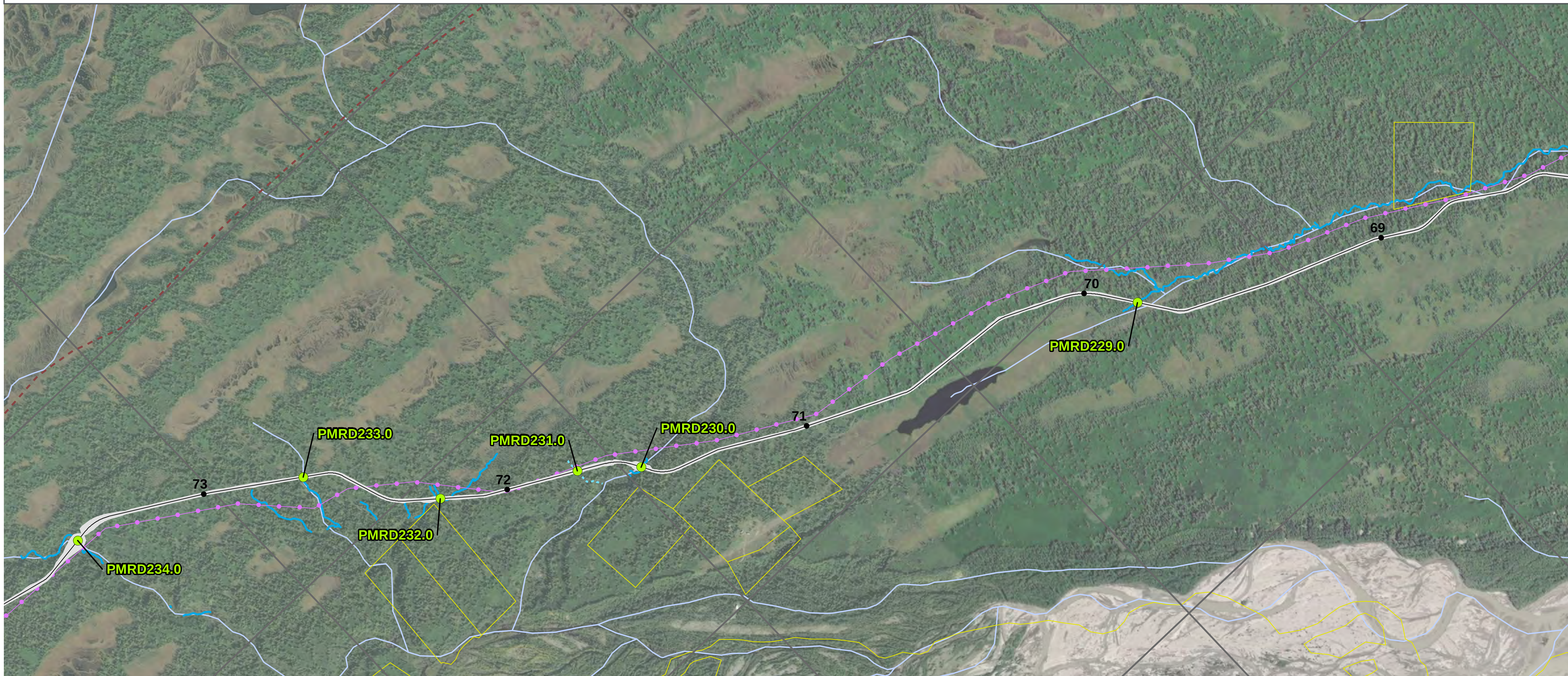

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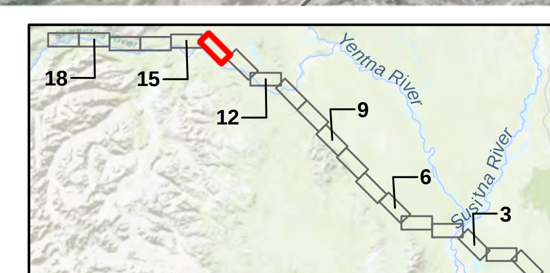

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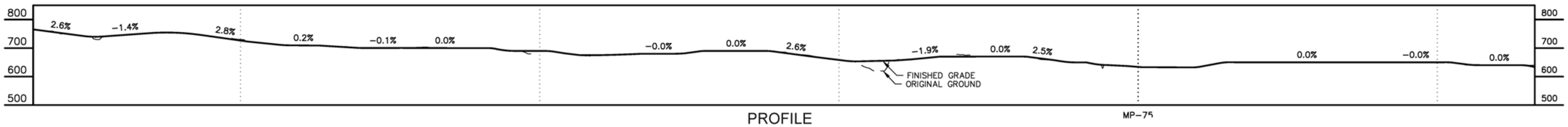

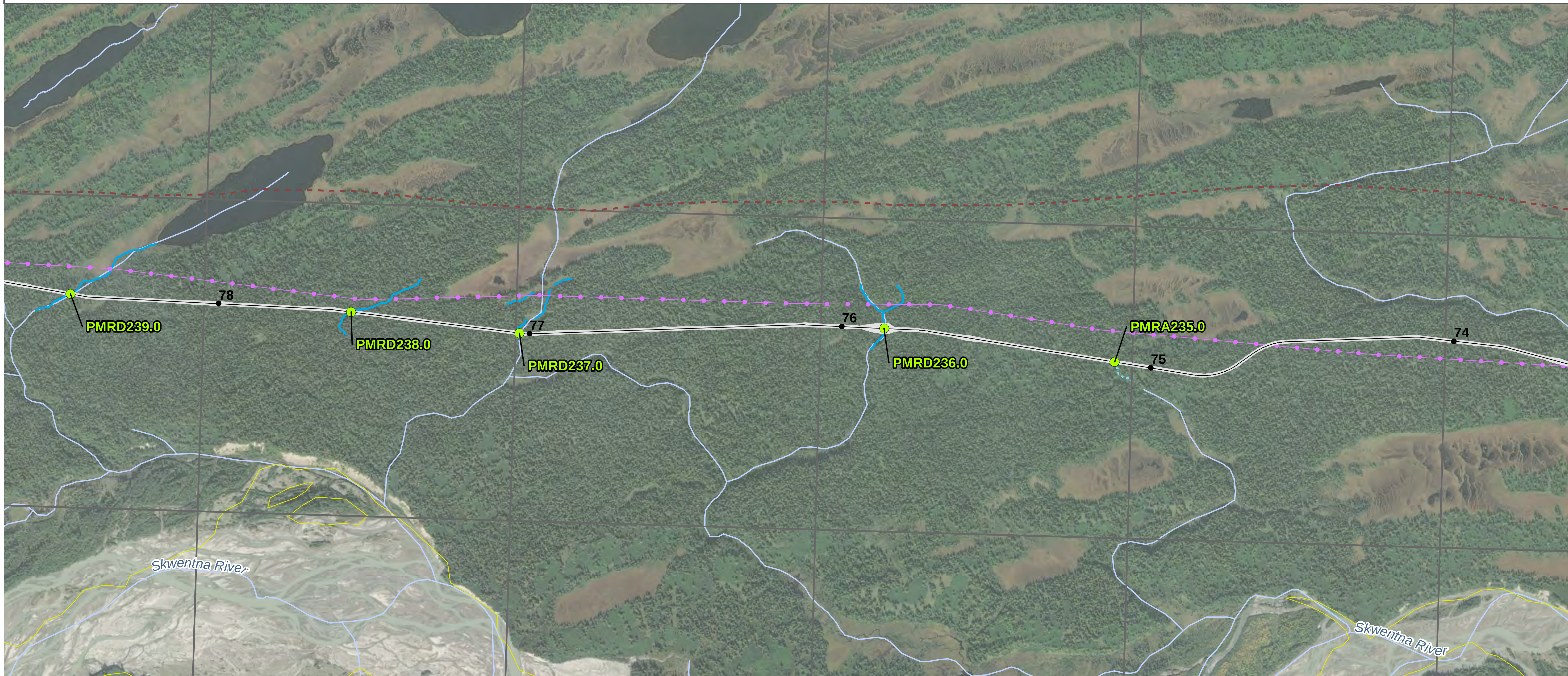

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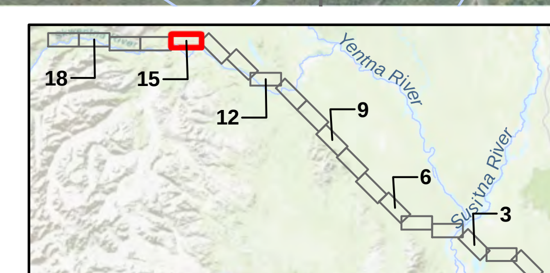

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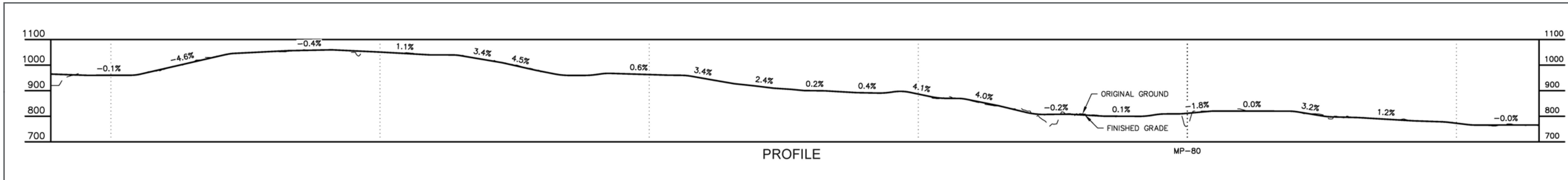

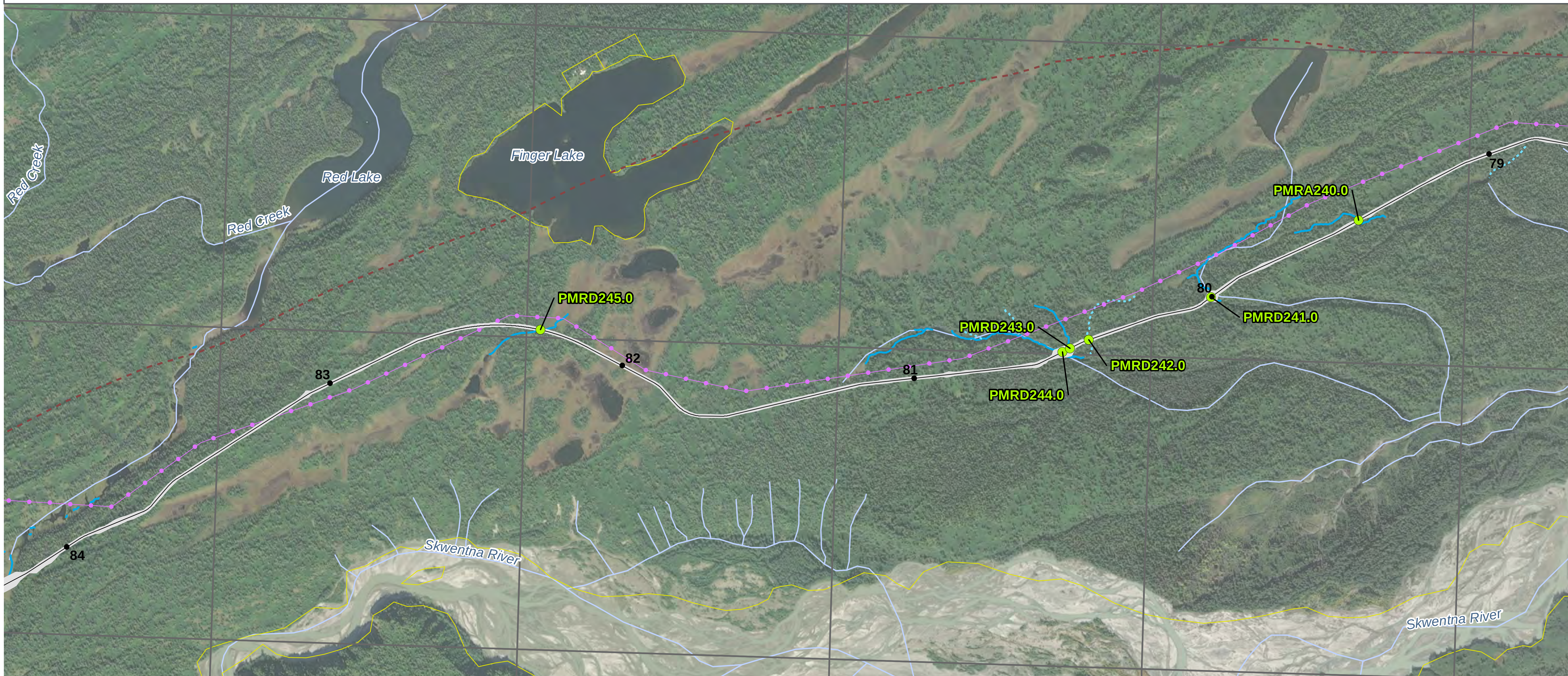

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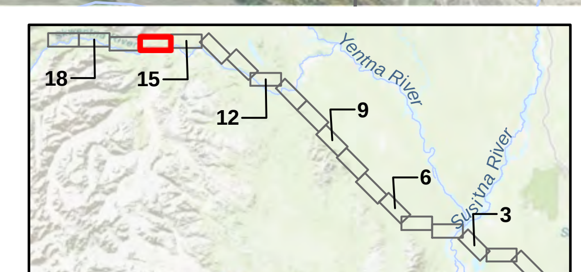

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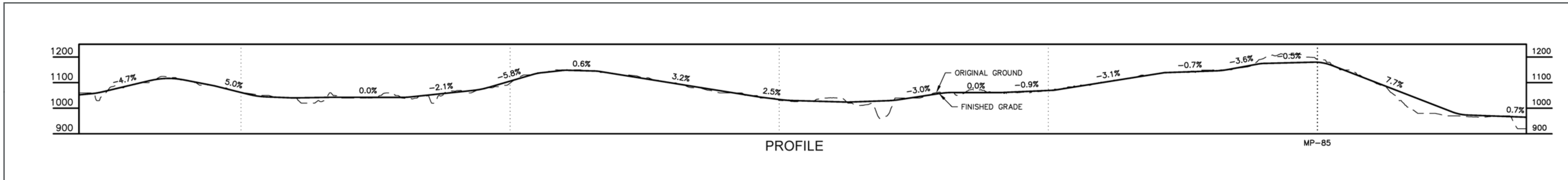

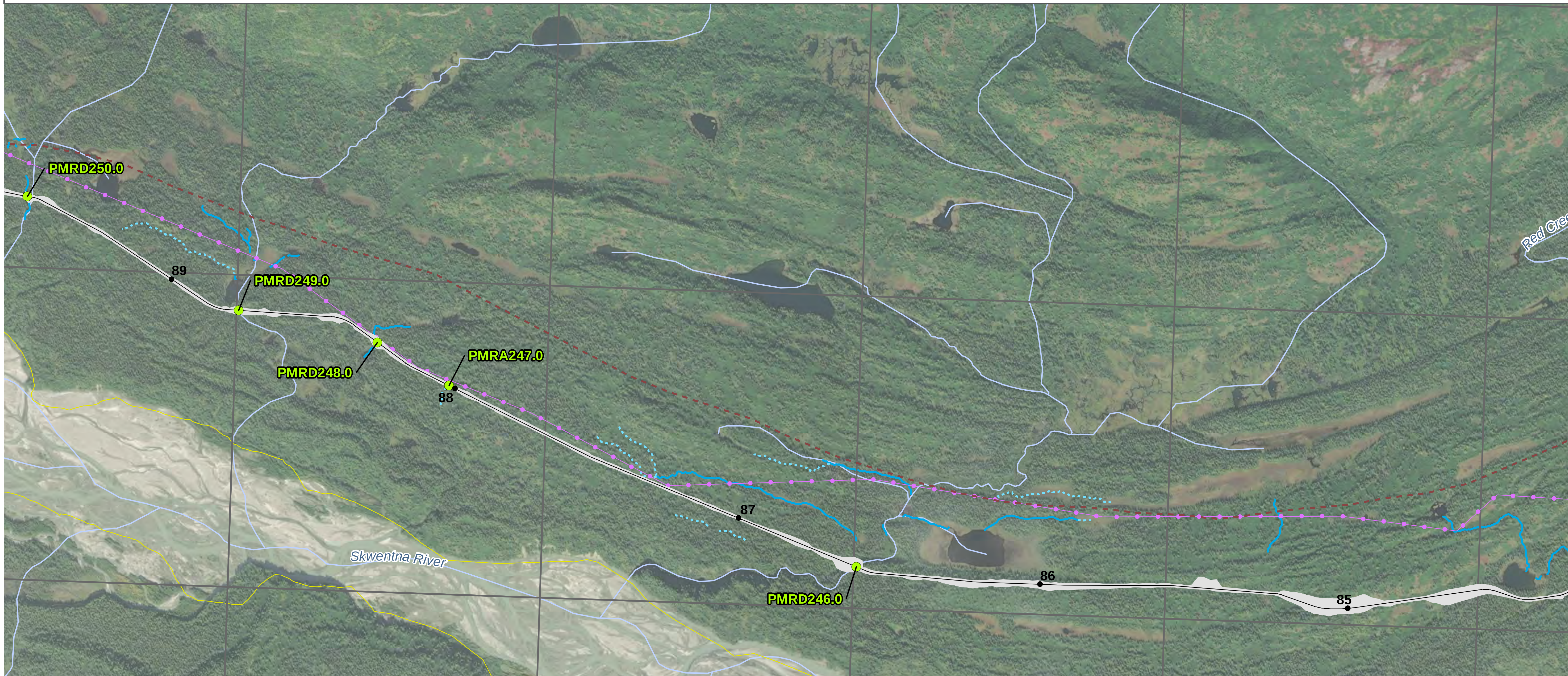

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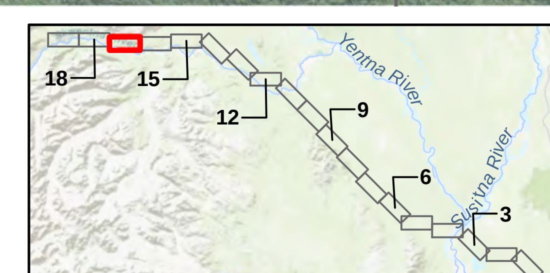

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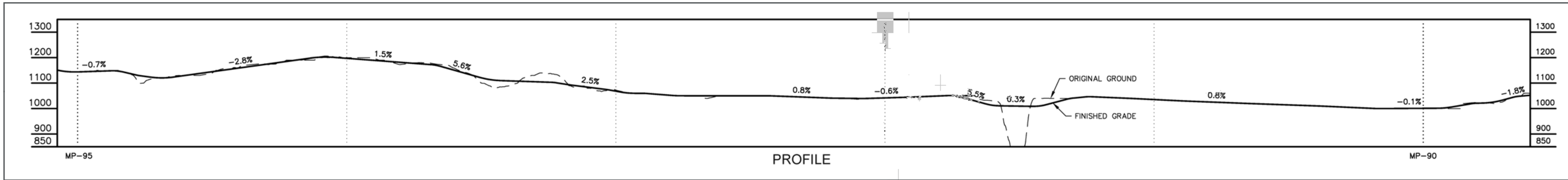

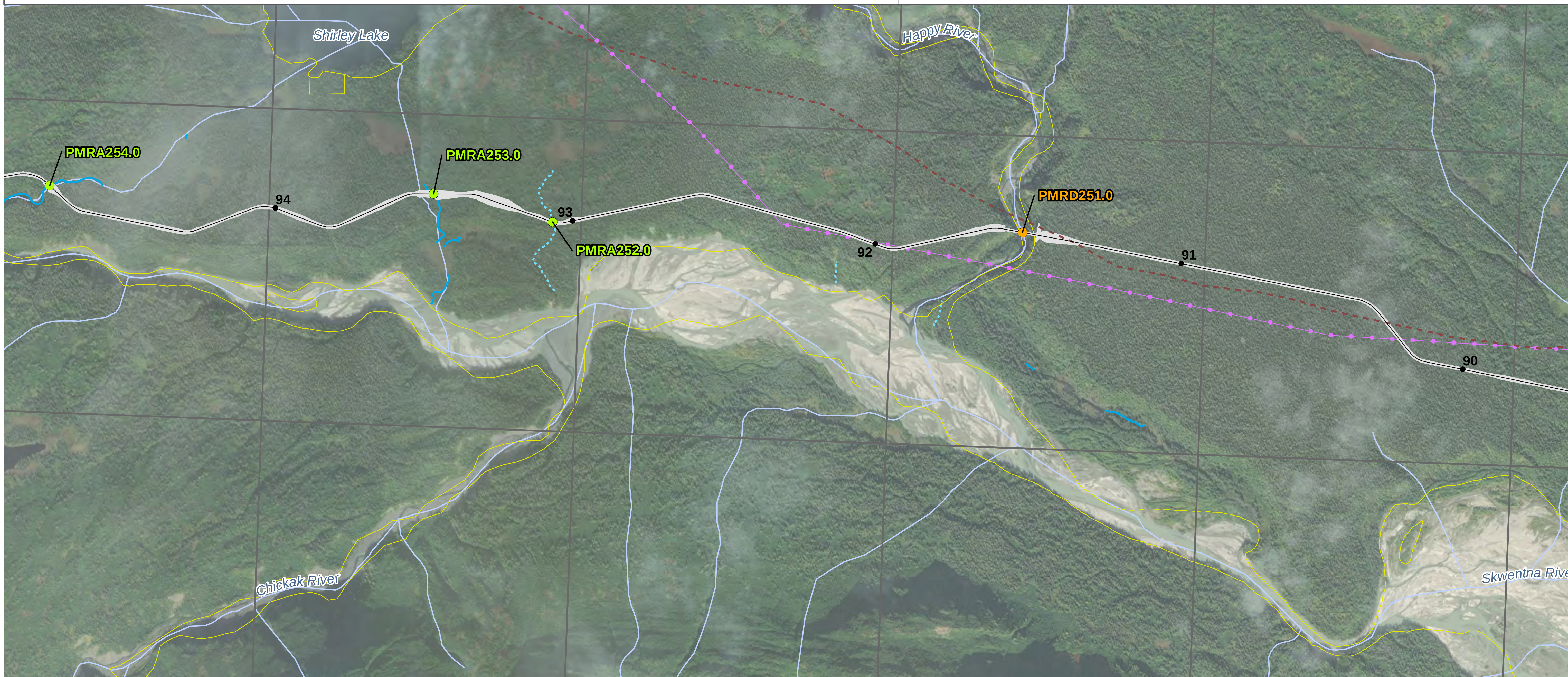

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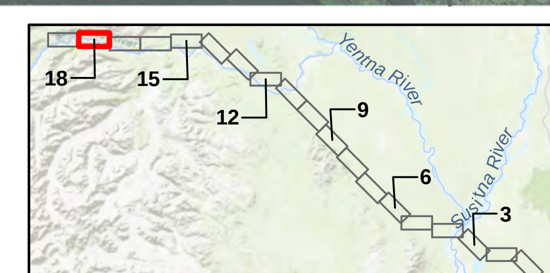

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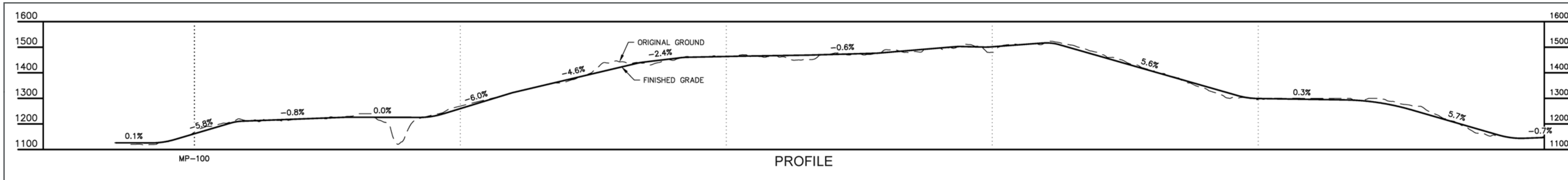

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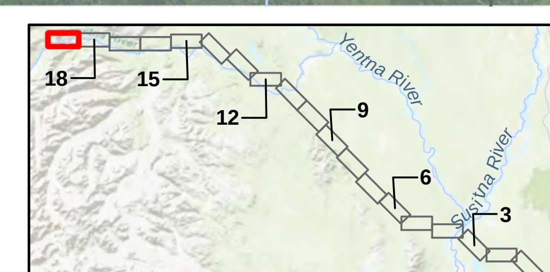

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